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Duesternbrooker Weg 120
24105 Kiel (Germany)

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# The Welfare Costs of HIV/AIDS in Eastern Europe: An Empirical Assessment Using the Economic Value-of-Life Approach

by

**Julia Fimpel and Michael Stolpe**

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Julia Fimpel (Andrássy University of Budapest) and Michael Stolpe (The Kiel Institute for the World Economy)

**Abstract:**

*Based on the aggregation of individual willingness-to-pay for a statistical life, we calibrate an intertemporal optimization model to determine the aggregate welfare losses from HIV/AIDS in 25 Eastern European countries. Assuming a discount rate of three percent, we find a total welfare loss for the whole region of 1.2 trillion US-$, approximately 16 percent of the region's annual GDP between 1995 and 2001. Although prevalence and incidence rates diverge sharply between countries – with central Europe far less affected than the major countries in the Commonwealth of Independent States and the Baltics – the epidemic is likely to spread to all countries unless a coherent strategy of prevention and treatment is backed up by substantial increases in health care investments. The sheer size of this task and the international nature of the epidemic render this one of the most important current challenges for all of Europe.*

Keywords: HIV/AIDS; Survival Probabilities; Value of a Statistical Life; Willingness-to-Pay; Eastern Europe

JEL: D91, I12, I18, J17

*Corresponding author*:
Dr. Michael Stolpe
The Kiel Institute for the World Economy
24100 Kiel
Telephone: +49-431-8814-246
Fax: +49-431-8814-502
Email: michael.stolpe@ifw-kiel.de

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Abbreviations

| | |
|---|---|
| QALY | quality-adjusted life year |
| WTP | willingness-to-pay |
| HIV | human immunodeficiency virus |
| AIDS | acquired immunodeficiency syndrome |
| CBA | cost-benefit-analysis |
| CES | constant elasticity of substitution |
| IES | inter-temporal elasticity of substitution |
| DALY | disability-adjusted life year |
| GDP | Gross domestic product |
| GDPTT | Gross domestic Income adjusted for terms of trade |
| w.r.t | with respect to |
| s.t. | subject to |
| ARV | antiretroviral therapy |
| HAART | highly active antiretroviral therapy |
| WHO | World Health Organization |
| UNESCO | United Nations Education, Scientific and Cultural Organization |
| CEECs | Central and Eastern European Countries |
| CAFE | Clean Air for Europe Initiative |

## 1 Introduction

The objective of this paper is to assess the full economic cost of HIV/AIDS in Eastern Europe on the basis of the neoclassical “value-of-life”or “willingness-to-pay” approach that was first utilised by Philipson and Soares (2005) to estimate the welfare loss due to HIV/AIDS for Sub-Saharan Africa. This approach essentially attempts to measure the aggregate social willingness to pay for an HIV/AIDS-free life, given the rising threat of the epidemic in Eastern Europe. We find that the social willingness to pay for the absence of HIV/AIDS is much higher in Eastern Europe than in Africa, as current per capita income in these countries is higher and expected future growth in income is also higher because the people in Eastern Europe have accumulated more human capital.

Our paper contributes empirical estimates to quantify the welfare loss from HIV/AIDS at the country level in monetary values. Our findings have relevance for a number of policy choices: How high should Eastern European governments’ expenditures on HIV/AIDS-prevention and treatment be? Which countries would gain the most from a mortality reduction? How much external help would these countries need from the world at large or the European Union, respectively? And which countries would need support most urgently?

HIV/AIDS impacts a country’s economy in many ways. Greater morbidity and mortality reduces the supply of labour, thereby lowering the government’s tax revenue at a time when a large more increase in health spending is needed. In an inter-temporal context, HIV/AIDS may lead to decreased public and private savings and investment, especially in human capital, as a result of diminishing returns to savings and investment in a poorer health state. Eventually, the spread of HIV/AIDS may accelerate the expected demographic decline throughout Eastern Europe.

In most Eastern European countries the number of AIDS-cases is still comparatively low. Nevertheless the figures for Ukraine and Russia are striking, and some of their smaller neighbours suffering more losses than is commonly thought. Furthermore the lack of empirical data might cause underestimation, and a highly risky behaviour in the countries of South Eastern Europe might lead to a further expansion of the epidemic in that region. In contrast of Africa, the rate of HIV-infected children is about zero. Eastern Europe’s more developed system of medical care apparently succeeds in preventing HIV-infected pregnant women from passing the infection on to their baby, for example by using powdered milk instead of breastfeeding.[1]

The main transmission route for HIV/AIDS in Eastern Europe is through intravenous drug use.[2] There is a clear predominance of young people between 15 and 30 years of age affected by the HIV/AIDS problematic.[3] The countries differ significantly and can therefore not be considered as a homogeneous aggregate.[4] In parts of South Eastern Europe, especially in countries affected by conflict and problems of transition, drug use and risky sexual behaviour are the main risk factors with the potential to accelerate the spread of the epidemic in the forthcoming years, if no systematic prevention takes place. Access to antiretroviral therapy (ART) differs sharply across countries in Eastern Europe. For example Russia, with one of the highest HIV prevalence rates, provides access to ART for less than 2% of the people in need of treatment. Yet despite all differences in prevalence and treatment, it is clear that the dynamics involved in the spread of HIV/AIDS challenge the whole region.

The remainder of this paper is structured as follows. In Section II we discuss the theoretical basis of our approach. The issue of measuring the value of life and of health improvements has become more and more urgent and we will therefore give an overview of the results of previous theoretical approaches.

Section III discusses the empirical methods some of which are new and thus not yet widely applied. We introduce these methods and explain the specific assumptions we have to make in the Eastern European context. In section IV the data set is presented and the quality of the data and measurement issues are discussed. Descriptive statistics for selected countries and regions are introduced.

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[1] This cannot be done in Africa, as the water quality is very low and the threat of dying from diarrhoea is even stronger than that of being infected.

[2] According to UN AIDS Data, 80% of HIV cases through intravenous drug use in the Russian Federation are in persons under 30 years of age.

[3] In Belarus, 60% of HIV-infected persons are aged 15-24, in Ukraine 25% are under 20, and in Kazakhstan about 70% are under 30 years of age.

[4] For example, the most affected Central European countries are Poland and Romania, where about 2/3 of all HIV-infections across Central Europe were reported. Countries like the Czech Republic, Slovak Republic, Hungary and Slovenia still show a low vulnerability to HIV/AIDS and their numbers of HIV/AIDS-cases have been kept constant. In these countries, men having sex with men are the most vulnerable group.

In Section V we calibrate the model to obtain the individual and aggregate welfare costs of HIV/AIDS for Eastern Europe. A discussion of these findings and further methodological questions follows in Section VI.

## 2 Theory

The theory on which we base our estimates has been developed very recently. The relevant considerations of valuing a life according to personal utility were first worked out by Rosen (1988) and further developed by Nordhaus (2002), Murphy and Topel (2003), Becker, Philipson and Soares (2004). They were first applied to the problem of HIV/AIDS by Philipson and Soares (2005). Also, results on the value of a statistical life by Viscusi (1993), Frankhauser, Tol and Pearce (1998) and Viscusi and Aldy (2003) contributed significantly to the approach.

### 2.1 Previous Approaches

Since the 1970s there have been a number of theories on how to best assess the value of a person's life. This is of great importance in the field of policy-making, for example in environmental decisions, decisions on speed-limit regulation (Ashenfelter, 2006:17), and recently also in health care decisions. In this section we shall briefly summarize several approaches in order to show what is the sui generis contribution of the willingness-to-pay approach.

There are two perspectives from which a person's life may be valued. While the extra-welfarist approach measures external indicators of the value of life such as labour income earned or QALYs describing a person's "objective health state", the welfarist perspective is based on the individual's own valuation.

From an extra-welfarist perspective, the value society assigns to a person's life may simply be the labour input to GNI. What has become known as the human capital approach to the value of life falls into this perspective. If the value of life depends on earned income, an ill person works less and therefore earns less. The approach does not capture older people or children, who work without gaining money. Although in theory the approach is appealing, the difficulties to measure these monetary contributions have evoked crude simplifications in practice. The approach ignores the contributions of children and pensioners to society. This raises serious doubts as the approach tends to ignore the value that people attribute to their own life. A person's income directly depends on his/her work which sometimes cannot be chosen freely. It is questionable whether one may reduce the value of people within a society to the income they earn irrespective of their social engagement. The approach does not consider that individuals save their income in order to consume at a later stage and they save more if the probability of this future consumption is high.

Nonetheless, a similar approach is still applied by the World Health Organization to estimate the welfare effects from health improvements. For example, Murray and Lopez (1996) assume the value of life to be higher in the middle of life than at either end, because of better health (a stronger bodily system) and a higher quality of life between the ages 20 and 40. This implies that infant mortality would be considered less important than adult mortality, and also that older people have a smaller weight in health care decisions.

The lifecycle consumption model with an uncertain lifetime is based on an inter-temporal approach within the welfarist perspective. This model assumes that the utility in a person's life comes from the consumption he or she can make during the lifecycle, but assigns no value to the time itself gained by living longer. The utility is mainly determined by two factors, the time preference which leads to discounting the future utility at a certain rate, and the inter-temporal elasticity of substitution, which expresses how flexible people are between consuming now and later. If the probability of a longer life is high, people have an incentive to save and invest more in order to be able to consume more in later periods. This choice-problem is one of inter-temporal optimisation. Our approach assumes methodological individualism, where the individual is the person best informed about his orher own situation, preferences and life plans. This is why the willingness-to-pay-approach for a longer life can reflect the value of life of an individual in a more appropriate way than, for example, the human capital approach.

The model, as opposed to the plain lifecycle consumption model, indirectly includes the value of non-market time in the valuation by incorporating a country-specific consumption elasticity in the utility function, $\varepsilon$, which is derived from data on the value of a statistical life. The expression of the value of life in monetary units permits the estimation of an aggregate monetary value of life of people in a specific society. If people live longer, they tend to invest into their future well-being in terms of consumption possibilities, which can be done by investment into the personal human capital or by saving a part of the disposable income in previous periods. Saving and investment as effects of these self-serving (selfish) motives are essential for the economic growth and (technological) progress of a society. Information about the quantitative effects of life expectancy within such a willingness-to-pay-approach can therefore be of considerable value to economists and policy-makers.

The theoretical foundation of the willingness to pay (WTP) approach lies in the consumer sovereignty consideration it is based on, i.e. individuals are the best judges of their own well-being. Second, the approach does not make interpersonal comparisons of utility which would not be allowed if the marginal utility of income varied across income groups.[5] Third, it assumes the Kaldor-Hicks compensation criterion as underlying value judgement in order to produce normative statements.[6]

A major advantage of this approach in our context is that it provides an aggregate assessment of the social costs on the country-level and facilitates international comparison. The WTP essentially measures the benefits produced by a collectively funded health care program or interventions which cannot be allocated in private markets. In the recent literature on WTP, especially in environmental economics, the “value of a statistical life” is often obtained by asking people about their willingness to pay for environmental improvements or their willingness to accept compensations for impairments thereof. This will be further elaborated in section 5.1. With respect to health care programmes, we can distinguish between the WTP for certain health outcomes, for certain treatment with uncertain outcomes and for access to treatment for which future use and outcome are uncertain. While the willingness-to-pay for an AIDS-free life might be very large, the WTP for access to treatment with uncertain future use and uncertain outcomes may be lower due to people’s time preference and risk aversion of the individual.

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[5] If richer people and poorer people value an additional dollar differently, the marginal utility of income is not equal across the population.

[6] Reasons for this are (a) that efficiency-considerations should come before distributional ones, which are left to the realm of politics and (b) that more or less arbitrary weighting produces inefficiencies where lump-sum transfers after maximizing the aggregate utility would be more efficient. Welfare efficiency is considered as superior to welfare equity and therefore the aim of the approach is to maximize overall utility first before addressing equity concerns of welfare. This, however would mean that safety improvements in upper income groups have to be conducted first while addressing the lower income groups by redistributive policies ex post. The problem here is how to compensate the “losers” if they are affected by severe illness, disability or premature death. From an ethical perspective it might be argued that there is no justification for the Kaldor-Hicks Criterion, as the compensations only take place *hypothetically*. But it is thinkable that those who profit from a longer life despite HIV, can compensate those who finance the treatment technology not only by lowering the risk of infection.

## 2.2 The suitability of the value-of-life approach

The arguments for the superiority of WTP over QALYs are usually that the former is (i) theoretically founded in welfare economics[7], (ii) that it allows for the valuation of all kinds of attributes of a health care program[8], and (iii) that the valuation is made in the same units as costs (i.e. monetary), which is important to decision makers. However, it is not our aim to compare different approaches to valuing health programmes; for an extensive discussion see (Olson/Smith, 2001).

The goodness of WTP-estimates also strongly depends on how carefully the valuation is carried out. A partial valuation, as it is often done for new health technologies and programmes, cannot be used for decision making, as the WTP for deferred programmes is not known and hence we do not know if the new programme really constitutes an improvement to prior programmes. Partial valuation only works if the source of funding is private income because in public funding the opportunity costs are not known (revealed). Still, most existing WTP-studies are partial, i.e. without a comparator. In this case, cost-utility analysis might provide more valuable conclusions than the WTP-approach.

A unique advantage of the WTP-approach is that it can assess the intensities of preferences and thus provide guidance to decision makers in deciding how many resources should be spent on health care programmes. But WTP is not income-neutral. While health state utility scales lie between 0 (death) and 1 (perfect health), WTP scales do not have an upper limit, the only constraint is the respondent's budget, i.e. a higher income implies a higher WTP for health improvements. This scale is essential for assigning a money value to the problem of HIV/AIDS. A health state between bad and good health cannot account for such a value. Critics might reject the approach on the basis of its income-bias (which is also clearly visible in our results). The determining factor here is the *relative* income**,** and "needs" for health care differ between income groups. Using WTP unadjusted for income will skew resource allocation to the preferences expressed by the wealthy. Despite the availability of

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[7] The approach is based on consumer sovereignty, i.e. individuals are considered the best judges of their own well-being; no interpersonal comparisons of utility are made and the Kaldor-Hicks-Compensation criterion is used (efficiency-considerations have priority over distributional ones, weighting produces inefficiencies, therefore the aim is to maximize aggregate utility).

[8] It accounts for people's valuation of other characteristics of health care beyond health outcomes, such as process utility (e.g. degree of patient autonomy), option value (e.g. the access to treatment which might be necessary in the future) or externalities (e.g. onto family members). Furthermore some medical treatment does not yield measurable outcomes and other non-outcome-benefits but still may be valued. For example a person may be willing to pay for the treatment of other people because this lowers the risk of contagion.

internationally comparable indicators, such as the GDP in purchasing power parities adjusted for terms of trade, the per capita income still differs significantly between countries. Nevertheless the WTP, although income-determined, constitutes a solid, if not the best currently available, indicator for welfare costs because other valuations would be based on a variety of unestablished assumptions (e.g. how should we assign the “moral” value of one human life?). For further elaborations on pharmaceutical pricing and income-differences across countries, see Jack & Lanjouw (2003).[9]

### 2.3 The willingness to pay for a longer life

The theoretical foundation of the willingness to pay approach goes back to utility theory and the necessity to value non-marketed goods and services. Sherwin Rosen first developed a model which could account for the value of changes in life expectancy. For this purpose, preferences had to be state-dependent, such that in the death state, the utility of a person would be normalized to zero.[10] The approach also assumed that there exists a minimum consumption level satisfying the basic needs of a person, below which the utility of death would be preferred to the suffering of being alive.

[Figure 1 about here]

Interesting about this is that on the part of the utility function, where the marginal over the average utility evaluated at c is larger than 1, an individual would even pay for reducing his survival probabilities. Stated differently, below a certain break-even level of consumption, individuals only prefer life over death if they are compensated.

Becker et. al. (2004) develop a model for valuing the effects of health improvements on longevity and hence on the welfare of individuals and nations. The willingness to pay for health improvements was not derived according to the conventional method, but it was calculated by calibrating a general inter-temporal utility model. Philipson and Soares further modified this approach to incorporate the probabilities of survival in the “normal” and in a

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[9] They suggest that drug pricing should be adjusted to the health needs and to the marginal utility of income in each country. This would mean that Ramsey-prices are higher in richer countries and lower in poorer ones, respectively. This takes account of the fact that even though income constrains the willingness to pay for health care, the elasticity of demand and the needs may nevertheless be high. We can therefore conclude that our estimations might be underestimating the welfare losses due to HIV/AIDS.

[10] This was done by subtracting a constant factor from the utility in each state and the expected utility was composed of the probability of being alive times that utility and the probability of being dead consequently normalizing all surplus utility to zero.

hypothetical "No-AIDS"-scenario. We will apply basically the same model, but estimate the welfare losses by incorporating conditional survival probabilities dependent on access to antiretroviral treatment. In the following we will briefly review the model, which gives us the marginal willingness to pay of an individual for a longer life and hence the social marginal willingness to pay.

Traditional accounts on individuals' income measure the living standards in terms of the flows of consumption and income in the lifecycle. Nowadays it is obvious that the longevity, over which an individual can spread this consumption, as well as the health of a population have a significant value in themselves. Current approaches pose the question as to how much of their disposable income individuals would be willing to give up for more health or for a longer life. Older approaches such as the human capital approach or the risk-cost-approach fail to captivate the value of life to the individuals *themselves*. In economics, the axiom of methodological individualism requires that the personal willingness to pay and hence the indirect individual utility function be considered. This approach is particularly useful, as it (i) yields results which can be *measured*, (ii) it provides pecuniary values as benchmarks for political decision makers, and (iii) the estimation is based on a non-arbitrary method.

As in Philipson and Soares (2005), the model used in our approach is based on individual survival-functions which are finally aggregated to form a social survival function. The individual survival function contains the cumulative probability to survive up to a given age as of an individual's the current age, i.e. the length of the remaining life. We sum up the average consumption per period over all of these remaining years, which yield the aggregate utility for one individual, and, analogously, for the society as a whole. The individual survival function is defined as $S(t,a)$ and expresses the probability, with which an agent at age a will survive up to age t. We assume that technological developments or improvements in medical practices on the one hand, and the emergence of new diseases or epidemics on the other shall be described by an exogenous factor θ which shifts the survival function according to $\frac{\partial S(t,a;\theta)}{\partial \theta}$. The model aims at assigning a monetary value to the welfare gains due to changes in S induced by changes in θ, $S_\theta(t,a)$. From a macroeconomic perspective, health improvements are indirectly reflected in the longevity of a society, i.e. the survival function will suffice to account for health and longevity gains. Furthermore, the survival function can incorporate conditional survival probabilities given the probabilities of being infected.

The model discounts utility over the lifetime, so that

$$V(a) = \int_a^\infty e^{-\rho(t-a)} S(t,a) u(c(t)) dt \qquad (1)$$

denotes the indirect utility function, where c(t) is the consumption at t and ρ is the rate of time preference. V(a) represents the value of saving a current life (at age a). The rate of time preference states an agent's degree of impatience, i.e. how much stronger the present is valued over the future. The time preference is typically higher in countries with a lower per capita income.

The implicit assumption made in the utility function is, that in the death state, the utility is normalized to zero.[11] This will be further elaborated below. Further, assume a complete contingent claims market in which the individual's budget constraint is

$$g(a) = \int_a^\infty e^{-r(t-a)} S(t,a) y(t) dt - \int_a^\infty e^{-r(t-a)} S(t,a) c(t) dt = \int_a^\infty e^{-r(t-a)} S(t,a) \big(y(t) - c(t)\big) dt\,, \qquad (2)$$

where y(t), c(t) are the income and consumption at age t respectively. The First Order Conditions for the agent's optimum (∂V(a)/∂y, s. t. the budget constraint) are

$$e^{-\rho(t-a)} u'(c(t)) = \lambda_a e^{-r(t-a)}\,,^{12} \qquad (3)$$

for every t.[13]

The marginal willingness to pay for changes in S(t,a) as an effect of changes in θ per definition is: $MWP_a = \frac{\partial V(a)}{\partial \theta} \cdot \frac{1}{\lambda_a}$, which can be interpreted as the *income value of the marginal utility of health improvement* (θ), or the marginal rate of substitution between income and health improvement. When applied to mortality and morbidity changes, the

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[11] In expected utility theory, preferences are independent states and the utility function is defined only up to an increasing linear transformation. Rosen 1988 solves the problem by subtracting a constant M (assigned to the state of death) from the utility in each state. This is acceptable, because when preferences are state-dependent as in the case discussed here, any increasing linear transformation is acceptable so long as the same transformation is consistently applied to the utility function of each state.

[12] Discrete time FOC: $\rho^{(t-a)} u'(c_t) = \lambda_a (\frac{1}{1+r})^{(t-a)}$

[13] The agent can only influence the variables y and c to reach her optimum. That is why we get:

$$\frac{\partial L}{\partial c(t)} = \int_a^\infty e^{-\rho(t-a)} \cdot S(t,a) \cdot u(c(t)) dt - \lambda \int_a^\infty e^{-r(t-a)} \cdot S(t,a) \cdot c(t) dt$$

$$= u'(c(t)) \cdot e^{-\rho(t-a)} \cdot S(t,a) - \lambda \cdot e^{-r(t-a)} \cdot S(t,a) \cdot 1 = u'(c(t)) \cdot e^{-\rho(t-a)} - \lambda e^{-r(t-a)}$$

willingness to pay measures which change in income would leave the individual's utility unchanged for a given change in the risk of mortality or morbidity.

The envelope theorem states that in an optimum, all indirect effects are equal to zero and therefore cancel out. From this we are left with the indirect utility function differentiated with respect to θ plus the budget constraint differentiated w.r.t. θ:

$$MWP_a = \frac{1}{\lambda_a} \cdot \left[ \int_a^\infty e^{-\rho(t-a)} u(c(t)) S_\theta(t,a) dt + \lambda_a \int_a^\infty e^{-r(t-a)} (y(t) - c(t)) S_\theta(t,a) dt \right] \qquad (4)$$

If we rearrange the terms and substitute the first order conditions, we can write:

$$MWP_a = e^{-r(t-a)} \int_a^\infty \left[ \frac{u(c(t))}{u'(c(t))} + y(t) - c(t) \right] S_\theta(t,a) dt \qquad (5)$$

The ratio of marginal to average utility evaluated at c denotes a key determinant in the value of life and henceforth will be referred to as the consumption elasticity of the instantaneous utility function u(.), $\varepsilon(c(t))$. Introducing this ratio into the above equation, we get

$$MWP_a = e^{-r(t-a)} \int_a^\infty \left[ \frac{c(t)}{\varepsilon(c(t))} + y(t) - c(t) \right] S_\theta(t,a) dt, \qquad (6)$$

so that the utility function is expressed in terms of c(t). This equation contains the main determinants of the willingness to pay for each individual's changes in survival probability. Discounting the future implies that individuals are willing to pay more, the closer they are to the largest changes in survival probability. Nordhaus uses the term "health productivity growth" for describing life expectancy changes, i.e. the greater the changes in life expectancy, the higher is the health productivity growth in a society. The direct utility gain from increasing the survival probability is expressed by $\frac{c(t)}{\varepsilon(c(t))}$ and denotes that a higher consumption at a given moment raises the utility gain from extending the survival probability. An individual with a consumption such that u(c) = 0 will be indifferent between being alive and dead, as her minimum needs cannot be satisfied. The income surplus at point a is the additional income disposable for consumption in forthcoming periods. The higher therefore the savings and investments [y(t)-c(t)], the higher the gains from raising the survival probability.

Eastern Europe might face a bigger threat from HIV/AIDS than hitherto expected. In Eastern Europe, the income per capita is significantly higher than in African countries, which means that even a smaller loss in survival probability will result in greater welfare losses.

Analogously, extending the survival probability can result in higher consumption and greater utility gains. When introducing the fact that personal human capital first has to be built up, the value of an additional life-year might depend directly on age. If the curve follows a strong flexion, people between 20 and 40 years of age would value their own lives more because of the human capital they already built up while younger people often expose riskier behaviour. Hence an increased adult mortality in this age-group (20-40) would have a much heavier impact on the country's welfare. From this perspective, Eastern Europe might face a threat from AIDS just as big as Africa.

The marginal willingness to pay (MWP) can be used to assess the welfare gains from mortality reductions for the case of one individual, whereas the social marginal willingness to pay for mortality reductions will account for the welfare gains for the whole country. In order to obtain this aggregated MWP, we need to integrate the individual $MWP_a$ through all ages, weighting the value for each age group by the population in the respective group. Let the density function f(.) denote the distribution of the population across all ages. The social marginal willingness to pay for changes in the survival function induced by changes in θ would then be

$$MWP_{social} = P\int_0^{\infty} MWP_a f(a)da \,, \qquad (7)$$

with P standing for the population. The discrete version would hence be: $MWP_{social} = \sum_{t=a}^{\infty} MWP_a \cdot p(a)$.[14]

Because the data on income and consumption for every point in time are not available, and the goal is to compare lifetime welfare levels, Philipson and Soares abstract from life-cycle-considerations by assuming that r = ρ and y(t) is constant, i.e. y(t) = y. This allows us to calculate the changes in mortality rates solely based on the per capita GDP.[15] This implies that the average consumption per period is also constant, i.e. c(t) = c = y.

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[14] Actually, the social MWP would be calculated in the following way: $MWP_{social} = \sum_{t=a}^{\infty} MWP_a \cdot p(a,0) + \sum_{\tau=1}^{\infty} MWP_0 \left(\frac{1}{1+r}\right)^{\tau} p(0,\tau)$ but as we do not have data for the subsequent years, we assume that the population distribution remains constant over the years, which simplifies our equation. τ indicates the year and p(a, τ) the population which is at age a in the year τ. The equation states the aggregated MWP of the individuals at age a in the first observed year (τ = 0) plus the MWP of all the newborns (aged 0) in the following years, i.e. for τ = 1 to 110.

[15] Of course, this assumption underestimates the welfare losses, and in section 2.4 we will consider a distribution in which y(t) varies across ages.

The individual marginal willingness to pay for changes in survival probability can now be expressed solely in terms of the per capita GDP variable y:

$$MWP_a = \frac{y}{\varepsilon(y)} \int_a^\infty e^{-r(t-a)} S_\theta(t,a)dt \qquad (8)$$

In a given country, at a given point in time, an individual earning the average income of the country in every period of life would be willing to pay some specific amount for changes in the survival probabilities expressed by the term $S_\theta(t,a)$. We also assume that all individuals in one country share the same average material living standards of that country, and that individuals at age a face the cross-sectional mortality profile observed from a onwards in this country.

The instantaneous utility function assumes the following form:

$$u(c) = \frac{c^{1-1/\gamma}}{1-1/\gamma} + \alpha \qquad (9)$$

By expanding equation (9) by the factor ($c^{1/\gamma}$) and substituting y for c (we assumed that y = c), we get the first part of the willingness to pay, which includes the parameters α and γ. The term in brackets of equation (10) can be interpreted as $u(c) \cdot c^{1/\gamma}$, which is the utility from consumption in the case of life and death over all years. The term under the integral is the discounted survival gain for each period.

$$MWP_a = \left( \frac{y}{1-1/\gamma} + \alpha y^{1/\gamma} \right) \int_0^\infty e^{-r(t-a)} S_\theta(t,a)dt\,. \qquad (10)$$ [16]

The above equation can be interpreted as follows: The first term in brackets expresses the income value of the utility when alive and dead. The higher the factor of relative risk aversion, 1/γ, the more valuable is utility when being alive relative to that of being dead. The second term represents any survival gains (or losses) aggregated over the remaining lifetime. This equation can be used to value the utility gains from health improvements in monetary units.

[16] The discrete time version would be: $MWP_a = \left( \frac{y}{1-1/\gamma} + \alpha y^{1/\gamma} \right) \sum_{t=a}^{\infty} \left( \frac{1}{1+r} \right)^{(t-a)} \cdot S_\theta(t,a)$

### 2.4 Extensions of the model: Capturing the impact of higher education

We want to show that the social value of measures to combat HIV/AIDS is higher, the more people invest in human capital, assuming that the motivation to invest in the personal education depends on the expected length of life. Human capital comprises the knowledge, capabilities and professional skills within a population. It is a theoretical concept which can have valuable implications in many contexts; however, it is difficult to capture this phenomenon empirically. The level of educational attainment is a readily available indicator even though it does not take into account the human capital which is built up during professional work. Human capital plays an increasingly important role in the social and economic achievements of individuals and societies. That is why states as well as individuals invest in their human capital as an important immaterial asset. This investment is considered to pay off in the long run, for the individual and the society as a whole. In many countries, human capital is the most important factor in economic growth. By a higher mortality rate due to HIV/AIDS, the incentive to invest in human capital could be undermined. Ignoring the disease-sensitive investment in human capital, which is also affected by HIV/AIDS, would lead to an underestimation of the true welfare losses to HIV/AIDS.

For our calculations, we make use of the fact that all countries in Eastern Europe belonged to the former Soviet Union and were therefore bound to follow the Soviet Union's education system. This system assigned tertiary education to a relatively high percentage of the population, as seen in the case of Russia. We assume that the distribution of educational attainment over the different age groups follows the data for Russia, whereas the absolute level of tertiary education attained is assigned to each country according to the existing data. If there was no data available, we assigned the data according to similarities in GDP and gross enrolment ratio (GER), which is an index used by the UNESCO to measure the number of students enrolled in a given level of education stating the overall number of students enrolled as a percentage of the population in the theoretical age group.

[Table 1: Level of educational attainment (in %), gross enrolment ratio and estimates for the distribution of university degrees in each age-group, for 14 countries]

Ideally, we would like to know how much each increment in human capital is worth at the individual level. However, because we do not have data on the differences in income based on the educational degree, we have to make a number of simplifying assumptions. We assume that the wages of academics typically exceed those of skilled workers (blue- and white-collar). This is the case for Russia, and we will assume that all former Soviet countries share the same income structure.

The empirical distribution of human capital suggests that people aged between 25 and 65 generally have higher incomes than those younger or older. More specifically, we assume that the population younger than 20 and over 65 earns the average pension in the respective country. Most students, for example, only have enough income to finance food and the basic costs of living. Furthermore the unemployment rates for under 25-year-olds are about double the average national unemployment rates (Simai:10). Those between 20 and 50 years of age are assumed to earn at least the average income, with age-specific incomes in this group assumed normally distributed over the mean of age 35. For those between 50 and 65 we assume the average per capita income.

To determine the income distribution in the human capital scenario, we calculate the social income by multiplying the per capita GDP by the total population. We then subtract the income which goes to under 20-year-olds and pensioners (see Table 2) and the income earned by 50-65-year-olds. We assume the income between ages 20 and 70 to be normally distributed, peaking at age 35, to account for learning on the job, which tends to complement the skills acquired through formal education.

## 3 Empirical methods

Empirical methods must be consistent with the underlying theory and deal with the gaps in the data quality. In this chapter we introduce the methods with which we can obtain the relevant variables and finally assess the welfare losses due to HIV/AIDS in Eastern Europe. It is not the aim to develop entirely new methods but rather to combine the latest methods with the available data in a way that yields new insights which matter in real-life issues.

### 3.1 Methods

Economists believe that any counterfactual analysis is impossible without a coherent theoretical framework and that only models which are consistent with economic theory should be used. In empirical research, the model best fitting the data is usually selected for the analysis. Most of these models, however, are very generic or simple. Calibration is one method to spell out the implications of a model in greater detail and to generate quantitative predictions that can inform policy choices. This is normally done by setting some parameters exogenously, leaving other parameters to be calibrated endogenously, and then using the model to reproduce a known benchmark data set. This benchmark or pre-change solution becomes the reference point, containing the observed outcome under an existing policy regime and the values of the exogenous parameters. Against this benchmark, the effects of unobservable counterfactual changes (e.g. survival probabilities) can be assessed. For our purposes of valuing changes in counterfactual survival probabilities, model calibration is essential.

Most calibrated macroeconomic models work with estimated parameters from the literature, while in micro-models the calibrated parameters are derived from a “benchmark set” and elasticities are considered as given. The calibrated parameters derived from micro-data may, and should, be used in macro-models, but the estimates have to be conditioned on the right variables and the conditioning variables in the elasticity estimation have to match the use of the parameter in the model. The model chosen for the estimation is not explicitly tested by the data, but it might have been tested on other data. The model we use has successfully been applied to the HIV/AIDS-epidemic in Sub Saharan Africa. The functional form in our model is additively separable across time, because preferences are assumed to be inter-temporally separable. That is, the consumption in one period does not directly influence the consumption in later periods. This functional form meets the purpose of our model, which is to show the welfare effects resulting from individual inter-temporal optimisation and exogenous impacts on health or survival. The indirect utility function assumes the consumption goods to be “normal” with all the income elasticities of demand equal to one, as in a Cobb-Douglas function. The condition of a unitary uncompensated own-price elasticity and of zero-cross-price-elasticities is relaxed. This means, consumption and longevity are not regarded as economically independent, but they are complements (cross-price elasticity < 0).

Critics might argue that calibration erroneously imposes a wrong marginal willingness to pay when transferring the consumption elasticities of utility from richer to poorer countries. This problem does not arise because the flexible functional form of u(.) already incorporates an *income elasticity of the marginal willingness to pay* that actually changes with income. If this elasticity is high, then the income will strongly influence the marginal willingness to pay for consumption goods, if it is low, income will have no influence. As a result, the utility function does not impose the marginal willingness to pay observed from industrial countries with higher per capita income on the poorer countries in Eastern Europe. For example an average annual income of 10,000 $ implies an income elasticity of the marginal willingness to pay for changes in life expectancy of about 1.2 ($\varepsilon_{y,MWP} = \frac{\partial MWP_{\theta} / MWP_{\theta}}{\partial y / y}$). For low income values the elasticity will reach higher values and vice versa. For 1000$ it would reach 1.9 and for 500$ about 3.8) Although for higher incomes, people would be willing to pay more for mortality reductions, the marginal willingness to pay for health improvements is always high. An income elasticity, which is greater than 1 for all cases implies that survival is a luxury good independent from the average income in a country. We can therefore conclude that it is not necessary to calibrate different utility functions depending on the per capita GDP and in this also favours comparability-purposes between the countries.

### 3.2 Parameterization

The model is based on four essential parameters, the consumption elasticity of the utility function, the inter-temporal elasticity of substitution, the life-death indifference parameter and the rate of time-preference. These estimates are either taken from the literature or from studies based on micro-data.

The *consumption elasticity of the utility function u(.)* expresses, how changes in consumption in one period affect the individual's instantaneous utility of that same period. In other words, how much of her longevity, in terms of future consumption possibilities, would an individual trade for a change in her consumption possibilities in the present? Hence, ε is the marginal utility of consumption compared to the average utility evaluated at a certain consumption level c. This parameter expresses the trade-off between longevity and goods in that it considers how much a person would be willing to pay for death risk reductions. This willingness-to-pay rises as ε approaches 0. For ε > 1, an individual would even pay to increase his risk of dying. $\boldsymbol{\varepsilon}(c(t)) = \frac{\frac{\partial u(c,l)}{u(c,l)}}{\frac{\partial c(t)}{c(t)}}$ is calculated at c, defining ∂c(t) as the numéraire equal to unity.

In utility theory, 1/γ is usually interpreted as the coefficient of relative risk aversion while γ is the inter-temporal elasticity of substitution (IES). The *intertemporal elasticity of substitution (γ)* is a measure for the substitutability of consumption across different time periods. It indicates how flexible people are between consuming now and later, or how changes in consumption in one period affect the individual's instantaneous utility in a later period. The higher $\gamma$, the lower the willingness to pay for life extensions, because quality (consumption) and quantity (length of life) are better substitutes, i.e. I can achieve the same utility by consuming more now instead of extending my life (see Rosen: 286). When $\gamma$ is low, i.e. current consumption and longevity are no good substitutes, the value of a life-year is larger. It expresses, how much of her future consumption possibilities an individual would trade for a change in her consumption possibilities in this period. The IES cannot be directly inferred from consumption or labor supply (Rosen: 297), but has to rely on compensating differentials from studies on occupational risk.[17]

The utility function u(.) is provided with a *life-death indifference parameter* $\alpha$. It is a method of handling state-dependent utilities, as already stated by Rosen (1988). $\alpha$ influences the level of annual consumption at which the individual would be indifferent between being alive and being dead ($\alpha \cdot y^{1/\gamma}$). The parameter $\alpha$ is set to such a value that an individual's utility equals zero and thus would be indifferent between being alive and being dead. If we assume a positive inter-temporal elasticity of substitution, $\alpha$ is necessarily negative. Because every individual knows that in the death state, utility will be normalized to zero, $\alpha$ affects the utility of being alive relative to being dead and therefore is included in the calculus of the willingness to pay for changes in longevity under uncertainty.

The constant *rate of time preference,* $\rho$, refers to the preference of immediate utility over the utility in later periods.[18] The rate of time preference then is the degree of impatience, according to which the utility from future consumption is discounted. The bigger $\rho$, the more present consumption is preferred over future consumption, i.e. the higher $\rho$, the higher the rate of impatience. When considering the future, people integrate new alternatives with their existing plans and evaluate them according to how they change the aggregate consumption in all future periods. This can be understood as a private cost-benefit-analysis. Frederick, Loewenstein and O'Donogue compared various estimations for discount rates, and found that

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[17] Murphy and Topel (2003) estimate this consumption elasticity by using data on the willingness to pay of workers for a reduction in their mortality-risk at work. For US data they assumed a value of $500, which an individual would be willing to accept for an increase of 1/10000 in the probability of dying on the job. In 10000 workers, one person would "statistically" die. The "value of a statistical life" would therefore be $10000 \cdot \$500 = \$5m$.

[18] The rate of time preference has to be distinguished from the inter-temporal elasticity of substitution which expresses the substitutability between consumption now and a longer life, which implies consumption at later stages.

these happen to be much higher than the market interest rate (Frederick et. al.: 389). Economics is more concerned with changing restrictions while psychology considers changing preferences. That is why even if it is true that in considering health states, people show a strong preference for improvement[19], which can be stronger than the time-preference itself,[20] this will not affect the outcome of our calculations. In this study, the time preference rate will be assumed as constant for all periods and of the same size as the interest rate.

The interest rate, r, also affects the inter-temporal choices in making saving more or less profitable at a specific time t. One could also say, r is the rate of return on savings. It is assumed that the money saved at a certain interest rate grows exponentially with time, because the interest rate is calculated on the saved income, which actually grows with time. Just as the rate of time preference "punishes" savings or future consumption, the interest rate makes this more attractive.

The life-death indifference parameter α is an essential constant in the additive-separable utility function. Its purpose is to normalize a person's lifetime aggregated utility to zero once the person reaches the death state. It is assumed that in the personal utility-calculus of a self-interested individual, relatives and offspring who inherit the savings are not taken into account. α determines the level of annual consumption at which an individual is indifferent between being alive or dead. At this level, subsequently referred to as the break-even level ($\alpha \cdot y^{1/\gamma}$), the overall utility equals zero.

In choices involving survival probabilities, α affects the utility of being alive relative to being dead, because it determines, when the utility will be normalized to zero and assures that it will be normalized. α may be positive or negative, but if γ is larger than one, α necessarily is negative.[21]

The higher the IES, the smaller the life-death-indifference parameter. If gamma is high, current consumption and consumption in the future are good substitutes, which means that the individual is more likely to trade longevity against instantaneous consumption. This means

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[19] A preference that states improve with time or a strong aversion against states that deteriorate with time.
[20] For an example, see Frederick/Loewenstein/O'Donogue (2002), p.375
[21] For their calibration, Philipson/Soares use: ε from Murphy/Topel (2003), the US per capita income in 1990, PPP in 1996 international prices (from which ε was calculated), alpha = -16.16 and gamma = 1.25

that the MWP for a longer life is more likely to be lower than if current and future consumption were less substitutable (see Table 10).

Values peak for gamma slightly over one, leading to the lowest values for alpha ($\gamma$=1.01 leading to $\alpha \approx$ -100) and the highest break even levels. For gamma = 1.1, the average alpha for all countries is – 20.2. For gamma = 1.2 we obtain an average alpha of –17.9, and for gamma = 1.15, we obtain alpha = –18.18.

# 4 Data

## 4.1 Sources and quality of the data set

*Income variables.* Income determines the consumption possibilities and therefore the utility of a person. It has an impact on how people value changes in survival probabilities in terms of opportunity costs over future consumption. The time horizon for spending the income is extended by increasing the survival chances, and more income earned by an individual thus leads to higher utility gains. Because the data on income and consumption for every point in time are not available, and the goal is to compare lifetime welfare levels, Philipson and Soares abstract from life-cycle-considerations by assuming that $r = \rho$ and $y(t)$ is constant, i.e. $y(t) = y$. This allows to calculate the value of changes in mortality rates solely based on the available national income figure, the per capita GDP.

We use the Real Gross Domestic Income adjusted for changes in the Terms of Trade (RGDPTT) as an indicator for per capita income. In our data set, the average RGDPTT between 1995 and 2000 from the Penn World Table 6.1 (PWT 6.1) was used, and in the case of missing data, the average from the available years was drawn. The RGDPTT measures domestic absorption in international price value for 1996 for a given country and year, but allows for *current* export and import prices in valuing the net foreign balance. It takes into account a country's changing ability to use its exports to buy imports, as its terms of trade change over time. This is particularly important for developing countries, which rely on a limited range of products for their overall export earnings. The "Real" stands for PPP-converted GDPL (Gross domestic Income after Laspeyres), with the impact of inflation already taken into account. This was done by using a weighted basket of goods and services according to the Laspeyres Index.[22]

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[22] The Laspeyres-Index is the geometric mean of the price ratios for products characteristic of a base country, regardless of whether the products are representative or not of the other countries to be compared with. The Laspeyres Index produces a bias because it does not take into account the changes in relative prices, and hence,

Many Eastern European countries still have a narrow export base, i.e. only few primary export products, such as metal, steel, oil, or fruit.[23] Furthermore some countries are very small making them even more dependent on their exports and imports. The adjustment for changes in the Terms of Trade includes the impact of international price changes onto the Gross Domestic Income due to imports and exports and therefore should be used for our purposes. (For the two countries Bosnia and Herzegovina and Serbia and Montenegro the RGDPTT could not be obtained from the Penn World Tables 6.1. We therefore additionally used GDP in purchasing power parities from the IMF economic outlook database: http://www.imf.org/external/pubs/ft/weo/2006/01/data/dbginim.cfm. The IMF-figures were higher for the Balkan region meaning that these countries are all very import-intensive. For the purpose of our calculations we carried out a regression for the Southern region and predicted RDGPTT for Bosnia and Herzegovina and Serbia Montenegro.)

*Number of AIDS deaths.* The number of deaths is usually a reliable figure, but the number of reported AIDS-deaths is still very low. This is why our result very likely underestimates the true welfare losses from HIV/AIDS. The annual number of reported AIDS deaths was obtained from the EuroHIV – HIV Surveillance report for Europe in 2004. We assumed these deaths to be distributed proportionally to the population and then calculated counterfactual survival probabilities if no AIDS existed. This was calculated as described in section 4.4.

*The estimated number of people living with HIV.* Today an HIV-infected person can survive for a long time and so her life will not become worthless after an infection. But this person still suffers utility reductions having to protect others from being infected, loss of reputation or friends due to fear of potential infection etc. This utility reduction is difficult to determine empirically but it can be incorporated if we assume that at a certain stage these HIV-infected people succumb to AIDS, and finally, to death.

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substitution effects in consumption. That is why in higher income countries, the costs of living still supersede those of countries with lower per-capita income. This could explain why for countries with a higher income, the calculated life-death indifference parameter $\alpha$ is lower.

[23] Between 1990 and 1995, Hungary exported very much the same products (Hoekman/Djankov, 1997); while Romania and Bulgaria significantly changed their composition of exports (esp. with regard to the EU).
Kasakhstan and Russia's principal exports are oil (which is why they owe their positive GDP to rising international oil and gas prices). Georgia's main export items are metals, wine and mineral water. The same applies to The republic of Moldova and Ukraine, a main metal and steel-exporter. All of these countries are vulnerable to changes in the external economic environment because of their narrow export base.

The share of a population currently living with HIV is expressed by a prevalence rate. An HIV-incidence rate, on the other hand, only counts the newly diagnosed cases of HIV per specified population in one year. The incidence rate is a measure of the speed, at which the epidemic is spreading while the prevalence measures the overall burden at a given time. UNAIDS provides estimates[24] for the HIV-prevalence in adults between 15 and 49 years of age.

*Age distribution of the total number of deaths.* The distribution of deaths across the population is important to assess the relative impact of HIV/AIDS in the respective group and hence the importance of treating the disease.
The distribution of actual altogether deaths were available from the WHO life tables (see below) for the years 2000 and 2001 stating the total number of deaths per age-group.

*Population.* The population distributions are especially important from a social perspective, because they can help to estimate the weight of a mortality reduction in each of the respective age groups. The data on population distribution for the years 2000 and 2001 was retrieved from the WHO Life tables. These state the actual population size for each country in the year 2000 and 2001 within different age groups of 5-year-intervals. (http://www3.who.int/whosis/life/life_tables/life_tables.cfm?path=whosis,life,life_tables&language=english). For Serbia and Montenegro, this data was not available, so that for this case, we found that the figures from the UN Population Division, providing the percentage of the total population in different age groups (0-4, 5-14, 15-24, 60+, 65+ and 80+) as well as the median age for 1995, 2000 and 2005 are very similar to the population distribution of Bosnia and Herzegovina. That is why we assumed a the same distribution for both countries. (http://esa.un.org/unpp/index.asp?panel=3).

*Incidence rates.* The incidence rate is the rate of new HIV-infections in each year, while the prevalence rate constitutes the amount of people currently living with HIV. This means that a person infected with HIV in one year will be included in the prevalence rate for all following years until his/her death while the incidence rate counts each HIV-infected individual only

[24] The country-specific estimates were obtained by the UNAIDS/WHO working group in two basic steps. First, point prevalence estimates for 1994 and 1997 were carried out and the starting year of the epidemic was determined for each country. In a second step, these estimates of prevalence over time and the starting date of the epidemic were used to determine the epidemic curve that best described the spread of HIV in each particular country. A simple epidemiological program (EPIMODEL) was used for the calculation of estimates on incidence and mortality from this epidemic curve.

once. The incidence rate is calculated as the annual number of new infections divided by the population at risk in this period. The incidence rates for 1994 – 2001 could be obtained from the EuroHIV HIV Surveillance report for Europe. For estimating the distribution of HIV-incidence across the population, we do not assign HIV/AIDS-mortality proportionally to each age group (as Philipson/Soares did for Africa), as the HIV-prevalence in children under 15 is nearly zero in Eastern Europe. In Africa due to a high infection rate in children, HIV-mortality can be assumed to show a more continuous trend than in Europe. Hence we assume that the HIV/AIDS-prevalence in children is equal to zero and that there are no new infections beyond the age of 49 (because there are no figures available for over 50-year-olds).

*Human capital / Education.* The level of educational attainment is one available indicator to approximate the amount of human capital which is already present in a country. This indicator gives the percentage of the population with a completed university degree and was obtained from the UN Economic Commission for Europe (http://www.unece.org/stats/trends/ch3/3.1.xls).

We also use an index on the number of people enrolled in a certain level of education to quantify the amount of human capital which is currently being built up in the country. Percentages of children in school are represented by Gross Enrolment Ratios (GER). The GER is the number of pupils enrolled in a given level of education regardless of age expressed as a percentage of the population in the theoretical age group for that level of education (http://www.unesco.org/education/GMR2006/full/annex2_eng.pdf ).

*Treatment.* The survival of an HIV-infected individual depends on his/her immune-system but also on the access to and quality of medical treatment. A low rate of AIDS-treatment could pose a strong incentive for HIV-infected people to emigrate to countries providing better anti-retroviral treatment, leading to a lower prevalence rate in the affected countries. While in Western Europe basically every individual has access to ART, in Eastern Europe this medical treatment is still very limited. On the other hand it could be argued that people who can financially afford emigrating, can also afford to access ART in their own country. Furthermore the prices for ART are rapidly falling, from an initial price for an ART-three-drug-regimen of 10000 $, to currently 300$ in sub-Saharan Africa (in Europe, the costs are still higher) with a falling tendency.

In Eastern Europe, access to treatment in a country is significantly correlated to the Real GDP per capita. This leads to higher survival probabilities for HIV-positive individuals in the richer countries in our sample.

[Figure 2: Correlation between treatment access and Income per capita

[Table 3: Regression of treatment access]

[Table 4: Access to antiretroviral-therapy (ART) and annual treatment costs per patient (2002)]

### 4.2 The distribution of HIV-infections

In order to calculate the economic gains from decreasing the risk of contracting HIV, we have to estimate the distribution of HIV-incidence across age groups. Furthermore the survival probabilities after having contracted the HI-Virus have to be determined. For the survival probabilities, we make use of Philipson/Jena's (2005) estimation of HIV-survival curves. But the survival of an HIV-infected person also depends on the access to treatment, which an individual has. (Of course, the compliance to the drug-regimen in antiretroviral therapy is also a factor determining an individual's survival, but we cannot consider this issue due to lacking data.)

For determining an individual survival curve, it is necessary to know, at what age a person actually contracts the human immunodeficiency virus. An individual, once infected with HIV, will follow the survival curve for a significantly older individual, determining the overall cumulative survival function. This was shown by Philipson/Jena (2005b), who first calculated HIV-survival curves for the years 1980 to 2000. Asserting that several distributions do not account for the scenario of HIV/AIDS-mortality, they assume that the counterfactual survival probabilities of HIV-infected individuals resemble those of "normal" individuals at an older age. The exact age Y is found by comparing the survival curves for AIDS-patients in the first 5 years after diagnosis with the "normal" survival curves for those 5 years. An individual would start at age X and Y therefore equals X + 5. The survival of an AIDS-patient will therefore be approximated by the survival function of an individual at age Y.[25] For example in the year 1984, survival after HIV-diagnosis was about equivalent to the survival of an 86-year-old while in 2000 the survival can be compared to that of an 68-year-old person.

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[25] see Philipson/Jena 2005b, Appendix

As Table 4 shows, access to fully developed HIV-treatment varies significantly among the countries in Eastern Europe. We therefore assume that the countries find themselves in lower stages of development than the US. From WHO-surveys on the year of introduction of ART and the ART coverage in 2003 and 2005, we assign different development statuses to each country (from 1 (>80% coverage) to 6 (<10%)). We then assign earlier years from Philipson/Jena's study on the USA to Eastern Europe according to the above factors (1 means one year behind the current US treatment technology, 6 means 6 years behind). This is based on the following reasoning: the lower the access to ART in a country, the more this country is backward compared to the USA and the lower is the estimated survival curve for each individual in this country. This fact is also supported because the Global Fund to fight HIV/AIDS particularly supports countries with very low treatment coverage (e.g. Russia, Ukraine, Moldova). We did not determine how far a country lies behind the US in terms of treatment methods, as the newest technologies can be directly implemented in Eastern Europe and therefore the development paths are not comparable.

Having assigned these years to each country in the data set, we calculate the counterfactual survival probabilities as follows: Conditional on an HIV infection (incidence rate), what is the probability of getting access to treatment, and what are the respective survival probabilities with (case 1) and without (case 2) access to ART? Having calculated these survival probabilities, we can proceed with the distribution of HIV/AIDS across the population. For case 2, Rangsin et. al. (2004) found that the probability of death for an HIV-positive person without receiving ART is around 30% in the first seven years after infection, which is ten times higher than the mortality risk of an HIV-negative person. Philipson/Jena (2005b) calculated improvements of 15 years in life expectancy between 1984 and 2000 due to earlier HIV diagnosis and -treatment. We thus assume that the age from which the survival curve continues after HIV-infection, when the person is not treated, is that of an 86-year-old, like the survival of an HIV-positive person in 1984 (this represents a conservative perspective).

*Age-specific Incidence rates.* Keeping in mind that the incidence rates are higher in the younger population between 15 and 30 years of age and in specific sub-populations, we assume that the infection with HIV/AIDS occurs only in the ages between 15 and 49 years of age, and that in the CIS-States, 70% of all HIV infections occur between 15 and 30 years of age (see Table 5).

If we assume the HIV-incidence to be distributed proportionally to the population distribution, the cumulative number of annual new HIV infections in the population between 15 and 29 amounts up to about 50%. For the CIS-States, we therefore use a Weibull distribution[26] for the number of HIV-infections, such that the fact of a very young affected population in these countries is taken into account.[27]

The Weibull-distribution is frequently used in survival analysis and depends on the characteristic age and the failure steepness (failure slope).[28] The distribution contains the probability that an object/subject with limited life expectancy will not exceed an upper-bound-age t. The distribution is suitable for our case, as the failure slope, expressed in HIV-positive people, again determines the incidence rate of HIV. In other words the more elements of the chain are impaired, the weaker will the be the survival of the whole entity. The distribution shows, in which group the failure probability (HIV-infection) is highest. Weibull-distribution as opposed to an exponential form, supposes rising (or falling) failure rates.

To calculate the age-specific incidence rates, the population at risk was determined by subtracting the people already living with HIV/AIDS from the population in each age group.[29] We then multiplied the population at risk by the incidence rate (as percentage of the total population) to get the number of annual new infections in each age-group. The ratio of HIV cases per age-group over the total population at risk gives us the age-specific incidence-rates with which we proceed to calculate the conditional survival probabilities.

## 4.3 Measurement issues

Often the data which would be needed by theory cannot be obtained empirically, such that it perfectly matches a model's requirements. To solve this problem, the model has to be operationalized in order to incorporate the available data. That is why a lot of assumptions have to be made that can be appealed against by critics.

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[26] Pelletier (2004) suggests a Weibull distribution for modelling the age-specific distribution of HIV incidence rates.

[27] The countries fro which a Weibull-distributed age-specific incidence was assumed are: Armenia, Azerbaijan, Georgia, Ukraine, Belarus, Russia, the Republic of Moldova and Kazakhstan.

[28] We use $\alpha$ = 1.96 and $\beta$ = 1.7 as well as a characteristic lifetime T of 20 (defined as the point in time at which 63.2% of the cases are infected, i.e $1-e^{-\left(\frac{T}{T}\right)^{\alpha}} = 1-e^{-1} = 0.632$ ). The form parameter $\alpha$ usually lies between 0.25 and 5 and expresses the failure slope of the curve. For $\alpha > 3.5$, the curve approximates the normal distribution.

[29] For this purpose we used the prevalence rates from UNAIDS (2004).

In other cases, the available data has to be adapted and missing values have to be predicted from limited data, so that it matches the model as appropriately as possible. Because we cannot measure the data we would need for the calculations ourselves, we are bound to use the data which is currently available. This implies that the data used sometimes is based on estimations. Furthermore there are data collections on HIV/AIDS which only measure the prevalence rate of HIV/AIDS in specific sub-populations such as intravenous drug users, pregnant women, blood donors and sex workers. From these sources it is not possible to calculate the loss for the whole population, because several groups such as older people are not taken into consideration. Another problem is connected with the income variables. Because we do not have data on the age-specific consumption or income, we have to use the best indicator available, which is per capita GDP.

### 4.4 Results: descriptive analysis

We calculate the differences in counterfactual survival probabilities using the “infra-marginal valuation formula” as introduced by Becker et. al. (2004). The “normal” survival curves are calculated as follows: $S(t+1,t) = 1 - \frac{N(t+1,t)}{P(t+1,t)}$, with N(t+1, t) representing the number of deaths between ages t and t+1, and P(t+1, t) being the actual population between these ages. Because we only had the age-specific population and death figures for the years 2000 and 2001, we assumed the population and the HIV-incidence rates to be constant in the following time-series considerations. This will underestimate the final value as the incidence rates have been increasing over the past years, but the assumption has to made due to lack of data.

[Figure 5: Development of HIV-incidence from 1995 - 2001]

Further the counterfactual survival probabilities as of an HIV-infection are calculated according to the considerations of chapter 4.2. We construct a contingent survival probability in which we include the probability of being infected, as well as the probabilities of getting access to treatment after an infection.

$S_{HIV} = \eta \cdot [\psi \cdot S_{treat} + (1-\psi) \cdot S_{notreatt}] + (1-\eta) \cdot S$, where η is the age-specific incidence rate, ψ the probability of getting access to treatment (percentage of those in need), and S is the normal survival probability for the case of not being infected.

The survival function conditional on age a is defined as the quotient of the cumulative survival up to age t by the cumulative survival up to age a, i.e. $S(t,a)=\frac{S(t)}{S(a)}$ for all t ≥ a. The counterfactual change in survival probabilities that would result from an elimination of the AIDS epidemic can now be computed as $S_{\theta}(t,a)=S(t,a)-S_{HIV}(t,a)=\frac{S(t)}{S(a)}-\frac{S_{HIV}(t)\cdot S(t-1)}{S(a)}$. This value is aggregated for all t ≥ a and discounted according to our assumed interest rate. This aggregate value expresses expected statistical years of life lost to HIV/AIDS.

We calculate the cumulative survival probabilities without HIV/AIDS for every age between 0 and 110 depending on the number of annually reported AIDS deaths in each country. For the scenario with HIV/AIDS, we calculated conditional survival probabilities by assigning a special survival curve to each individual depending on when the virus was contracted (see section 4.2). These conditional probabilities take into account the fact that survival probabilities depend on the access to medical care, as an ART-treatment can significantly extend a person's life. This means that as of the moment of infection with HIV, an individual has a given survival probability in every following year, depending on exogenous factors such as the availability of medication, the immune system of the person etc.

## 5 Calibration

Our estimation involves cross-sectional data for the different Eastern European countries. Although we use an inter-temporal model, we compare the countries from a macro-perspective. In our approach we estimate the consumption elasticities from micro-data on the basis of the "value of a statistical life". We also use estimates from the literature, where appropriate. In this chapter, we will assign values to the parameters described in Section 3.2, and following that we will assess the individual and social welfare costs.

Following Becker, Philipson and Soares (2004), we use an inter-temporal utility function of the form

$$u(c)=\frac{c^{1-1/\gamma}}{1-1/\gamma}+\alpha .$$

We assume a setting in which choices involve survival probabilities, not the margin between life and death. By the following equation Murphy & Topel (2003) estimate the consumption elasticity of utility[30] arising from a higher risk but higher consumption utility at the same time: $\frac{dV(a)}{\varepsilon(c(a))} = \lambda \int_a^{\infty} e^{-r(t-a)} \sigma \cdot c(t) \frac{S(t)}{S(a)} dt = \lambda W(a)$, where W(a) gives the willingness to pay to reduce the annual mortality risk by the probability 1, i.e. life. Usually, the WTP is easier to determine for smaller risks, which is why λ stands for a very small change in death probability. $\frac{dV(a)}{\varepsilon(c(a))}$ is the expected lifetime utility at age a divided by the marginal utility of consumption at age a, which is the same as the marginal willingness to pay for changes in health and longevity as of age a. We include the value of non-market time in the calculations, so that the total utility at t clearly exceeds the value of income or consumption, because full consumption can then be defined as c(t) + w(t)l(t). Furthermore there is a surplus in the utility of consumption, if the consumed object is valued more than its average price, i.e. the consumption surplus. This consumption surplus is assumed to be a constant ratio which we define as σ. We then have $\sigma = \frac{u(c(t), l(t))}{u_c c(t) + u_l l(t)}$. L(t) is the time, which is not spent on market activity, S(t)/S(a) measures changes in the survivor function, and σ is the ratio of utility to the marginal utility of full consumption, i.e. the utility surplus which is not caused by full consumption[31] and therefore is caused by the survival functions. ε is defined as 1/σ, i.e. the consumption-based part of instantaneous utility.

For the Eastern European countries available, we could calibrate more appropriate values for σ and ε, using data on the value of a statistical life in the different countries. These estimates can be taken from cost-benefit analyses made for assessments on how much value should be attributed to environmental or other improvements. The consumption elasticity of utility is calculated as:

$$\varepsilon = \frac{u'(c)c}{u(c)} = \frac{c^{1-1/\gamma}}{\frac{c^{1-1/\gamma}}{1-1/\gamma} + \alpha}.$$ [32]

ε is needed to calibrate the value of α for the different countries. In the formula for the individual MWP, equation (10), the only parameters left are γ, α and the time preference, r.

[30] They find a value of σ = 2.9 which implies ε = 0.346 for the US for a VSL of 5 million $.

[31] Becker (1971) defines full consumption as the market value of consumption and leisure, i.e. $C_F(t) = c(t) + w(t)l(t)$

[32] Philipson and Soares calibrate the value for α using the consumption elasticity of the utility function (ε) as estimated by Murphy and Topel (2003) for the year 1990, and use the US per capita income from the Penn World Table 6.1 for the same year to estimate the consumption (c = $ 26,365).

Philipson/Soares take their estimate for the IES from microeconomic calibration data (Browning et. al.), which is generally acceptable if the issue of the model is correctly met. Browning et. al. suggest an IES of slightly above one and Philipson/Soares use $\gamma = 1.25$. We suppose that the inter-temporal elasticity of substitution is a little lower, at around $\gamma \approx 1.1$, due to a lower propensity to save in Eastern Europe. This assumption is checked by applying a sensitivity analysis, in which the values in the range of the point estimates for the elasticities are varied to find the best fit (see Table 11).

### 5.1 The value of a statistical life

The “value of a statistical life” (VSL) is a value used to assess the aggregate value of a change in risk affecting a given population. This approach may be based on compensating wage differentials, but is also used in governmental decisions on speed limit regulations or assessment of environmental impacts on health. The value of life varies significantly with the characteristics of a population, and with the level and type of risk an individual is exposed to. Hence there exists no universal value which could be applied in every situation. This poses a problem as there still barely exist measurements on VSL for European countries. The VSL is usually based on a trade-off between mortality risk and some kind of monetary value. Following the theory of equalizing differences, it gives the value at which an individual would be indifferent between the monetary compensation and the increase in the death probability say by 1/10,000. Then, for 10,000 people, one life would be lost, i.e. this monetary compensation times 10,000 would be the value of a statistical life in a wage-risk differential. The same can be applied to higher health risks in environmental issues such as the concentration of particulate matter and ozone levels.

Measuring an individual’s life according to his/her preferences is difficult and the estimates differ among studies.[33] According to Kaderják (1997), “complete uncertainty about the economic value of a statistical life in the CEECs and the impact of this uncertainty on the environmental valuation results clearly underlay one basic problem of the benefit transfer technique in the Central and Eastern European context, namely, the transfer of valuation figures across populations with significantly differing preferences.” Today, these VSLs are

[33] See Miller (2000), Krupnick et. al. (1995) and Viscusi/Aldy (2003)

already available for some Eastern European countries, but the problem of preferences and context-specific valuation remains unsolved.[34]

Widely accepted estimates for Europe lie between 2.5 and 3.6 million US$[35]. The general problem of VSL is that the estimates are obtained in a very specific context (in our case environmental health and landmine clearance) which may be considered problematic to transfer to health care issues. On the other hand, as our estimates are slightly lower, we will rather underestimate the welfare loss.

We obtain ε by using the method applied by Murphy and Topel (2003) for the USA, but calculate it according to the "value of a statistical life" in specific Eastern European countries. The "value of a statistical life" is usually estimated through hedonic wage models, wage-risk differentials, contingent valuation, or other equalizing difference models involving a trade-off between a certain probability of dying and a willingness to pay. We then group the countries in our sample according to similarities and apply a suitable elasticity respectively.

To calculate ε from these country-specific VSL we use the following equation:

$\frac{dV(a)}{\varepsilon(c(a))} = \int_a^\infty e^{-r(t-a)} \sigma C_F(t) \frac{S(t)}{S(a)} = W(a)$. This would be equal to

$W(a) = \sum_a^\infty (\frac{1}{1+r})^{(t-a)} \cdot \sigma \cdot c(t) \cdot \frac{S(t)}{S(a)}$ in the discrete time version. For the consumption surplus we would get: $\sigma = \frac{W(a)}{c(t) \cdot \sum_a^\infty (\frac{1}{1+r})^{(t-a)} \cdot \frac{S(t)}{S(a)}}$, and ε = 1/σ.

The consumption elasticities of the instantaneous utility function for those countries in the sample, for which the VSL could be obtained, are depicted in Table 8 below.

The elasticities obtained for the higher VSL-values approximate the estimate by Murphy and Topel and thus may be applied to our sample. Other VSL values, as the one for Cyprus, yield elasticities above 1. This means that a person would actually pay to increase his/her death risk. A reason explaining these low VSL-values in the highest-income countries of our sample

[34] Moreover, Kniesner et. al. (2005) remark that the VSL-estimates can be biased. For example, unobservable productivity (black market) leads to an upwardly biased VSL, and unobservable safety-related skill and preferences generate a downward bias.

[35] The value of 3.6 million $ was adopted by the ExternE-project for Europe.

could be the fact that the VSL-values from CAFE are calculated on the basis of environmental questions and not health considerations.

As a comparison, Viscusi (1993) estimated the value of a statistical life to be around 5 million 1995 US$. Our estimations, adjusted for currency changes, are thus consistent with Viscusi's results. Converting the Euro-values back to their equivalent SDRs in 1995, we find that the equivalent would be about 2.295 million € in 2000. The values obtained in the CAFE-study are very much below this benchmark. But even if we assume a lower value of a statistical life in these countries, the willingness to pay for the eradication of HIV/AIDS remains high.

[Table 6: The value of a statistical life, from CAFE estimation for 2000]

The lower the value of a statistical life, the less money a person would be willing to pay for a reduction in her personal mortality risk. This leads to a lower consumption surplus ($\sigma$, see equation above) and hence to a higher consumption elasticity of the utility function. This means that the marginal utility of consumption in the current period is high relative to the marginal utility of longevity. A higher $\varepsilon$ leads to a lower value for $\alpha$, the life-death-indifference parameter, and yields a higher "break even" or minimal income, at which the individual would be indifferent between being alive or dead. This means that when the VSL is lower, the income in the current period is valued higher than longevity.

As we did not have data on the value of a statistical life for all countries, we performed a simple regression to estimated the missing values. The problem with this method is that it only regresses VSL according to GDP and excludes cultural determinants which otherwise might account for the large variance in the VSL.

[Figure 4: Regression estimates for the VSL]

The values for the VSL in Eastern Europe are quite low compared to measures of the VSL in other countries. The average $\varepsilon$ (excluding the elasticities for the 4 countries in the highest income group) is 0.552. We assume $\varepsilon = 0.346$, like in previous approaches (Murphy/Topel), for comparability purposes (to compare with Sub-Saharan Africa).

[Table 7: Regression of the value of a statistical life on GDP ]

## 5.2 Welfare losses from HIV/AIDS at the individual level

It is evident that HIV/AIDS means a serious reduction in life quality to each individual, be it in terms of having to change one's way of living or even the threat of dying soon. But although we know that this loss in life quality is high, we cannot quantify it if we cannot measure the utility loss for one individual. In this section we will assess this utility loss for an individual at different ages.

For assessing the welfare losses from HIV/AIDS at the individual level, the counterfactual survival probabilities with and without an HIV have to be considered. From the distribution of HIV-incidence across the various age-groups we infer the expected statistical life years lost to HIV/AIDS in the case of an infection. We term these lost life years "statistical" because they include the probability of being HIV-infected as well as consequently the conditional probability of getting access to treatment or not. The constructed survival probabilities in the case of an HIV infection hence reflect the cumulative expected survival given a specific risk for an HIV infection (incidence). The years of life lost to an infection with the HI-Virus thus must be a "statistical" rather than a "natural" notion. According to equation (10), the welfare losses are calculated for the different parameters and ages.

[Table 10: Marginal willingness to pay of a 25-year-old for different calibration parameters]

[Table 11: The economic costs of HIV under the human capital scenario]

The human capital scenario assumes that in those age-groups most affected by HIV/AIDS, human capital is also higher which raises the welfare losses. This is true if we assume a distribution of the human capital (or income earned) as discussed in section 2.4. As we can see in Table 11, for younger ages the willingness to pay does not differ significantly between the scenarios. While at age 40 the difference can clearly be seen. This is an important fact which ought to be considered when comparing Eastern Europe with Sub-Saharan Africa, for example. It is striking that the MWP in younger people is high in terms of longevity gains, but the income in younger people is also lower. This might explain why younger people often expose riskier behaviour than older individuals.

## 5.3 Welfare losses from HIV/AIDS at the social level

For a government it is important to know the dimension of the threat which faces its country's society. It is therefore helpful to evaluate the welfare costs separately for each country in the sample, to draw comparisons to similar countries in some relevant aspects (neighbouring countries, population size, GDP) within the sample. This can help to locate the “hot spots”, where measures need to be taken most urgently. The neighbouring countries can decide on the basis of this assessment, whether they would have to increase measures in order to prevent the intrusion of the disease across the border. Further these estimates are helpful to determine how much investment into medication and treatment of HIV/AIDS would be optimal from the perspective of the individuals’ willingness to pay for improvements in their own lives. We first aggregate the marginal willingness to pay for an AIDS-free life for all the countries separately. Finally this allows us to calculate the total aggregate value for the whole region. It is likely that the true welfare loss due to AIDS will be underestimated, as the value of mortality reductions is higher for individuals in higher income groups and with higher education and HIV-infected people tend to die at ages where their personal value of life is high.

Even though at an individual level, WTP is without doubt an important and vital approach to measure the value of life and health, the aggregation at the social level might be criticized. It can be argued that aggregating individual welfare is usually no reliable indicator of the social value (e.g. in other public goods), and that here for pragmatic reasons this method is still applied. This aggregation would be permitted if the marginal utility of income was equal across income groups. That is, only if an extra dollar of income would be equally valued by a millionaire and by someone with an income just above the poverty line, interpersonal comparisons of utility would be allowed. In our case, even though the average PPP-income is applied as a measure of income and these are already less divergent across countries, still the GDP figures differ significantly between countries in the central and southern region of Eastern Europe.

Still, this method is one method of estimating the losses, which is a helpful benchmark for decision makers. For the aggregation of the social marginal willingness to pay, we weight the individual MWP according to the number of individuals at each age. Because we only have data on age-groups, we assume the number of people to be distributed equally over all ages within one age group.

[Table 12: Social welfare costs due to HIV/AIDS]

The social welfare costs of HIV/AIDS in Europe are not ignorable. They make up around 1 billion US$ for the whole region. But this number most likely does not capture the whole welfare loss. This is because people suffer from the mere potential to become infected, incidence rates have been rising tremendously in the recent years, and the no. of reported HIV/AIDS cases is lower than the real prevalence. Under a human capital scenario, where people make investments into their future earnings and consumption possibilities, the welfare loss is most likely to be even higher.

The aggregated costs also show that the countries in Eastern Europe still differ strongly with respect to the HIV/AIDS-problematic. The most affected countries are without doubt Estonia, Russia, Latvia, Ukraine, Belarus, Kazakhstan and Moldova. In Russia, the economic costs amount to between 22.5 and 67.5 % of the country's GDP, while in Estonia the costs are even higher, between 38 and 114% of GDP. Ukraine, although the willingness to pay is not tremendously high, recently exposed the most rapidly rising prevalence rate, just ahead of Estonia (see Figure 6). Under the human capital scenario, Russia's welfare losses rise significantly, as well as for Ukraine. For these countries, the consequences of HIV/AIDS are the most striking.

# 6 Discussion

## 6.1 Sensitivity of results

In order to make sure that our model is calibrated with solid elasticity estimates, we perform a sensitivity analysis. That is, we run the model for different parameters and time preference rates and compare the results. It is controversial whether the calibration should favour parameters used in the literature, as this allows for international comparisons, or if it should use more exact parameters by estimating own parameters. In our case, a lower interest rate and lower IES might approximate the real welfare loss in a better way, on the other hand this makes the results less comparable to those reported by Philipson and Soares for Sub-Saharan Africa.

It is evident, that there is great need for further research and more data on the problem of HIV/AIDS in Eastern Europe. Seeing how the VSL can account for the value of many hitherto "non-valuable" issues, there should now be a strong incentive to make more accurate measurements of the VSL in different countries. As can be seen in Table 13, the rate of time preference, too, has a major impact on the value of longevity gains. While Viscusi/Moore

(1990) suggest a discount rate between 1 and 14%, newer estimates mainly lie below the 10% assumed by Philipson/Soares.[36]

### 6.2 Some possible health policy implications

With the results presented in this paper we hope to help in answering the following questions: Which countries should be invested in and how much? Who should invest into fighting the AIDS epidemic? Should the EU help? What could be achieved by AIDS-medication, which does not cure the disease, but still extends the expected lifetime of people infected with HIV/AIDS?

The countries with the greatest welfare losses should of course be invested in with priority. On the other hand it may be very important to come up with targeted prevention strategies in countries which are not yet affected, but vulnerable, for example because they are neighbours to a more strongly affected country. The evidence in Table 5 suggests that Cyprus and Croatia, for example, owe a large percentage of their HIV-patients to the epidemic in other countries. When considering the amount which should be invested into each country for the sake of combating HIV/AIDS, it should be kept in mind, that the annual treatment in most countries exceeds the per capita income (see Table 4). Should the EU help in fighting the AIDS epidemic? This is of course an issue up to policy makers, but as can be seen in our calculations, EU-accession states are still very marginally affected. Greater welfare losses could therefore be avoided, if the EU invests into the countries which are closest to Europe, in terms of geography or economic relations. Providing AIDS-medication extends the lifetime of people infected with HIV/AIDS. This in turn give HIV-positive individuals a greater incentive to invest in their personal human capital, and thereby contribute to a country's economic growth.

## 7 Concluding remarks

Based on the aggregation of individual willingness-to-pay for a statistical life, we have calibrated an inter-temporal optimisation model for 25 Eastern European countries and found welfare losses for the region that exceed more than a trillion US-$. If a smaller time preference rate is assumed, the welfare losses are even greater. The countries which would profit most from combating the HIV/AIDS problem, according to our assessment, are the

[36] For example Johannesson & Johansson (1997) discount life year by 0–3%, and Cairns and van der Pol (1999, 2001) discount health effects by 6–9 %. On the other hand Ganiats et. al. (2000) calculate rates from negative to 116%. These estimates are all based on contingent valuation, i.e. hypothetical WTP.

Baltic States – above all: Estonia which suffers the highest per capita welfare loss from HIV/AIDS in the region. The fellow Baltics Latvia and Lithuania are not yet affected to the same degree, but they are particularly threatened by the further spread of the epidemic if policies are not changed in the near future. In line with previous studies by the WHO and UNAIDS, we find that Ukraine, Russia, Belarus, Kazakhstan and Moldova also suffer very high per capita welfare costs from HIV/AIDS. As a caveat, we note that even our study has probably underestimated the true welfare costs because we have only included the welfare losses from increased mortality, not the actual suffering of HIV-infected persons prior to death.

We conclude that a much greater effort in prevention and treatment is needed to maintain economic growth in the long term and to reverse the size of the welfare losses that the Eastern European region has already incurred. We therefore welcome the special emphasis that the European Commission is planning to place within its 7th framework program for research cooperation on supporting HIV/AIDS-related research networks that focus on the situation in Eastern Europe and develop strategies to fight HIV/AIDS more effectively.

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# 9 Appendix

Countries in the dataset:

The WHO declared the following countries as belonging to Eastern Europe: Belarus, Bulgaria, Czech Republic, Hungary, Poland, Republic of Moldova, Romania, Russian Federation, Slovakia and Ukraine. We extended this list by adding countries from South Eastern Europe, i.e. Albania, The former Yugoslav Republic of Macedonia, Bosnia and Herzegovina, Serbia and Montenegro, Slovenia, Croatia. Further, we extended the sample by Cyprus and Turkey because of their geographic situation, the Baltic states Estonia, Latvia and Lithuania, as well as the Caucasian countries Azerbaijan, Armenia and Georgia which can be considered as Eastern Europe from a historical perspective. While Kazakhstan belongs to Central Asia, a small part of it lies on the outer border of Eastern Europe, which is why we also considered this country in the dataset. This leaves us with 25 countries in the list.

# Tables

**Table 1: Level of educational attainment (in %), gross enrolment ratio and estimates for the distribution of university degrees in each age-group, for 14 countries**

| Country | Per capita GDP | Level of attainment in age-group 25-34 | 35-44 | 45-54 | 55-64 | Total 25-64 |
|---|---|---|---|---|---|---|
| Albania | 3041 | 0.091 | 0.096 | 0.089 | 0.073 | 0.089* |
| Armenia | 2503 | 0.091 | 0.096 | 0.089 | 0.073 | 0.089* |
| Azerbaijan | 2445 | 0.091 | 0.096 | 0.089 | 0.073 | 0.089* |
| Belarus | 6647 | 0.550 | 0.580 | 0.540 | 0.440 | 0.54* |
| Bosnia and Herzegovina | 3522 | 0.091 | 0.096 | 0.089 | 0.073 | 0.089* |
| Bulgaria | 5798 | 0.187 | 0.197 | 0.184 | 0.150 | 0.1835 |
| Croatia | 8005 | 0.187 | 0.197 | 0.184 | 0.150 | 0.1835* |
| Cyprus | 15991 | 0.234 | 0.247 | 0.230 | 0.187 | 0.23 |
| Czech Republic | 13560 | 0.122 | 0.129 | 0.120 | 0.098 | 0.12 |
| Estonia | 8578 | 0.258 | 0.272 | 0.253 | 0.206 | 0.253 |
| Georgia | 4799 | 0.195 | 0.206 | 0.192 | 0.156 | 0.1918 |
| Hungary | 9429 | 0.153 | 0.161 | 0.150 | 0.122 | 0.15 |
| Kazakhstan | 6347 | 0.550 | 0.580 | 0.540 | 0.440 | 0.54* |
| Latvia | 6746 | 0.167 | 0.176 | 0.164 | 0.134 | 0.164 |
| Lithuania | 7097 | 0.392 | 0.414 | 0.385 | 0.314 | 0.385 |
| Poland | 8248 | 0.109 | 0.115 | 0.107 | 0.087 | 0.107 |
| Republic of Moldova | 2214 | 0.091 | 0.096 | 0.089 | 0.073 | 0.089* |
| Romania | 4745 | 0.091 | 0.096 | 0.089 | 0.073 | 0.089 |
| Russian Federation | 7549 | 0.550 | 0.580 | 0.540 | 0.440 | 0.54 |
| Serbia and Montenegro | 3814 | 0.187 | 0.197 | 0.184 | 0.150 | 0.1835* |
| Slovak Republic | 10899 | 0.112 | 0.118 | 0.110 | 0.090 | 0.11 |
| Slovenia | 14334 | 0.147 | 0.155 | 0.144 | 0.117 | 0.144 |
| The former Yugoslav Republic of Macedonia | 4753 | 0.187 | 0.197 | 0.184 | 0.150 | 0.1835* |
| Turkey | 6691 | 0.102 | 0.107 | 0.100 | 0.081 | 0.1 |
| Ukraine | 4554 | 0.550 | 0.580 | 0.540 | 0.440 | 0.54* |
| Whole Region | 6892 | 0.219 | 0.231 | 0.215 | 0.175 | 0.215 |

Notes: * - total level of educational attainment available, but age-specific distribution assumed as in Russia
** - educational attainment levels were assigned according to similarities to other countries in GDP and gross enrolment ratio (GER)
Source: UNECE (2003) and UNESCO (2006)

**Table 2: Pension replacement rates for countries in Eastern Europe**

| Country | Average pension as share of per capita GDP | Average pension as share of wage |
|---|---|---|
| Albania | 36.4 | - |
| Armenia | 18.7 | 24.0 |
| Azerbaijan | 51.4 | 29.0 |
| Belarus | 31.2 | 43.0 |
| Bulgaria | 39.3 | 31.0 |
| Croatia | - | 48.6 |
| Cyprus | 41.8 | |
| Czech Republic | 37.0 | 48.6 |
| Estonia | 56.7 | 25.0 |
| Georgia | 12.6 | 36.0 |
| Hungary | 33.6 | 57.9 |
| Kazakhstan | 18.8 | 31.0 |
| Latvia | 47.6 | 62.8 |
| Lithuania | 21.3 | - |
| Poland | 61.2 | 55.4 |
| Romania | 34.1 | 43.1 |
| Russian Federation | 18.3 | - |
| Slovak Republic | 44.5 | 42.5 |
| Slovenia | 49.3 | 68.7 |
| The former Yugoslav Republic of Macedonia | 91.6 | 63.5 |
| Turkey | 112.7 | - |
| Ukraine | 30.9 | 32.0 |

Notes : all figures are for a year between 1994 and 1997 (except for Cyprus (1989) and Turkey (1993)). Value for Turkey was changed to 80 for the calculations.
Source: Palacios/Pallerès-Miralles (2000), The World Bank

**Table 3: Regression of treatment access on GDP per capita**

| Dependent variable | Treatment access for HIV+ persons |
|---|---|
| Real Gross Domestic Income per capita | 0.073 |
| | (4.85)** |
| Constant | -0.064 |
| | (0.55) |
| Observations | 25 |
| R-squared | 0.51 |

Notes: Absolute value of t-statistics in parentheses

* significant at 5% level; ** significant at 1% level

**Table 4: Access to antiretroviral-therapy (ART) and annual treatment costs per patient (2002)**

| Country | Estimated ART coverage (%) | Average annual costs per patient (in US$) |
|---|---|---|
| Albania | 15 | |
| Armenia | 0 | 10,000 |
| Azerbaijan | 0 | 11,000 |
| Belarus | 5 | 9,700 |
| Bosnia and Herzegovina | 10 | |
| Bulgaria | 44.5 | 8,400 |
| Croatia | 98.7 | |
| Cyprus | 90 | 9,000 |
| Czech Republic | 93.9 | 7,500 |
| Estonia | 17 | 15,000 |
| Georgia | 49 | 10,000 |
| Hungary | 97 | 10,000 |
| Kazakhstan | 15 | |
| Latvia | 31 | 6,500 |
| Lithuania | 64 | |
| Poland | 100 | 10,000 |
| Republic of Moldova | 39 | |
| Romania | 64.4 | |
| Russian Federation | 5 | |
| Serbia and Montenegro | 26.4 | 7,140 |
| Slovak Republic | 100 | 10,000 |
| Slovenia | 100 | 2,000 |
| The former Yugoslav Republic of Macedonia | 20 | |
| Turkey | 9 | 10,000 |
| Ukraine | 7 | |
| Total Region | 44 | 9,083 |

Source: WHO (2003): HIV/AIDS treatment: antiretroviral therapy

**Table 5: HIV prevalence in selected countries and subpopulations**

| Country | Prevalence rate (in %) | Population aged 15-24 | Population aged 25+ | Other |
|---|---|---|---|---|
| Azerbaijan | 0.03 | | | 45% of HIV-infections contracted outside the country, esp. in Russia |
| Belarus | 0.23 | 60% of HIV infections 15 – 24 | 15% of HIV infections 25 – 29 | |
| Bulgaria | 0.01 | 48.6% of HIV-infections between 20 and 39 and male | | |
| Croatia | 0.01 | | | Over 90% of HIV-positive men infected outside the country |
| Cyprus* | 0.3 | 3% of HIV-infections 15 – 19 | 80% of infections 20 - 44 | |
| Kazakhstan | 0.2 | 15.7% of HIV-infections | 53.4% of infections 20 - 29 | 84% of registered HIV-infections caused by IDU |
| Latvia | 0.61 | | | 70% of HIV infections caused by IDU |
| Moldova | 0.24 | | | 78% of HIV-infections caused by IDU |
| Russia | 1.1 | 80% of all IDU-HIV-infections in under 30-year olds | | |
| Ukraine | 1.3 | 25% of HIV-infections 15 - 24 | | |

Source: UNAIDS (2005): AIDS epidemic update 2005
Notes: * most HIV-infections in non-permanent residents

**Table 6: The value of a statistical life, from CAFE estimation for 2000**

| Country | VSL (2000) in € (‘000) | | VSL (2000) in 1995 US $ | |
|---|---|---|---|---|
| | low (median) | high (mean) | low (median) | High (mean) |
| Cyprus | 405 | 716 | 1 199 494 | 2 120 587 |
| Czech Republic | 1077 | 1997 | 3 189 765 | 5 914 542 |
| Estonia | 542 | 1021 | 1 605 249 | 3 023 909 |
| Hungary | 1507 | 2846 | 4 463 302 | 8 429 036 |
| Latvia | 711 | 1296 | 2 105 778 | 3 838 381 |
| Lithuania | 711 | 1363 | 2 105 778 | 4 036 815 |
| Poland | 1046 | 1931 | 3 097 952 | 5 719 069 |
| Slovakia | 980 | 1802 | 2 902 479 | 5 337 007 |
| Slovenia | 993 | 1822 | 2 940 981 | 5 396 242 |

Source: assessment for Clean Air for Europe (CAFE) programme (European Commission DG Environment) mainly based on PM- and ozone-levels, transformation into US$ added

**Table 7: Regression of the value of a statistical life on GDP**

| Dependent variable | VSL |
|---|---|
| Real Gross Domestic Income per capita | 0.195 |
| | (2.12) |
| Constant | 3.065 |
| | (3.15)* |
| Observations | 6 |
| R-squared | 0.53 |

Notes: Absolute value of t-statistics in parentheses
* significant at 5% level; ** significant at 1% level

**Table 8: Predicted VSL and consumption elasticities for Eastern Europe**

| Country | VSL (in 1995 US$) | ε (predicted) |
|---|---|---|
| Albania | 3 495 826 | 0.384 |
| Armenia | 3 551 956 | 0.309 |
| Azerbaijan | 3 540 700 | 0.298 |
| Belarus | 3 656 804 | 0.783 |
| BiH | 3 750 511 | 0.420 |
| Bulgaria | 4 534 469 | 0.566 |
| Croatia | 4 670 518 | 0.759 |
| Cyprus* | 3 951 419 | 1.866 |
| Czech Republic* | 3 998 983 | 1.532 |
| Estonia | 5 855 452 | 0.644 |
| Georgia | 4 193 543 | 0.498 |
| Hungary | 4 367 455 | 0.948 |
| Kazakhstan | 4 378 099 | 0.612 |
| Latria | 4 300 380 | 0.688 |
| Lithuania | 4 446 484 | 0.712 |
| Poland | 4 358 933 | 0.847 |
| Moldova | 4 623 307 | 0.205 |
| Romania | 3 990 106 | 0.526 |
| Russia | 3 988 541 | 0.798 |
| Serbia & Montenegro | 4 734 879 | 0.352 |
| Slovak Republic* | 4 900 432 | 0.991 |
| Slovenia* | 3 807 194 | 1.710 |
| T.F.Y.R. Macedonia | 5 704 772 | 0.369 |
| Turkey | 5 186 731 | 0.567 |
| Ukraine | 6 178 039 | 0.316 |
| Region | 4 406 621 | 0.552 |

Source: CAFÉ (2005)
Notes: VSL values in € (2000) were converted back to 1995 US$ by first converting € to DM (DM/€ = 1.95583) and then to US$ (US$/DM = 0.66037).
* - for countries with the highest income, the VSL provided by CAFÉ is too low relative to the income and to the VSL calculated for example by Viscusi (1993), which is why we upward biased estimates for the consumption elasticities. The regional average excludes the four countries marked by asterisk. For our calculations we use a value of 0.346, which Murphy & Topel (2003) calibrated for the U.S.

**Table 9: AIDS mortality and individual welfare costs**

| Country | Life exp | No. of registered AIDS deaths | AIDS gross mortality rate, in % | Life exp (NO AIDS) | HIV prevalence rate, in % | Life years lost to AIDS | GDP per capita | Value of AIDS eradication for an 18-year-old: Monetary value in US$ | Value of AIDS eradication for an 18-year-old: % of GDP per capita |
|---|---|---|---|---|---|---|---|---|---|
| Albania | 68.6 | 0 | 0 | 70.7 | 0.15 | 2.0 | 3,077.12 | 22 | 0.7 |
| Armenia | 68.8 | 98 | 0.00458 | 70.2 | 0.1 | 1.4 | 2,541.55 | 22 | 0.9 |
| Azerbaijan | 62.5 | 97 | 0.00215 | 62.8 | 0.03 | 0.4 | 2,512.32 | 35 | 1.4 |
| Belarus | 67.7 | 0 | 0 | 70.8 | 0.23 | 3.1 | 6,848.42 | 493 | 7.4 |
| Bosnia and Herzegovina | 72.0 | 0 | 0 | 72.6 | 0.04 | 0.6 | 2,040 | 6 | 0.2 |
| Bulgaria | 70.7 | 0 | 0 | 70.9 | 0.01 | 0.1 | 5,637.26 | 30 | 0.5 |
| Croatia | 72.1 | 9 | 0.00040 | 72.2 | 0.01 | 0.1 | 8,196.22 | 35 | 0.4 |
| Cyprus | 76.1 | 0 | 0 | 81.0 | 0.3 | 4.9 | 15,901.92 | 586 | 3.7 |
| Czech Republic | 74.6 | 10 | 0.00020 | 76.1 | 0.1 | 1.5 | 13,691.70 | 279 | 2.1 |
| Estonia | 70.4 | 150 | 0.02138 | 88.2 | 1.1 | 17.8 | 8,809.65 | 12129 | 141.4 |
| Georgia | 68.1 | 100 | 0.00365 | 69.6 | 0.11 | 1.5 | 5,758.30 | 86 | 1.8 |
| Hungary | 70.9 | 99 | 0.00198 | 72.3 | 0.1 | 1.4 | 9,552.81 | 42 | 0.4 |
| Kazakhstan | 62.1 | 306 | 0.00345 | 64.5 | 0.2 | 2.4 | 6,346.62 | 514 | 8.1 |
| Latvia | 69.9 | 150 | 0.01235 | 79.0 | 0.61 | 9.1 | 6,861.76 | 2680 | 39.7 |
| Lithuania | 72.1 | 150 | 0.00789 | 73.6 | 0.1 | 1.5 | 7,258.43 | 135 | 1.9 |
| Poland | 73.2 | 0 | 0 | 74.7 | 0.1 | 1.5 | 8,399.32 | 84 | 1.0 |
| Republic of Moldova | 67.2 | 300 | 0.01282 | 70.3 | 0.24 | 3.2 | 2,192.39 | 92 | 4.2 |
| Romania | 70.3 | 358 | 0.00305 | 71.1 | 0.06 | 0.8 | 4,738.99 | 72 | 1.5 |
| Russian Federation | 64.4 | 8,969 | 0.01147 | 79.8 | 1.1 | 15.3 | 7,608.28 | 5445 | 72.1 |
| Serbia and Montenegro | 68.8 | 50 | 0.00084 | 71.6 | 0.2 | 2.7 | 2,620 | 30 | 0.8 |
| Slovak Republic | 72.5 | 0 | 0.00000 | 72.7 | 0.01 | 0.1 | 11,075.03 | 11 | 0.1 |
| Slovenia | 75.1 | 50 | 0.00478 | 75.9 | 0.05 | 0.8 | 14,595.44 | 86 | 0.6 |
| Macedonia, F. Y. R. | 70.8 | 50 | 0.00464 | 71.5 | 0.05 | 0.7 | 4,792.20 | 15 | 0.3 |
| Turkey | 68.2 | 0 | 0 | 70.2 | 0.15 | 2.0 | 6,691.13 | 29 | 0.4 |
| Ukraine | 66.9 | 14,000 | 0.05544 | 86.8 | 1.3 | 19.9 | 4,515.50 | 669 | 14.7 |
| **Total region** | **69.8** | **24,947** | **0.15107** | **73.6** | **0.26** | **3.8** | **6,890.49** | **945** | **12.3** |

Notes: Value for an 18-year-old calibrated conservatively, with r = 0.1, $\alpha$ = -16.16 and $\gamma$ = 1.25

**Table 10: Marginal willingness to pay of a 25-year-old for different calibration parameters**

| | α = -16.16 | | | | | | α = -12.09 | | α = -14.89 | | α = -17.91 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | γ = 1.25 | | γ = 1.15 | | γ = 1.1 | | γ = 1.25 | | γ = 1.15 | | γ = 1.1 | |
| Country | r = 0.1 | r = 0.03 | r = 0.1 | r = 0.03 | r = 0.1 | r = 0.03 | r = 0.1 | r = 0.03 | r = 0.1 | r = 0.03 | r = 0.1 | r = 0.03 |
| Albania | 14 | 43 | 16 | 49 | 26 | 79 | 21 | 64 | 20 | 60 | 19 | 58 |
| Armenia | 23 | 69 | 26 | 78 | 43 | 130 | 35 | 105 | 32 | 97 | 31 | 93 |
| Azerbaijan | 37 | 112 | 42 | 127 | 71 | 212 | 57 | 171 | 53 | 159 | 51 | 152 |
| Belarus | 522 | 1,567 | 597 | 1,792 | 880 | 2,639 | 687 | 2,061 | 692 | 2,077 | 695 | 2,085 |
| BiH | 4 | 12 | 5 | 14 | 7 | 22 | 6 | 17 | 6 | 17 | 5 | 16 |
| Bulgaria | 23 | 70 | 27 | 80 | 40 | 119 | 31 | 94 | 31 | 93 | 31 | 93 |
| Croatia | 22 | 67 | 26 | 77 | 37 | 112 | 29 | 87 | 30 | 89 | 30 | 90 |
| Cyprus | 339 | 1,016 | 393 | 1,178 | 545 | 1,636 | 413 | 1,239 | 438 | 1,315 | 453 | 1,359 |
| Czech Republic | 241 | 722 | 278 | 835 | 390 | 1169 | 297 | 891 | 312 | 937 | 321 | 964 |
| Estonia | 8,274 | 24,827 | 9497 | 28,497 | 13,702 | 41,113 | 10,607 | 31,827 | 10,864 | 32,598 | 11,008 | 33,028 |
| Georgia | 89 | 267 | 101 | 304 | 154 | 462 | 121 | 365 | 120 | 359 | 118 | 355 |
| Hungary | 35 | 106 | 40 | 121 | 58 | 174 | 45 | 134 | 46 | 138 | 47 | 140 |
| Kazakhstan | 540 | 1,620 | 617 | 1,852 | 913 | 2,738 | 714 | 2,142 | 717 | 2,151 | 718 | 2,155 |
| Latvia | 1,741 | 5,223 | 1991 | 5,975 | 2,928 | 8,786 | 2,286 | 6,858 | 2,305 | 6,917 | 2,315 | 6,947 |
| Lithuania | 94 | 283 | 108 | 324 | 158 | 474 | 123 | 369 | 125 | 374 | 125 | 376 |
| Poland | 48 | 145 | 55 | 166 | 80 | 240 | 62 | 186 | 63 | 190 | 64 | 193 |
| Moldova | 95 | 285 | 108 | 325 | 184 | 552 | 149 | 447 | 137 | 411 | 130 | 391 |
| Romania | 55 | 166 | 63 | 189 | 96 | 287 | 76 | 227 | 74 | 223 | 74 | 221 |
| Russia | 5,770 | 17,313 | 6611 | 19,835 | 9,631 | 28,898 | 7,489 | 22,470 | 7,609 | 22,830 | 7,674 | 23,025 |
| Serbia and Montenegro | 21 | 62 | 24 | 71 | 37 | 111 | 29 | 88 | 28 | 85 | 28 | 84 |
| Slovakia | 7 | 22 | 8 | 25 | 12 | 36 | 9 | 28 | 10 | 29 | 10 | 29 |
| Slovenia | 61 | 183 | 70 | 212 | 98 | 295 | 75 | 225 | 79 | 237 | 81 | 244 |
| T.F.Y.R. Macedonia | 10 | 30 | 11 | 34 | 17 | 51 | 13 | 41 | 13 | 40 | 13 | 39 |
| Turkey | 20 | 60 | 23 | 69 | 34 | 102 | 26 | 80 | 27 | 80 | 27 | 80 |
| Ukraine | 708 | 2,123 | 806 | 2,418 | 1,232 | 3,697 | 974 | 2,924 | 956 | 2,867 | 944 | 2,834 |
| Total Region | 18,793 | 56,393 | 21,543 | 64,647 | 31,373 | 94,134 | 24,374 | 73,140 | 24,787 | 74,373 | 25,012 | 75,051 |

Notes: α = -16.16 is a value calculated by Philipson/Soares on the basis of ε = 0.346 which Murphy/Topel estimated on behalf on US data. On the right side of the table, we also use ε = 0.246, as well as the corresponding average for of all values for alpha from the countries in our data set at the given IES, γ.

**Table 11: The economic costs of HIV under the human capital scenario**

| Country | Value of HIV/AIDS eradication for an 20-year-old | | Value of HIV/AIDS-eradication for a 40-year-old | |
|---|---|---|---|---|
| | "normal scenario" | "human capital scenario" | "normal scenario" | "human capital scenario" |
| Albania | 76 | 76 | 21 | 36 |
| Armenia | 136 | 136 | 6 | 10 |
| Azerbaijan | 221 | 221 | 9 | 15 |
| Belarus | 3,015 | 3,022 | 135 | 197 |
| BiH | 20 | 20 | 8 | 11 |
| Bulgaria | 121 | 121 | 36 | 51 |
| Croatia | 125 | 125 | 34 | 43 |
| Cyprus | 1,961 | 1,964 | 542 | 787 |
| Czech Republic | 1,260 | 1,261 | 258 | 371 |
| Estonia | 41,745 | 41,792 | 14,556 | 18,483 |
| Georgia | 525 | 526 | 21 | 37 |
| Hungary | 191 | 192 | 39 | 58 |
| Kazakhstan | 3,139 | 3,147 | 136 | 238 |
| Latvia | 8,648 | 8,660 | 3,207 | 4,218 |
| Lithuania | 455 | 456 | 150 | 235 |
| Poland | 294 | 295 | 66 | 84 |
| Moldova | 576 | 577 | 24 | 38 |
| Romania | 300 | 300 | 72 | 111 |
| Russian Federation | 33,273 | 33,353 | 1,484 | 2,253 |
| Serbia & Montenegro | 103 | 103 | 42 | 45 |
| Slovak Republic | 43 | 43 | 9 | 12 |
| Slovenia | 340 | 340 | 86 | 110 |
| T.F.Y.R. Macedonia | 52 | 53 | 16 | 20 |
| Turkey | 110 | 110 | 23 | 31 |
| Ukraine | 4,103 | 4,111 | 184 | 269 |
| Regional average | 4033 | 4040 | 847 | 1111 |

Notes: Values obtained for $r = 0.03$, $\gamma = 1.1$ and $\alpha = -17.91$

**Table 12: Social welfare costs due to HIV/AIDS**

| | Social value of AIDS eradication | | Social Value under Human Capital Scenario | |
|---|---|---|---|---|
| Country | Value in $ million | % of GDP | Value in million $ | % of GDP |
| Albania | 80.6 | 0.8 | 104.7 | 1.1 |
| Armenia | 118.4 | 1.2 | 146.8 | 1.5 |
| Azerbaijan | 419.8 | 2.1 | 492.5 | 2.5 |
| Belarus | 6,260.5 | 9.3 | 7,266.3 | 10.8 |
| BiH | 29.7 | 0.2 | 34.4 | 0.2 |
| Bulgaria | 266.5 | 0.6 | 316.6 | 0.7 |
| Croatia | 156.6 | 0.4 | 170.3 | 0.5 |
| Cyprus | 454.4 | 3.6 | 515.3 | 4.1 |
| Czech Republic | 3,327.5 | 2.4 | 3,805.9 | 2.7 |
| Estonia | 17,982.3 | 152.4 | 19,512.7 | 165.3 |
| Georgia | 554.8 | 2.2 | 691.6 | 2.8 |
| Hungary | 465.4 | 0.5 | 547.6 | 0.6 |
| Kazakhstan | 11,621.6 | 11.4 | 14,296.8 | 14.0 |
| Latvia | 6,712.3 | 41.4 | 7,393.5 | 45.6 |
| Lithuania | 540.3 | 2.1 | 687.9 | 2.6 |
| Poland | 3,223.2 | 1.0 | 3,309.7 | 1.0 |
| Moldova | 541.7 | 5.7 | 638.6 | 6.7 |
| Romania | 1936.6 | 1.8 | 2,362.7 | 2.2 |
| Russia | 979,852.3 | 89.7 | 1,158,537.1 | 106.1 |
| Serbia and Montenegro | 392.0 | 1.0 | 399.2 | 1.0 |
| Slovak Republic | 64.6 | 0.1 | 70.0 | 0.1 |
| Slovenia | 184.5 | 0.6 | 201.6 | 0.7 |
| Macedonia | 34.1 | 0.4 | 36.7 | 0.4 |
| Turkey | 2,444.7 | 0.5 | 3,020.9 | 0.7 |
| Ukraine | 39,652.7 | 17.7 | 45,372.4 | 20.3 |
| Total region | 1,077,317.0 | 14 | 1,269,931.9 | 15.8 |

Notes: Calculations for $r = 0.03$, $\gamma = 1.1$, $\alpha = -17.91$

**Table 13: Optimistic and pessimistic estimate of the welfare costs**

| Country | Optimistic case | | | Pessimistic case | | |
|---|---|---|---|---|---|---|
| | Value in $ million | % of GDP | Value ($) in Human Capital Scenario | Value in million $ | % of GDP | Value ($) in Human Capital Scenario |
| Albania | 19.9 | 0.2 | 25.9 | 59.8 | 0.6 | 77.9 |
| Armenia | 29.0 | 0.3 | 36.2 | 87.0 | 0.9 | 108.5 |
| Azerbaijan | 102.6 | 0.5 | 121.0 | 308.0 | 1.6 | 363.1 |
| Belarus | 1,568.7 | 2.3 | 1,812.7 | 4,706.8 | 7.0 | 5,439.0 |
| BiH | 7.4 | 0.1 | 8.6 | 22.1 | 0.2 | 25.7 |
| Bulgaria | 66.7 | 0.1 | 79.1 | 200.2 | 0.4 | 237.3 |
| Croatia | 39.2 | 0.1 | 42.6 | 117.7 | 0.3 | 127.7 |
| Cyprus | 113.2 | 0.9 | 127.5 | 339.6 | 2.7 | 382.5 |
| Czech Republic | 830.5 | 0.6 | 944.8 | 2,491.8 | 1.8 | 2,834.9 |
| Estonia | 4,505.0 | 38.2 | 4,876.8 | 13,517.0 | 114.5 | 14,632.6 |
| Georgia | 138.7 | 0.6 | 172.3 | 416.1 | 1.7 | 516.9 |
| Hungary | 116.5 | 0.1 | 136.4 | 349.7 | 0.4 | 409.4 |
| Kazakhstan | 2,911.6 | 2.9 | 3,559.4 | 8,736.0 | 8.6 | 10,679.8 |
| Latvia | 1,682.0 | 10.4 | 1,847.7 | 5,046.6 | 31.1 | 5,544.0 |
| Lithuania | 135.4 | 0.5 | 171.3 | 406.2 | 1.6 | 514.1 |
| Poland | 807.6 | 0.3 | 827.4 | 2,423.2 | 0.8 | 2,482.7 |
| Moldova | 131.7 | 1.4 | 156.2 | 395.0 | 4.2 | 468.5 |
| Romania | 483.9 | 0.5 | 589.4 | 1,452.0 | 1.4 | 1,768.5 |
| Russia | 245,549.2 | 22.5 | 288,474.6 | 736,758.4 | 67.5 | 865,554.0 |
| Serbia and Montenegro | 97.5 | 0.2 | 99.3 | 292.7 | 0.7 | 298.1 |
| Slovak Republic | 16.2 | 0.0 | 17.4 | 48.5 | 0.1 | 52.3 |
| Slovenia | 46.0 | 0.2 | 50.1 | 138.1 | 0.5 | 150.3 |
| Macedonia | 8.5 | 0.1 | 9.2 | 25.6 | 0.3 | 27.5 |
| Turkey | 612.6 | 0.1 | 756.5 | 1,838.0 | 0.4 | 2,270.0 |
| Ukraine | 9,902.3 | 4.4 | 11,309.4 | 29,711.3 | 13.3 | 33,933.2 |
| Total region | 269,921.8 | 3.5 | 361,251.9 | 809,887.1 | 10.1 | 948,898.3 |

Notes: Calculations for $\alpha$ = -16.16; $\gamma$ = 1.25. Optimistic scenario assumes a high time preference rate of 10%, whereas the pessimistic view assumes r = 0.03.

## Figures

**Figure 1: Utility of death vs. utility of survival (Rosen)**

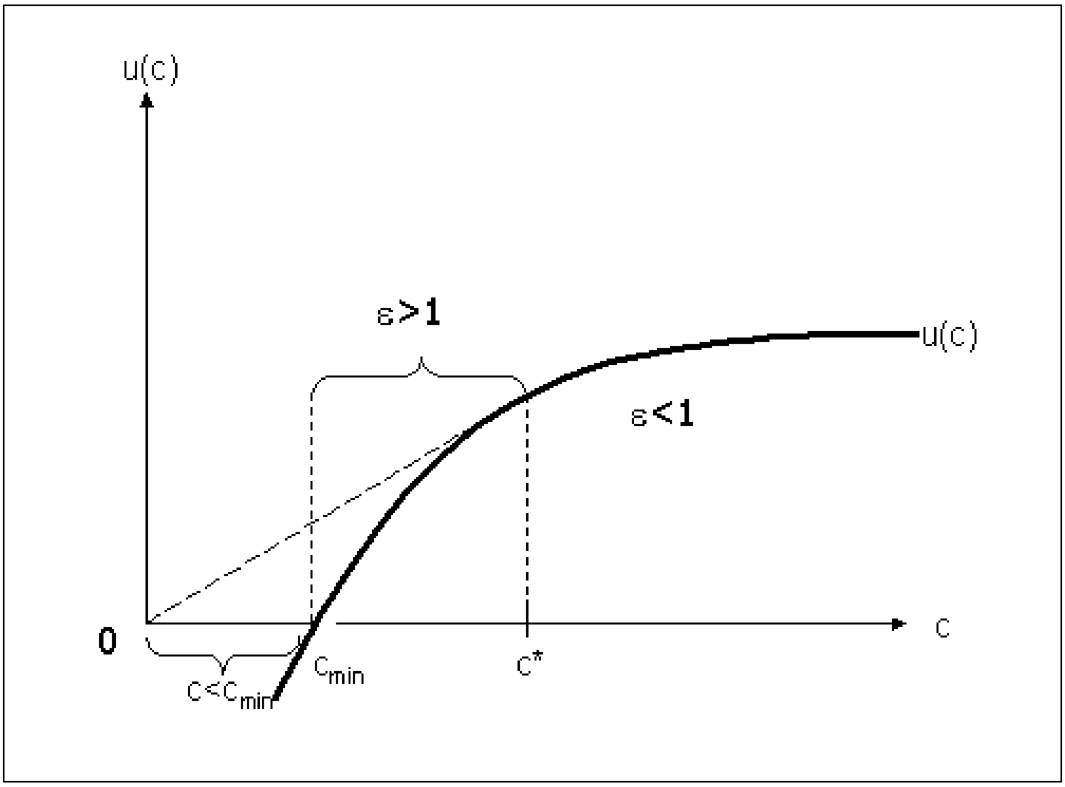


Figure 2: Correlation between treatment access and Income per capita

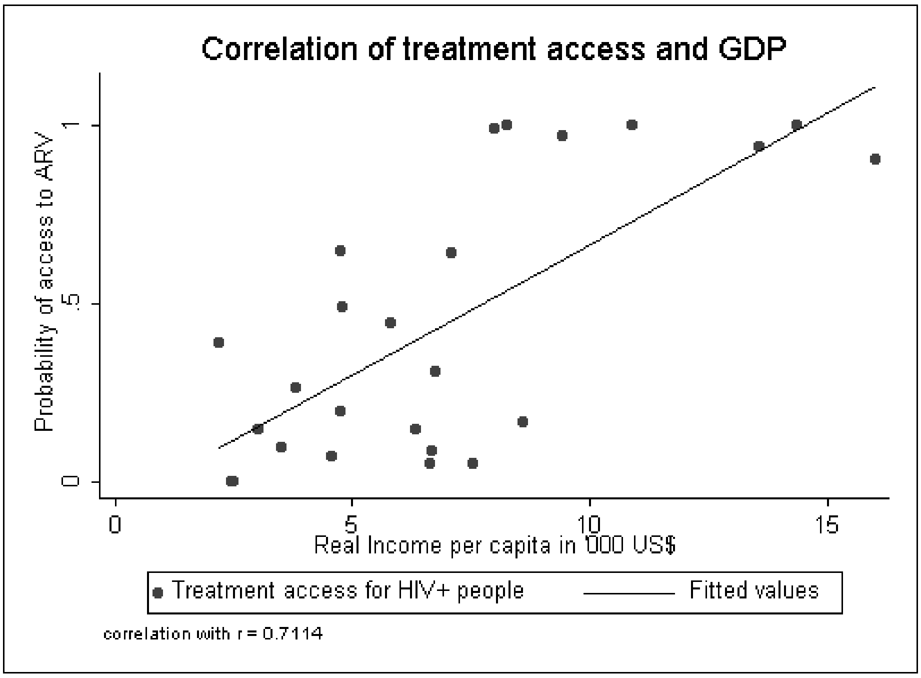


Figure 3: Cluster Analysis of regions in Eastern Europe according to real GDPTT

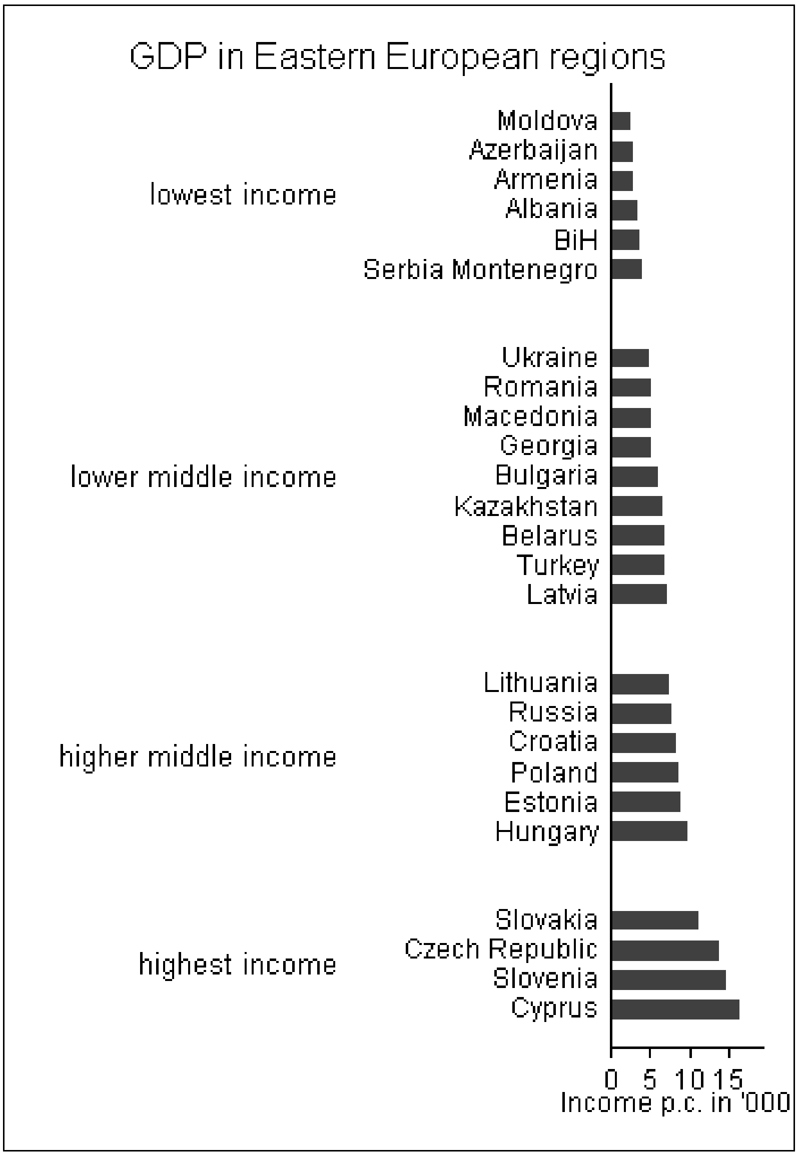


Figure 4: Regression estimates for the VSL

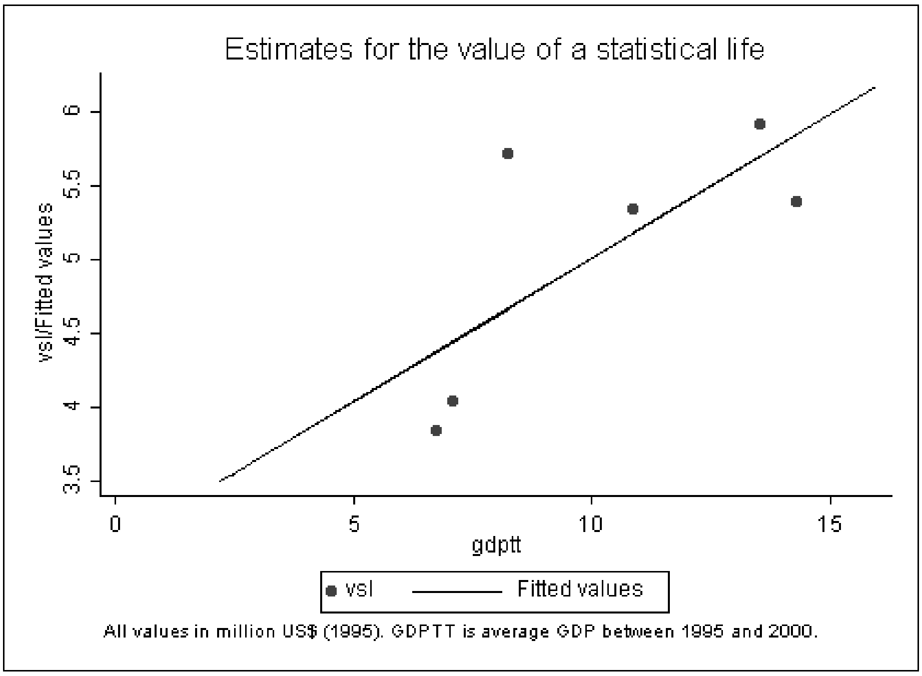


Figure 5: Development of HIV-incidence from 1995 - 2001

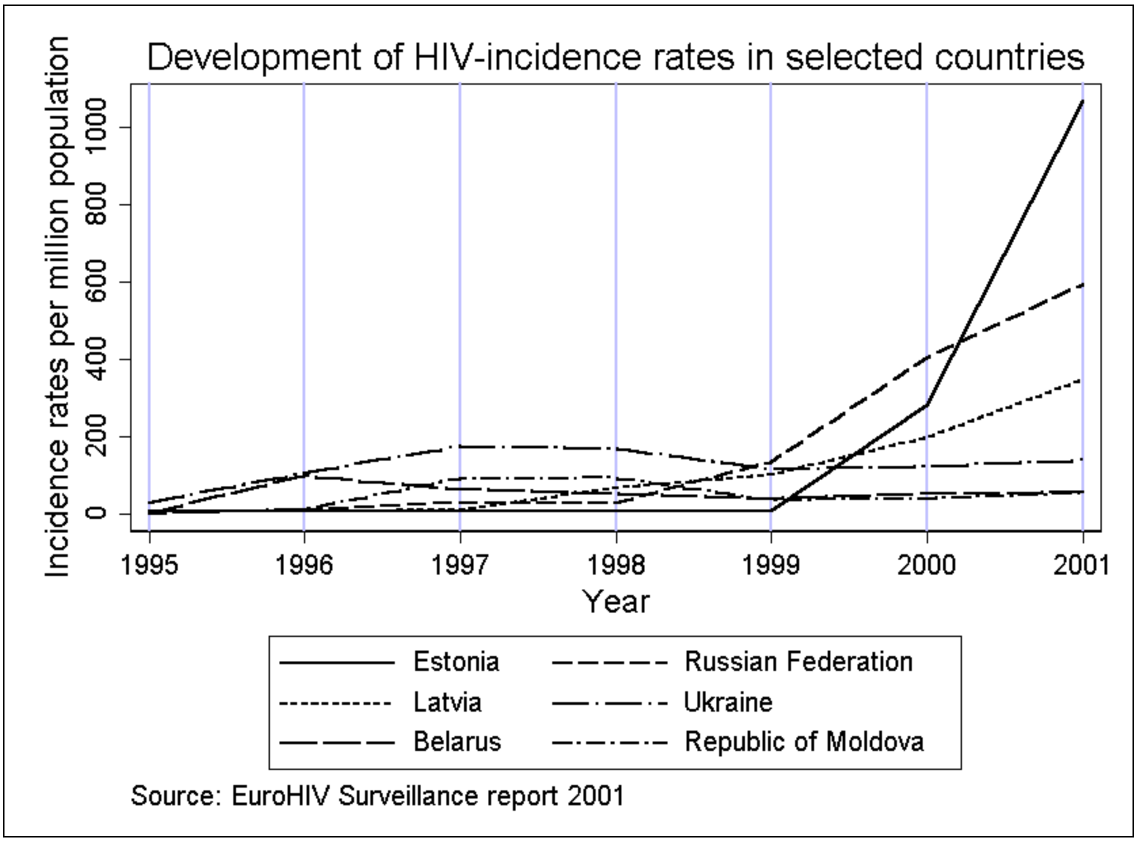
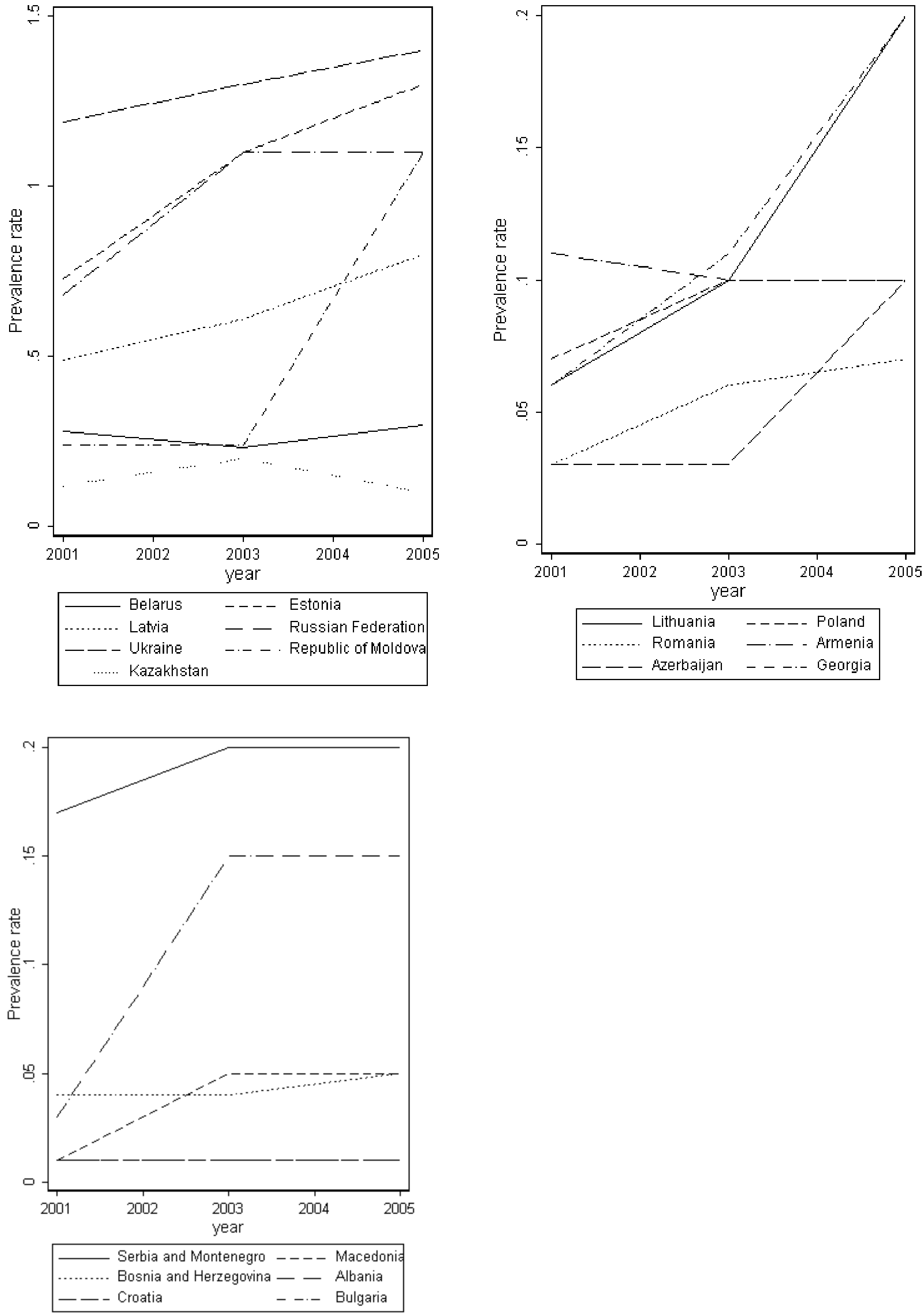
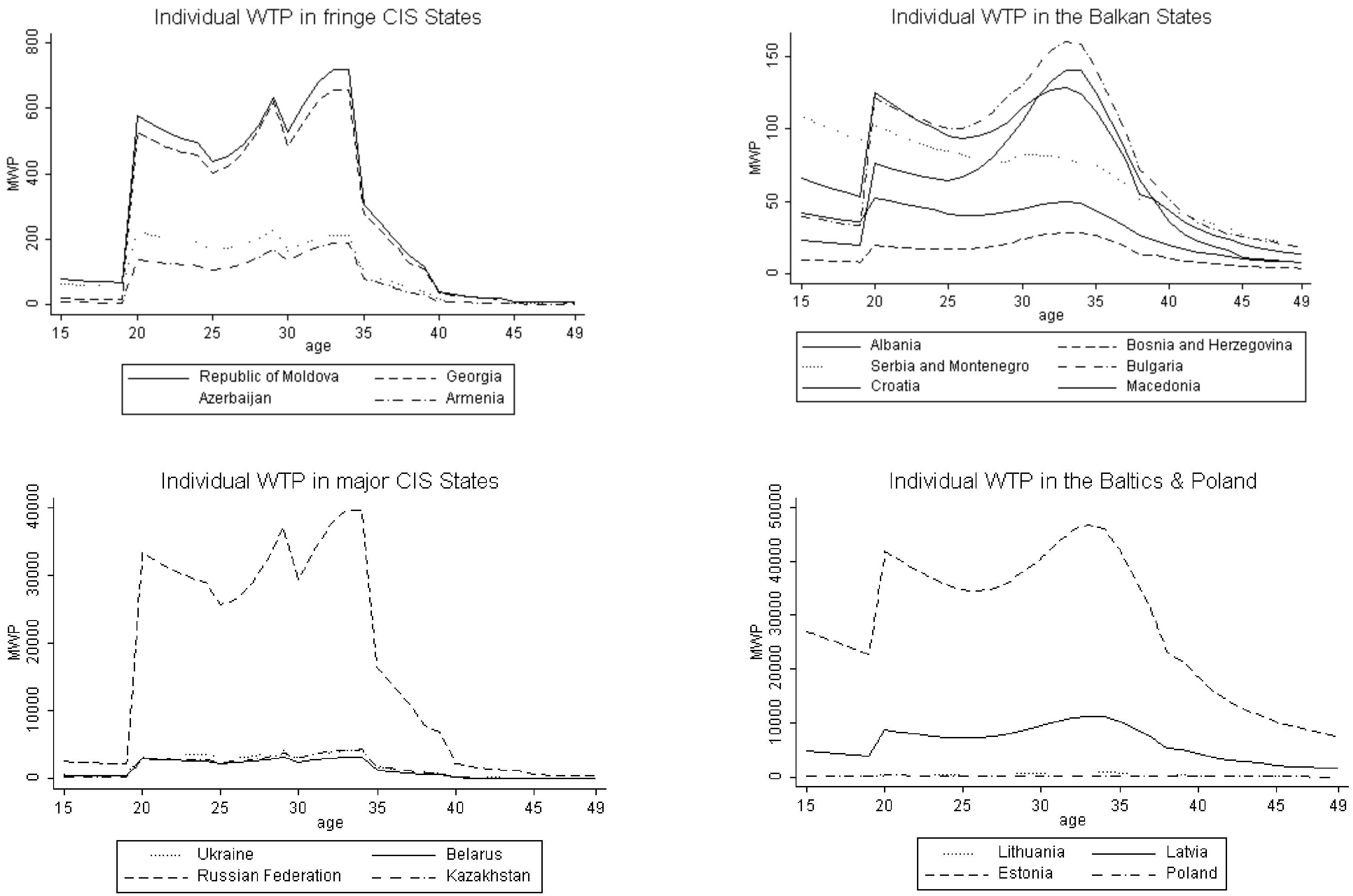


**Figure 6: Development of HIV-prevalence rates from 2001 - 2005**




Source: UNAIDS/WHO (2004, 2006). Report on the global AIDS epidemic, Annex 2:HIV and AIDS estimates and data.

**Figure 7: Individual WTP in Human Capital Scenario**




Notes: The curvature of the WTP also depends on the population distribution, which peaks at around 15 and then again at about 40.

Figure 8: Survival Curves with and without HIV for selected countries

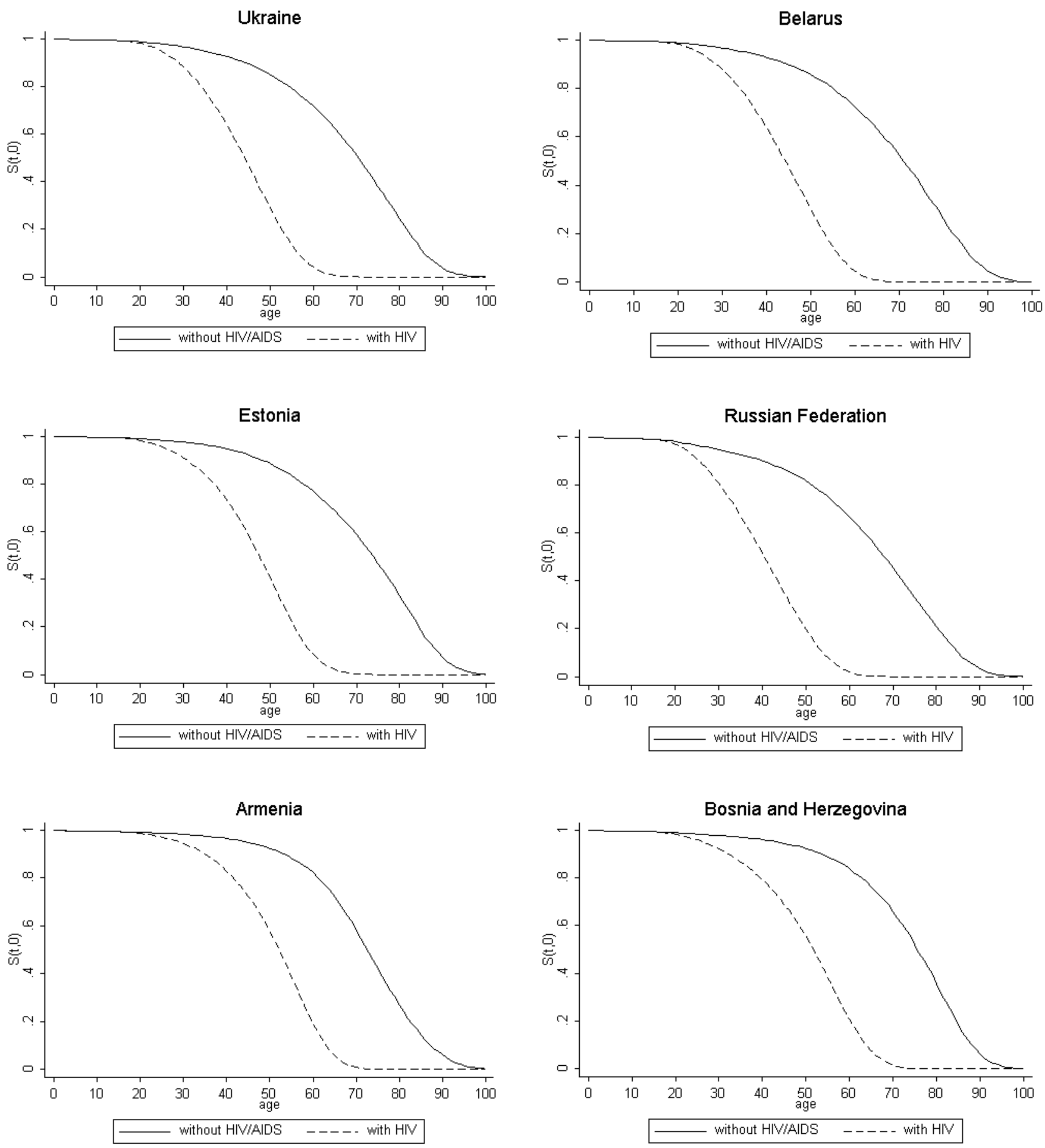
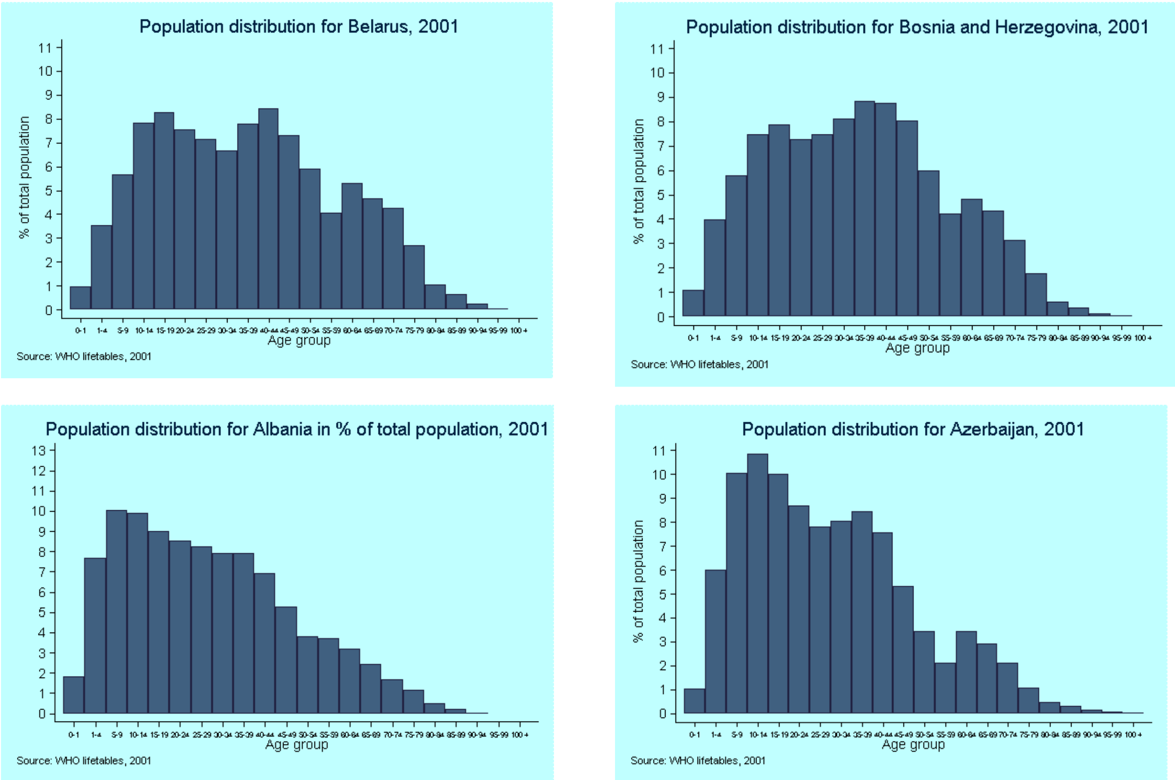


**Figure 9: Population distributions for selected countries**




Source: WHO Life Tables for 2001