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The macroeconomic impact of HIV/AIDS and HIV/AIDS interventions

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Evaluation Study

The macroeconomic impact of HIV/AIDS and HIV/AIDS interventions

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Table of contents

List of abbreviations

AIDS	Acquired Immune Deficiency Syndrome
ART	Anti-Retroviral Therapy
ASSA	Actuarial Society of South Africa
CEA	Cost-Effectiveness Analysis
CGE	Computable General Equilibrium
EPI-DEM	Epidemiological-Demographic
GDP	Gross Domestic Product
HIV	Human Immunodeficiency Virus
HIV+	HIV positive
OLG	Overlapping Generations
PMTCT	Prevention of Mother-to-Child Transmission
SAM	Social Accounting Matrix
SUT	Supply-use Table

1 Introduction

June 2011 marked 30 years since the first reported case of AIDS. Since then an estimated 65 million people have contracted HIV and more than 22 million people have died of AIDS. Africa remains the hardest hit continent – evident by the 17 million AIDS related African deaths and the fact that the continent is home to more than 70 per cent of all infected.

The past three decades have, however, also witnessed an unprecedented political response to HIV/AIDS. Billions of dollars have been allocated and national and international organisations, dedicated to the fight against HIV/AIDS, have been created. Unfortunately, the response has not been mirrored by a similar increase in the knowledge about the macroeconomic impact of HIV/AIDS. Estimates of the macroeconomic impact of HIV/AIDS vary considerably and answers to the basic question of what interventions work best under a given set of circumstances are still tentative – at best.

Two current trends accentuate the importance of acquiring knowledge about the macroeconomic impact of HIV/AIDS epidemics and HIV/AIDS interventions: first, the decline in donor government support for HIV/AIDS and second, the recent economic growth in many countries with high HIV/AIDS prevalence. Kates et al. (2011) document how international HIV/AIDS assistance financed by donor governments declined by 10 per cent over the 2009-2010 period – the first recorded drop in assistance levels. As a result, the pressure to identify effective and efficient interventions has increased. In addition, continued high economic growth in countries with high HIV/AIDS prevalence may cause decision makers to underestimate the seriousness of the epidemic and question its negative economic impact. This could lead to the paradoxical situation that less rather than more domestic resources may be allocated to the fight against HIV/AIDS when the domestic capacity to pay increases thus accentuating the need for better evidence about the macroeconomic impacts of the disease.

The purpose of this synthesis study is to assess the different methodological options commonly used to estimate the macroeconomic impact of HIV/AIDS epidemics and interventions. By providing a better understanding of the evidence about existing approaches and their strengths and weaknesses the study will enable policy discussions on the most efficient way to fight the disease and facilitate better and more systematic future assessments of HIV/AIDS interventions.

This study is based on a comprehensive literature review, covering commissioned studies, reports and scientific articles – all in the public domain. The search has indicated that the macroeconomic impact of HIV/AIDS has until now primarily interested academic researchers, using scientific journals to publish their findings. The lack of policy studies addressing methodological questions has implications for this synthesis study. Firstly, the study has had to rely heavily on scientific articles, and secondly, the study will add to the discussion by considering (albeit briefly) the potential relevance and realism of the different methodologies covered.

While the study is focused on the assessment of methodologies, it does also include a discussion of the magnitude of the impacts uncovered. The discussion will, however, be brief and focused on the analytical perspectives as the country-specific nature of impact estimates reduces their potential use and relevance considerably.

Following this brief introduction, section 2 outlines the analytical framework, describing the multiple channels through which HIV/AIDS can have a macroeconomic impact. Subsequently, section 3 presents a synthesis of simulation-based macroeconomic impact assessment studies (section 3.1) with in-depth discussions of applied growth models and Computable General Equilibrium (CGE) models. Next, section 4 provides an overview of statistical analyses of HIV/AIDS including a discussion of economic cross-country regressions and systematic reviews of cost-effectiveness analyses. Finally, Section 5 concludes and summarizes the main findings.

2 Analytical framework

The analytical framework has two elements: (i) overview of the methodologies used to assess impact, and (ii) the unit and type of impact.

2.1 Methodologies used to assess impact

The methodologies used to assess the macroeconomic impact of HIV/AIDS and HIV/AIDS interventions can be grouped into the simulation-based approaches and the statistical approaches.

1. The **simulation-based approach** entails the construction and calibration of economy-wide simulation models, assessing the ex ante expected impact of HIV/AIDS and HIV/AIDS interventions. Applied growth models (section 3.1.1) and multi-sector Computable General Equilibrium (CGE) models (section 3.1.2) dominate this approach.

2. The **statistical approach** focuses on estimating the ex post observed impact of HIV/AIDS through the specification of a statistical model. The main methodologies are cross-country regressions (section 4.1) and systematic reviews of cost-effectiveness analyses (section 4.2).

To ensure a comprehensive basis for policy decisions both approaches will be analysed in this study, highlighting the strengths and weaknesses of each approach.

2.2 Unit and type of impact

This study, as mentioned, focuses on the macroeconomic impact of HIV/AIDS epidemics and HIV/AIDS interventions. Macroeconomic impact is, in this context, defined as the estimated effect on GDP or GDP per capita. Compared to current discussions of "impact" in the evaluation literature this represents an operational, quantifiable and strictly economic definition of impact. This does not reflect ignorance about or a lack of concern for the human suffering associated with the disease. Rather, it reflects the fact that knowledge of the net public cost of fighting (or not fighting) HIV/AIDS, whether we like it or not, matters for the political interest in and the resource allocations to the fight against HIV/AIDS. In addition, the complexity of the issues at hand necessitates a narrow focus and clarification.

Overall, the macroeconomic impact of HIV/AIDS will materialise through the impact on the size and composition of the labour force and the capital goods, which for non-economists can be "translated" into the workers in an economy and the machinery they use for production. Effects can be divided into direct and indirect effects. The **direct effects** include:

- AIDS-related increases in **mortality**, reducing the size and composition of the population, which in turn affects the size of the labour force and thus the total output produced. Given that HIV/AIDS primarily affects people in their most productive and reproductive years, the direct (and indirect) economic impact of AIDS mortality is likely to be larger than that of other infectious diseases.
- HIV-related increases in **morbidity**, leading to absenteeism and reduced work capacity of the infected, potentially lowering total output in the economy through its effect on the labour force. Again, the demographic profile of the infected – a group of working-age people characterised by (relatively) low morbidity in the absence of HIV/AIDS – implies that the economic impact can be significant.
- HIV/AIDS-related increases in **private and public expenditures**. At the household level this includes: medical expenses and costs incurred in relation to, for example, funerals. At the macroeconomic level, HIV/AIDS related expenditures include expenses for prevention interventions targeted at the non-infected, and expenses for

care and treatment focused on the infected. In both cases, expenditures could have been saved or used for other welfare-improving purposes in the absence of the disease.

The **indirect effects** arise from the interaction between the direct effects, the associated changes at the individual, household, corporate, and government levels, and the structural characteristics of the affected economy. This includes:

- How HIV/AIDS-related mortality affects the **size and composition of the labour force**. This includes the incentive to have children, the incentive to participate in the labour force, and the scale and infection pattern of the epidemic. Apart from the scale of the epidemic, which will lower the size of the labour force, net effects cannot be ascertained beforehand.
- How HIV/AIDS-related morbidity affects the **productivity** of the labour force. This includes how absenteeism and reduced work capacity affects the productivity of HIV+ workers. The productivity loss depends on the stage of the disease and whether infected individuals are under treatment.
- How HIV/AIDS-related mortality and morbidity affects **education and skill-accumulation** in society. This includes reduced incentives for education and skill-accumulation due to a lack of future opportunities, reduced income of HIV+ parents to pay for their children's education, and the death of experienced workers.
- How HIV/AIDS-related increases in private and public expenditures affect **savings and other forms of spending**. This will depend on the form of financing chosen. The increased healthcare costs can be financed either by development assistance or reduced domestic expenditures. Sustainable domestic financing may be achieved either through reduced current consumption or reduced investment (and thereby reduced future consumption). Financing out of reduced current consumption may allow economic growth to be maintained, while reduced investment will lower economic growth. Sustainable financing will therefore always lower household welfare (consumption), but economic growth may be maintained to varying degrees depending on whether HIV/AIDS expenditures are financed out of consumption or investment.

It is important to note that the indirect effects will also arise from expected effects from HIV/AIDS as individuals, households, corporations and governments seek to prevent and mitigate the macroeconomic impact of HIV/AIDS.

A key question to be assessed by the different methodologies is to determine the net effect of both direct and indirect effects – not an uncomplicated matter given that many of the indirect effects represent households' and firms' attempts to circumvent and/or mitigate the negative effects of HIV/AIDS. In addition, HIV/AIDS related increases in mortality imply that both the numerator (GDP) and the denominator (size of the population) of GDP per capita will be affected; complicating attempts to determine the net effect on GDP per capita. If, for example, AIDS-related deaths cause a percentage drop in population size that exceeds the associated decline in GDP, the result will be a paradoxical increase in GDP per capita.

In terms of interventions**,** this study **covers both preventive and curative interventions, that can be classified as individual, separable interventions** such as the provision of anti-retroviral treatment (ART), condom distribution and education campaigns. This **excludes integrated interventions** whereby, for example, access to treatment increases the effectiveness of preventive interventions. This is a delimitation dictated by the lack of evidence rather than a failure to understand the importance of synergies and complementarities between interventions. The focus on individual and separable interventions also **excludes policies directed at general health system strengthening** - an important condition for the effectiveness of HIV/AIDS interventions. It is, however, outside the scope of this study and is additionally inhibited by the lack of systematic developing country evidence.

In order to enhance the comparability of the different methodologies **a common analytical structure** will be used in the assessment of each methodology. First, a brief description of the methodology and its application to the field of HIV/AIDS will be provided, summarising how HIV/AIDS has been modelled within the specific methodology. The multitude of direct and indirect effects implies that individual studies most often focus on a limited number of macroeconomic impact channels in the assessment of HIV/AIDS. In addition, an assessment of the likely future developments and what is needed in order for improvements within each methodology will be provided. Next, the strengths and weaknesses of the different methodologies will be assessed. This entails an identification of the type and scope of questions that a specific methodology can answer as well as an assessment of the information and data required in order to apply the different methodologies. The result is an analysis of the relevance and potential use of the specific methodology for policy analysis.

3 Simulation-based macroeconomic impact assessment of HIV/AIDS

Section 2 outlined how HIV/AIDS mainly affects the economy through changes to the labour market, including the size and composition of the labour force, and the productivity of workers. Accounting for such structural effects of HIV/AIDS mortality and morbidity is crucial for a proper assessment of the macroeconomic impact of the disease. This section will identify and discuss the dominant simulation-based approaches to macroeconomic impact assessment. First, section

3.1 contains a discussion of how the different methodologies include the above-mentioned structural mechanisms, and to what extent they account for the ways in which households and firms seek to ameliorate the negative impact of HIV/AIDS. Further, the ability of the methodologies to include policy- and evaluation relevant indicators will be discussed.

Subsequently, the existing macroeconomic impact assessment studies are reviewed in Section 3.2, with a focus on the methodologies for measurement and quantification of labour market impacts and health-system costs, and the general lessons emerging from macroeconomic impact measurements. Four sub-sections will discuss: the use of epidemiological-demographic models for measuring mortality and morbidity effects (Section 3.2.1); how to measure health-system costs of HIV/AIDS interventions (Section 3.2.2); and the existing evidence and challenges of estimating macroeconomic outcomes of HIV/AIDS epidemics and interventions (Sections 3.2.3 and 3.2.4).

3.1 Methodology

The macroeconomic simulation models have primarily focused on analysing the macroeconomic impact of HIV/AIDS, whilst only a limited number of studies seek to estimate the impact of HIV/AIDS interventions. Furthermore, the studies that do include HIV/AIDS interventions predominantly concentrate on treatment interventions, resulting in a severe lack of studies that estimate the macroeconomic impact of prevention.

As already mentioned in section 2.1 two types of macroeconomic simulation models dominate the simulation-based macroeconomic impact assessment of HIV/AIDS[1]:

[1] A third (albeit less widespread) type of model is the applied econometric model. Applying the co-integrated vector autoregressive (VAR) method (see Johansen (1992), and Johansen and Juselius (1994) for a presentation of the method) this methodology typically produces small-scale, short-term, demand-driven models, i.e. where growth is determined by changes in domestic and foreign demand (independent of the labour market). This represents a problem vis-à-vis modelling the impact of HIV/AIDS, as the disease mainly has long-term consequences on the supply-side of the economy (through the labour market). The econometric simulation methodology is therefore not well suited for analysing the long-term macroeconomic consequences of HIV/AIDS and will not be discussed further in this survey. For examples of econometric simulation model studies see: Laubscher (2000); Laubscher, Smit and Visagie (2001); Smith, Ellis and Laubscher (2006) and Abdulsalam (2010).

1. **Applied growth models.** [2] The aggregate nature of growth models means that they are typically applied for illustrating conceptual issues. Within the HIV/AIDS literature, three different types of applied growth models have been applied to study the HIV/AIDS labour market effects. All three types of models assume that economic growth is supply-driven, meaning that it is determined by primary production factors including labour force growth and accumulation of physical and human capital.

2. **Computable General Equilibrium (CGE) models.** [3] The disaggregate nature of CGE models means that they are typically applied for policy-relevant analyses. CGE models account for multiple production sectors and multiple market participants (producers, consumers, government, and foreign agents), and enable tracking of economy-wide income, expenditure, and (as they assume that economies are open) trade flows. CGE models also assume that economic growth is supply-driven, and – in contrast to the applied growth models – that prices are flexible.

To fully capture the macroeconomic impact of HIV/AIDS both types of macroeconomic simulation models need to include the ways in which the economy adjusts to HIV/AIDS.[4] Here, three key adjustment mechanisms can be identified: (1) price changes for goods from affected production sectors,[5] (2) re-allocation and replacement of workers between production sectors,[6] and (3) changes in international trade patterns that potentially compensate for HIV/AIDS related changes in a country's comparative advantage.[7] Each of these mechanisms acts as a buffer against the negative macroeconomic impact of HIV/AIDS. The following

[2] Applied growth models are aggregate (typically one sector) macroeconomic simulation models, which rely on aggregate national accounts data and solves for aggregate consumption and GDP growth paths. Applied growth model studies of HIV/AIDS include: Cuddington (1993a) and (1993b); Cuddington and Hancock (1994); Cuddington, Hancock and Rogers (1994); Haacker (2002); Ferreira and Pessoa (2003); Bell, Devarajan and Gersbach (2003), (2004) and (2006); Corrigan, Glomm and Mendez (2005); Young (2005); Bell, Bruhns and Gersbach (2006); Johansson (2007); Roe and Smith (2008); Ventelou et al. (2008); Vasilakis (2010) and Ferreira, Pessoa and Dos Santos (2011).

[3] Computable general equilibrium (CGE) models are multi-sector models which rely on sector-level economic data and solves numerically for income and expenditures flows and levels of supply, demand and price that support equilibrium across a specified set of markets. CGE models can consequently analyse the aggregate welfare and distributional impacts of policies whose effects may be transmitted through multiple markets and sectors. CGE based studies of HIV/AIDS include: Kambou, Devarajan and Over (1992); Arndt and Lewis (2000); Arndt and Wobst (2002); Arndt (2006); Jefferis et al. (2008); Ventelou et al. (2008) and Thurlow et al. (2009).

[4] The first published macroeconomic evaluation study (Kambou, Devarajan, and Over, 1992) stressed the need for a model that captured the way prices adjust and resources re-allocate in response to HIV/AIDS.

[5] E.g. the relative price of non-traded services may increase or decrease depending on how HIV/AIDS affects the skill composition of the workforce.

[6] E.g. re-allocation of workers across multiple production sectors may allow workers to replace workers lost to HIV/AIDS.

[7] E.g. an epidemic with a bias towards low-skilled workers would change the comparative advantage of an economy towards the production of "high skill"-intensive products, and vice versa.

two subsections will discuss to what extent applied growth models and CGE models incorporate these stabilising mechanisms, and their ability to analyse policy- and evaluation relevant (tax) instruments and (poverty/public finance) indicators.

3.1.1 Applied growth models

Three types of applied growth models have found use in the HIV/AIDS macroeconomic simulation literature:

1. **The Solow model** [8] is a stylised representation of GDP formation and growth, which is assumed to require the use of primary production factors; typically labour and capital. Long-run per capita growth is determined by factor productivity growth – i.e. the ability to use these primary production factors more efficiently. Behaviour related to savings and investment is assumed to be static. The model is simulated over annual periods.

2. **The Ramsey model**[9] assumes – like the Solow model – that production requires primary production factors including labour and capital. The focus of the Ramsey model is to analyse optimal savings behaviour over time, resulting in long-run growth being determined by productivity growth and savings behaviour. Behaviour is dynamic and consumption and savings are determined by long-run inter-temporal considerations. The model is estimated over annual periods.

3. **The Overlapping Generations (OLG) model**[10] again assumes that production requires primary production factors including labour and capital. The contribution of OLG models is to further incorporate micro aspects of economic behaviour, including economic agents that undergo different life stages (low-income youth, high income middle ages, and retirement where labour income drops to zero). Long-run growth is – like in the Ramsey model – determined by productivity growth and inter-temporal savings behaviour. The model is simulated over generational periods (20-30 years).

Most of the early growth model studies applied variations of the standard Solow growth model, while more recent studies have applied the Ramsey model or the OLG model.

The aggregate nature of the applied growth models is associated with both strengths and weaknesses. In terms of **strengths**, the applied growth models are typically

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[8] Solow growth model studies of HIV/AIDS include: Cuddington (1993a, 1993b); Cuddington and Hancock (1994); Cuddington, Hancock and Rogers (1994); Haacker (2002); Young (2005); Ventelou et al. (2008) and Cuesta (2010).

[9] Ramsey growth model studies of HIV/AIDS include: Johansson (2007) and Roe and Smith (2008).

[10] OLG model studies of HIV/AIDS include: Ferreira and Pessoa (2003); Bell, Devarajan and Gersbach (2003, 2004, 2006); Corrigan, Glomm and Mendez (2005); Bell, Bruhns and Gersbach (2006); Vasilakis (2010) and Ferreira, Pessoa and Dos Santos (2011).

fairly easy to construct (calibrate). This is especially so for the relatively simple Solow model framework. As applied growth models enable the illustration of selected direct or indirect effects (as identified in section 2.2) without having to worry about more complex issues like sector level details or distinction between effects on the private sector and the government, this type of models have been instrumental in describing and identifying key channels through which HIV/AIDS impacts macroeconomic developments. Accordingly, most of the applied growth model studies have been undertaken with the specific purpose of illustrating specific macroeconomic effects. Solow growth studies typically illustrate short- to medium-term HIV/AIDS-related mechanisms (the effect on, for example, labour supply and employment and labour productivity) whilst Ramsey and OLG growth studies typically illustrate long-term HIV/AIDS-related mechanisms (such as the effect of HIV/AIDS on savings and investment in physical and human capital).

The aggregate and stylised nature of applied growth models is, however, also a **weakness**. By implication, they are not well-suited for incorporating stabilizing mechanisms such as: changes in relative prices, re-allocation of workers to replace those lost to HIV/AIDS, and re-orientation of international trade patterns. Not taking these adjustment mechanisms into account means that applied growth models are likely to overestimate the negative consequences of HIV/AIDS.

Furthermore, the aggregate and stylised nature of applied growth models implies that they typically omit basic relationships which are of interest for evaluation purposes. This includes (1) a clear distinction between private and government sectors, (2) a distinction between different government budget items, (3) a concrete link between health effects, healthcare unit costs and government budget implications, and (4) a distinction between different types of taxes and their potential for financing HIV/AIDS interventions.

In sum, the aggregate and stylised nature of applied growth models makes them well suited for the illustration of selected direct and indirect effects (key transmission mechanisms), but less suited for policy-relevant analyses of the macroeconomic impact of HIV/AIDS. In terms of HIV/AIDS interventions, it is difficult to adapt the Ramsey and OLG models to the level of disaggregation required for a proper policy-relevant macroeconomic evaluation tool. Similarly, the necessary re-specification of the simple Solow model typically goes beyond what that model is designed for.[11] Measures of the macroeconomic impact of

[11] In technical terms the Solow growth model is a fairly simple dynamically-recursive model. The necessary re-specification of the model to evaluate the consequences of HIV/AIDS, however, typically goes beyond what the model is designed for. Hence, previous attempts to include multiple sectors (including separate formal/informal production sectors) must be considered as a stylized representation rather than a basis for policy-relevant impact assessments.

HIV/AIDS, based on applied growth models, should consequently be regarded as illustrative. Similarly, applied growth models are typically of limited relevance to policy implementation questions, including the choice of strategy and financing options.

3.1.2 Computable General Equilibrium models

Turning to the second type of macroeconomic simulation models - the Computable General Equilibrium (CGE) models the disaggregated multi-sector nature of these CGE models[12] is also associated with strengths as well as weaknesses. The **strengths** originate from the disaggregated multi-sector nature of these models, which represents a natural advantage over applied growth models. This enables CGE models to account for the stabilizing macroeconomic mechanisms mentioned earlier, and provides a proper basis for including the key relationships of interest to evaluation studies[13], discussed above. CGE models have moreover gradually been refined over time to include, for example, dedicated modules to measure detailed government budget implications and poverty effects (Jefferis et al. 2006, 2008). These features are central to establishing a proper simulation tool for macroeconomic impact assessment purposes.

Traditionally, the main weakness of the CGE model approach has been the reliance on high data density. However, recent improvements in data availability have reduced or even removed this former weakness. Social Accounting Matrix (SAM) data sets, which form the basis for constructing CGE models, have mushroomed over the past two decades.[14] As a result, data availability no longer represents a significant constraint in many developing countries.[15]

The **main problem** in the existing CGE model literature is that it has yet to properly quantify and include many of the key direct and indirect effects identified in the growth model literature. Individual studies remain weakened by ad-hoc assumptions regarding, for example, the calculation of morbidity-related labour force shocks and labour productivity effects (see discussion in section 3.2.4). Similarly, the long-term macroeconomic impact of potential reductions in human

[12] All CGE model studies in the HIV/AIDS macroeconomic simulation literature are based on dynamically-recursive versions of the so-called 1-2-3 model. For model documentation, see: Devarajan et al. (1990) and Lofgren et al. (2002).

[13] The term Evaluation Studies refers, in this report, to evaluations of the impact of support to HIV/AIDS interventions.

[14] One indication of the growth in relevant data is the rapid expansion of the Global Trade Analysis Project (GTAP) database, which includes 113 countries/regions in the most recent version 7.1. (see www.gtap.agecon.purdue.edu/databases/v7/).

[15] This is also due to the recent recognition of donor organizations of the value of establishing up-to-date Supply-use Tables (SUT). SUT data sets contain essential structural information about the economy.

capital accumulation has yet to be properly implemented within a CGE model framework.[16] Nevertheless, recent methodological advances indicate that increased reliance on epidemiological-demographic models may solve many of these problems.

In sum, the existing CGE model literature remains deficient in terms of quantifying some of the key labour market effects. The literature has, however, made important advances in terms of incorporating epidemiological-demographic models as well as providing policy-relevant analyses of the implications HIV/AIDS epidemics and interventions has on the government budget and poverty levels. Consequently, the CGE model methodology provides the most appropriate starting-point for the development of a simulation-based macroeconomic impact assessment tool that can estimate the impact of different HIV/AIDS interventions. The multi-sector flexible-price open-economy CGE model framework enables the inclusion of both the labour market impacts of HIV/AIDS and of stabilising adjustments whereby households and firms seek to ameliorate the negative impact of HIV/AIDS. In addition, the CGE model framework is designed to measure policy-relevant indicators that could be of interest when undertaking evaluations of the impact of support to HIV/AIDS interventions. Due to the deficiencies of the existing literature, a largely untapped potential for model refinement exists in this area. This includes the measurement of morbidity-related labour force and labour productivity effects, the macroeconomic impact of changes in human capital accumulation, and the inclusion of (especially preventive) interventions. The latter is of particular relevance to policy studies and will be considered in detail in section 3.2.4.

3.2 Impact of HIV/AIDS epidemics and interventions

The following sub-sections describe and analyse key issues related to simulation-based macroeconomic impact assessments of HIV/AIDS. First, Section 3.2.1 focuses on epidemiological-demographic models and how they measure and quantify labour market effects of HIV/AIDS. Next, Section 3.2.2 outlines methodologies applied to the measurement and inclusion of health-system costs in macroeconomic simulation models. Finally, Sections 3.2.3 and 3.2.4 describe and analyse general lessons that can be derived from available macroeconomic impact assessment studies of HIV/AIDS epidemics and interventions.

[16] Arndt (2006) represents the only existing attempt at modelling the human capital impact of HIV/AIDS within a CGE model framework. For further discussion of the study by Arndt see Section 3.2.3.

3.2.1 Epidemiological-Demographic models used in macroeconomic simulation studies

Most macroeconomic simulation studies rely on **population projections** from epidemiological-demographic (EPI-DEM) models to measure the morbidity- and mortality-effects of HIV/AIDS.[17,18] EPI-DEM models are used to produce three types of population projections, including (1) Counterfactual "No AIDS" projections, (2) Baseline "AIDS" projections, and of late (3) Experimental "AIDS with intervention" projections. Advances in knowledge about transmission mechanisms and infection thresholds, in concert with the availability of effective treatment options, have prompted the development of more sophisticated EPI-DEM models. This has enabled a focus on (primarily treatment) interventions in more recent macroeconomic impact assessment studies.

In a Sub-Saharan African context, the **two most widely used EPI-DEM models** that take interventions into account are: the WHO/UNAIDS endorsed Spectrum model and the Actuarial Society of South Africa (ASSA) model. The former has been combined with a growth model to study the macroeconomic impact of the HIV/AIDS epidemics in six Sub-Saharan African countries (Ventelou et al. 2008), whilst the ASSA model has been combined with both growth and CGE models to study the macroeconomic impact of treatment interventions in Botswana (Jefferis et al 2006, 2008).

While the above-mentioned studies have analysed HIV/AIDS interventions, the lack of more developed EPI-DEM models has restricted the remaining macroeconomic literature, which has traditionally focused on evaluating the macroeconomic impact of the HIV/AIDS epidemics. Moreover, no studies have so far properly analysed the macroeconomic impact of prevention interventions. While the Spectrum model only allows for treatment-based prevention analyses, the ASSA model, in principle, allows for modelling of a number of different prevention interventions, including: improved treatment for sexually transmitted diseases (STD), information and education campaigns (EIC), voluntary counselling and testing (VCT), and prevention of mother-to-child transmission (PMTCT). The usefulness of the ASSA model is, however, limited by the relatively simple nature of the model framework. Hence, the ASSA model does not properly account for disease progression, and can therefore not be used for proper measurement of

[17] This includes: Cuddington (1993a) and (1993b); Cuddington and Hancock (1994); Arndt and Lewis (2000) and (2001); Haacker (2002); Arndt (2006); Johansson (2007); Jefferis et al (2008); Roe and Smith (2008); Ventelou et al. (2008) and Thurlow et al (2009).

[18] The main exception is the OLG model studies that rely on ad-hoc specifications of HIV incidence and transition. This includes: Ferreira and Pessoa (2003); Bell, Devarajan and Gersbach (2003), (2004), and (2006); Corrigan, Glomm and Mendez (2005); Bell, Bruhns and Gersbach (2006); Vasilakis (2010) and Ferreira, Pessoa and Dos Santos (2011).

treatment interventions and the progression of morbidity effects among infected individuals.[19]

Turning to the **labour market effects** discussed in Section 2, some have been properly estimated on the basis of EPI-DEM population projections. This includes: changes in labour stock, changes in labour productivity, and (in a few studies) changes in the stock of experienced workers.[20,21,22] In contrast, EPI-DEM projections have yet to be used to calculate changes in human capital accumulation – an impact mechanism which has so far mainly been analysed within stylized OLG model frameworks, using ad-hoc specifications.[23]

While most studies rely on EPI-DEM projections, only a few studies rely purely on population projections for measuring labour market effects.[24] Most specify **ad-hoc relationships** (see discussion in section 3.2.3), and a large part goes even further and specifies additional ad-hoc shocks to characterize HIV/AIDS epidemics. This includes ad-hoc assumptions about HIV/AIDS-related changes to: (1) Total Factor Productivity[25] (TFP) growth, (2) household health consumption and savings patterns, and (3) public health expenditures.[26,27,28] In addition to violating the basic

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[19] The limited ability of the ASSA model to assess the progression of morbidity effects also limits its usefulness for assessing prevention interventions, since it means that the counterfactual scenario (i.e. what would have happened without prevention) cannot be properly measured.

[20] This includes: Cuddington (1993a) and (1993b); Cuddington and Hancock (1994) and Jefferis et al. (2008)

[21] The methodology for estimating changes in labour productivity based on EPI-DEM projections is well established. Due to a lack of evidence, the existing macroeconomic literature has, however, focused solely on health effects during the final 'AIDS' stage of disease progression (measured by absenteeism, which is generally confused with labour productivity in the literature). Morbidity effects of treatment interventions have not been modeled so far. Evidence is, however, starting to emerge on both absenteeism (reduced number of work days) and presenteeism (reduced productivity when at work) throughout the different stages of disease progression (with and without treatment). Hence, the methodology for measuring morbidity effects based on EPI-DEM projections has potential for significant improvement.

[22] The starting point for the methodology to estimate changes in the stock of experienced workers is a set of aggregate population projections and an assumption that the age of workers can be used as a proxy for experience.

[23] This includes: Corrigan, Glom and Mendez (2005); Bell, Devarajan and Gersbach (2006) and Ferreira, Pessoa and Dos Santos (2011).

[24] They include: Cuddington (1993a) and (1993b), and Cuddington and Hancock (1994).

[25] Total Factor Productivity growth is defined as the unexplained residual in growth accounting – i.e. the share of economic growth not explained by changes in capital and labour (and other types of production factors).

[26] This includes: Arndt and Lewis (2000), Jefferis et al (2008); Ventelou et al. (2008) and Thurlow et al. (2009).

[27] The ad-hoc shocks to public and household health expenditures and household savings rates are not in fact labour market shocks, but financial shocks related to HIV/AIDS intervention and healthcare costs (see section 3.2.2).

[28] A similar problem of generic ad-hoc shocks is found in studies of HIV/AIDS interventions. For example, Ventelou et al. (2008) rely on an ad-hoc treatment shock specification. More specifically, their 'HIV treatment' intervention amounts to a simple 50 per cent price reduction on HIV treatment. The problem is that the study does not account for associated primary health effects. Instead, a structural relationship between health expenditures and health status is included to model the impact of (reduced) health costs on

principle that impact channels should be explicitly specified in the model framework, the generic ad-hoc shocks have, in some cases, been shown to account for the majority of the overall (negative) economic impact of the HIV/AIDS epidemic or treatment interventions under investigation.[29] This is problematic given the limited empirical basis for these ad-hoc assumptions.

Three lessons emerge from this discussion. First, mortality- and morbidity-related labour market effects should mainly be measured based on proper EPI-DEM population projections. Second, the EPI-DEM population projection has only recently allowed the estimation of the impact HIV/AIDS interventions, focusing almost exclusively on treatment-based interventions. Third, a large potential for model refinement consequently remains in this area. This includes the proper measurement of mortality and morbidity effects on human capital accumulation, and (very important for policy discussions) the inclusion of preventive interventions within properly specified EPI-DEM models.

3.2.2 Methodology for measurement of health-system costs

The heavy costs associated with care, treatment, and prevention of HIV/AIDS has attracted considerable attention – in particular from the development partners, who are investing heavily in treatment and prevention programs in developing countries. Evaluation studies should therefore ideally include the health-system costs associated with intervention and healthcare strategies. Not least because the scale and scope of Sub-Saharan African epidemics imply that the health-system costs can have macroeconomics consequences. Hence, the measurement of health-system costs serves the dual purpose of informing about fiscal impacts and providing a basis for measuring the macroeconomic consequences.

A basic distinction can be made between **three types of health-system costs**, including (1) cost of care for AIDS-patients, (2) cost of prevention, and (3) cost of treatment of HIV+ individuals. Initially, macroeconomic models focused on measuring the costs of care for AIDS-patients. The methodology consisted of applying unit medical costs to the number of AIDS-patients, where the number of patients was derived from epidemiological-demographic population projections. Some studies relied on actual country-specific unit cost estimates,[30] while other studies relied on ad-hoc assumptions.[31] No other methodologies have so far been adopted for measuring the costs of care for AIDS-patients in the macroeconomic

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(improved) health status. By implication, the study only accounts for secondary health effects of 'HIV treatment' cost reductions – health effects which are not directly related to actual HIV treatment.

[29] They include Jefferis et al. (2006) and (2008).

[30] This includes: Cuddington (1993a, 1993b)

[31] See Cuddington, Hancock and Rogers (1994)

simulation literature. Albeit simple, the available methodology for measuring the cost of treatment is useful and should be applied in future macroeconomic impact assessment studies.

The lack of focus on **prevention interventions** in the macroeconomic simulation literature explains the very limited number of studies attempting to include the cost of prevention. Only two studies have attempted to analyse prevention interventions,[32] but no proper methodology has so far been developed for measuring (and implementing) the cost of prevention interventions.[33]

The macroeconomic simulation literature has had a slightly broader (but still limited) focus on **treatment interventions**. Five studies have attempted to analyse treatment interventions.[34] The studies by Young (2005) and Johansson (2007) calculate available resources for treatment programmes, whilst Bell et al. (2006) and Ferreira et al. (2011) adopt aggregate ad-hoc relationships specifying interventions as a function of underlying costs (see also section 3.2.4).[35] Jefferis et al. (2006, 2008) is the only study, which has applied a proper methodology for measuring the actual cost of treatment interventions. Similar to the cost-of-care methodology discussed above, Jefferis et al. applied unit costs to the actual number of treated individuals in order to measure the overall programme cost. The methodology was based on proper epidemiological-demographic projections and detailed country-specific unit cost estimates.

Although interesting from a conceptual point of view, such adoption of **aggregate ad-hoc relationships,** specifying interventions as a function of underlying costs, does not provide a proper basis for evaluation. The aggregate nature of applied macroeconomic models makes it impossible to accurately measure intervention costs or to analyse whether (and in what combination) treatment interventions should be used. In contrast, applying unit costs to epidemiological-demographic projections provides a much more accurate assessment of the net costs of treatment programmes. This approach provides a superior basis for policy makers and

[32] Cuddington et al. (1994) focus on a condom distribution and education programme, and assume (ad hoc) that the programme cost per couple year is 10% of GDP per capita; Robalino et al. (2002) focus on a generic prevention programme and assume an ad-hoc relationship between prevention costs and HIV prevalence on the one hand, and labour productivity on the other.

[33] Robalino et al. (2002) refer to prevention cost estimates from the DARE project (World Bank 1999), but the methodological problems in their application of these estimates mean that their analyses do not properly reflect the financial impact.

[34] They include: Young (2005); Bell, Devarajaran and Gersbach (2006); Johansson (2007); Jefferis et al. (2008) and Ferreira, Pessoa and Dos Santos (2011).

[35] The OLG studies by Bell, Devarajan, and Gersbach (2006) and Ferreira, Pessoa and Dos Santos (2011) specify aggregate ad-hoc relationships covering multiple (prevention and treatment) intervention types, in order to derive optimal intervention time paths to maximize social welfare.

evaluation purposes – both for measurement of fiscal and macroeconomic consequences – and should therefore be adopted in future evaluation studies.

A potential complication relates to the **sources of funding for the increased health-system costs**, which have to be financed either from domestic or foreign sources. Since long-term financing from abroad is (typically) not sustainable, most macroeconomic simulation studies assume that increased health-system costs lead to reduced savings and reduced capital accumulation. However, domestic financing may also come from reduced current consumption. As the choice between reducing savings on one hand or consumption on the other makes a difference to economic growth, some studies have undertaken sensitivity analyses to address this issue.[36]

The **main lesson** emerging from this discussion is that appropriate methodologies (based on epidemiological-demographic population projections) exist for measuring costs of healthcare and treatment programmes, but not for measuring costs of prevention programmes.

3.2.3 Estimating the macroeconomic impact of HIV/AIDS – the case of South Africa

Given the abovementioned strengths and weaknesses of applied growth models and CGE models, a key question is how these differences affect the estimated macroeconomic impact of HIV/AIDS. In this context the South African epidemic represents an interesting and relevant case. Of the 17 studies that estimate the macroeconomic impact of Sub-Saharan African countries no less than nine study the macroeconomic impact of HIV/AIDS in South Africa. Appendix 2 provides an overview of the nine South Africa studies in Table 1, and presents the remaining eight studies in Table 2. The South African studies thus represent a unique opportunity to study how macroeconomic simulation studies of a given epidemic vary across different methodologies.[37]

Until around 2000, South Africa had one of the fastest expanding HIV/AIDS epidemics in the world. Since then, a growing political recognition of the epidemic has contributed to keeping HIV prevalence relatively stable. According to UNAIDS, general prevalence was 17.8 per cent in 2009 up from 17.1 per cent in 2001.

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[36] Most notably: Cuddington (1993a) and (1993b), and Cuddington and Hancock (1994). Others (e.g. Young 2005) argue against sensitivity analyses from a welfare perspective, stating that the issue boils down to a political decision about whether current or future generations should pay for the increased health-system costs. This discussion also shows the limitations of using GDP per capita as a macroeconomic indicator in impact assessments of HIV/AIDS. The problem is that increased health-system costs can be financed by a reduction in consumption, whilst economic growth is maintained. If this were the case household consumption (or another similar welfare measure) would be a more appropriate macroeconomic indicator of the impact of HIV/AIDS.

[37] In order to focus on methodological issues, the comparative analysis will be limited to the nine studies of the South African epidemic. However, a similar comparative analysis of the remaining eight studies of (other) Sub-Saharan African epidemics is available from the authors upon request.

Studies of the macroeconomic impact of HIV/AIDS in South Africa are, as mentioned, presented in Table 1 in the Appendix. At first sight, it looks as if the choice of methodology does not matter much. More specifically, the macroeconomic impact of the South African epidemic seems to be:

1. **GDP:** lowered by around 20% in 2010 and by around 60% in 2050,
2. **GDP growth rates:** lowered by around 1.4%-1.6% until 2025 and by around 1.9% in 2050,
3. **GDP per capita:** lowered or raised by around 10% in the short-to-medium term (2010-2025) and lowered by around 10%-20% in the very long term (2075+), and
4. **GDP per capita growth rates:** lowered by around 0.5% until 2025, but raised by around 0.2% in 2050.

The only significant issue for discussion, where the nine studies on South Africa disagree significantly in their projections, appears to be whether the short-to-medium term macroeconomic impact on GDP per capita is positive or negative. Estimates of the macroeconomic impact of HIV/AIDS range from a reduction of ÷8% in 2010 (Arndt and Lewis 2000, 2001) to an increase of +10% in 2025 (Young 2005). The different results are due to fundamental methodological differences, which can be traced back to the differences between CGE and applied growth models as discussed previously. A discussion of the problems associated with the studies by Arndt and Lewis and Young moreover illustrates how even apparently comparable results for the South African epidemic are, in reality, an illusion.

Arndt et al. apply a CGE model methodology, relying on epidemiological-demographic population projections to measure morbidity- and mortality-effects. In addition, a number of ad-hoc assumptions about labour market and health-system cost shocks are introduced to characterize the South African epidemic. This includes assumptions about: (a) reductions in productivity growth, (b) changes in savings rates and health budget shares for HIV-infected households, and (c) increases in the health share of government spending – all of which lacks empirical basis. The many ad-hoc specifications considerably reduce the credibility of Arndt et al.'s results. In particular, the estimated 8% reduction in GDP per capita is likely to depend, critically, on the assumption of a 'systemic' 50% reduction in productivity growth.[38]

The study by Young relies on a completely different methodology. Seeking to analyse how HIV/AIDS affects fertility rates and how this affects economic activity among the surviving population, Young develops an integrated Solow growth model and epidemiological-demographic model framework. The crucial difference between Young's study and other macroeconomic simulation studies is an empirical finding of a negative

[38] This type of ad-hoc assumptions has been found to have decisive influence in other CGE model studies (Jefferis et al. 2006, 2008). Reliance on ad-hoc specifications is not a general feature of the CGE model literature. Nevertheless, it seems to have been adopted throughout the HIV/AIDS sub-literature.

statistical relationship between (age-specific) HIV prevalence rates and fertility rates.[39] Using this relationship, Young predicts that medium-term population growth will be reduced significantly, by a combination of AIDS deaths and reduced birth rates. The sharp reduction in population growth results in a smaller workforce, which (paradoxically) leads to a medium-term increase in labour productivity (due to a sharp increase in the capital-labour ratio). As a result, GDP per capita increases by up to 10% in 2025. Young coins this effect as 'The Gift of the Dying'.

Young's study has played an important role in drawing attention to the conceptual issue of fertility rates and the importance of accounting for the demographic changes resulting from HIV/AIDS, but the results are neither likely to estimate the impact of HIV/AIDS in South Africa nor extend to other countries. Hence, Young's fertility specification has been criticized for not being representative for South Africa nor externally valid for other countries,[40] and his (Solow) model has been criticized for being an improper framework for evaluation purposes (with a focus on fertility).[41] In this way, Young's study reflects how the applied growth model literature is able to integrate particular issues (fertility) into the model framework, but unable to produce accurate and valid estimates. In Young's model, the fertility response is so strong that it turns an otherwise negative impact into a positive impact.[42]

The **main lessons** from the above discussion are twofold. First, HIV/AIDS epidemics may, under certain extreme conditions, raise incomes among the surviving population, but are most likely to lower future per capita income levels and growth rates. Second, macroeconomic impact assessment of HIV/AIDS epidemics relies critically on the adoption of a proper macroeconomic impact assessment methodology.

3.2.4 Estimating the macroeconomic impact of HIV/AIDS interventions

The macroeconomic simulation literature has, as indicated in the previous section, employed a number of methodologies to evaluate HIV/AIDS epidemics in a number of different countries. In contrast, the macroeconomic simulation literature on treatment and prevention interventions is limited. Two studies have attempted to

[39] Young's inverse relationship between fertility and HIV prevalence (within quinqennial age groups) is derived from a reduced form regression. Young's interpretation of the relationship emphasizes two mechanisms: A direct mechanism (reduced sexual activity) and an indirect socioeconomic mechanism (increased female opportunity cost of giving birth due to increased female labour market participation).
[40] See the discussion in: Young (2007); Boucekinne, Desbordes and Latzer (2009) and Kalemli-Ozsan and Turan (2011).
[41] It has also been argued that the Solow model may magnify the macroeconomic impact of reduced fertility, since long-run income is a negative function of population growth in this model (Ferreira, Pessoa and Dos Santos 2011).
[42] Young shows that the long-lived transitory income expansion is equivalent to a permanent 5.6% increase in per capita consumption. The fertility specification accounts for 7.3% of this increase (Young 2005). Hence, an income contraction, equivalent to a permanent 1.7% reduction in per capita consumption, would have resulted without the fertility specification.

analyse prevention interventions.[43] However, as both studies adopt crude methodologies for measuring the transmission impact of prevention interventions (condom use and generic prevention), the studies are best viewed as conceptual studies of relevance for the development of methodologies but without much relevance for actual policy evaluation purposes. As a consequence, the results are not reliable, and will not be discussed here.

The situation is only slightly better when it comes to **analysing treatment interventions**.[44] In spite of a limited number of studies (five in total), a number of different methodologies have been adopted including different model types and different output measures (Table 3 in the Appendix provides an overview of the studies). It is therefore difficult to draw general lessons from the available evidence. The few studies that report the actual macroeconomic impact on GDP and GDP per capita indicate that specific treatment programmes in Botswana and South Africa – ART (and PMTCT in South Africa) – may lower the negative per capita GDP impact of the South African epidemic by 12%, and lower the negative GDP growth impact of the Botswana epidemic by 0.4%-0.8%.

Most of the available macroeconomic evidence on treatment interventions again relates to the South African epidemic. This evidence seems to be fairly consistent. Most prominently, it confirms the high need (as well as high potential) for treatment interventions in South Africa. Young (2005) reports very high sustainable ART expenditures – i.e. that very high ART expenditures can be maintained without affecting household welfare – while Bell et al. (2006) find that economic growth can be maintained, but only with very high levels of treatment expenditures. Johansson (2007) supports Young's result, finding that an 'optimal' treatment programme may significantly increase public sector revenues, which in turn can finance the treatment programme itself.[45]

In sum, the available evidence seems to suggest that (full roll-out of) treatment programmes could be achieved without affecting household welfare or income growth in South Africa. This conclusion, however, rests on a very limited number of studies. Moreover, the two influential studies by Young and Bell et al. have been criticized for their adoption of controversial methodologies. More specifically, Young's result is based on his controversial fertility assumption, which (if correct) would imply that the HIV/AIDS epidemic has had a positive impact on South

[43] They include: Cuddington, Hancock and Rogers (1994), and Robalino, Voetberg and Picazo (2002).

[44] They include: Young (2005), Bell, Devarajan and Gersbach (2006), Johansson (2007), Jefferis et al. (2008), and Ferreira, Pessoa and Dos Santos (2011).

[45] This result does, however, not measure the resources which can be extracted 'without cost' from the South African economy for treatment purposes

African income levels (the 'Gift of the Dying' discussed in Section 3.2.3). However, as discussed above, this assumption has been challenged.[46]

Similarly, the result of Bell et al. has been challenged on methodological grounds. Their model has been criticized for failing to account for capital (and capital accumulation) as a productive resource in the economy (Ferreira, Pessoa and Dos Santos 2011). More importantly, their model does not rely on proper EPI-DEM population projections for measuring mortality- and morbidity-related labour market effects.[47] Moreover, treatment intervention costs are inaccurately measured by a single aggregate cost function, which is supposed to capture all types of treatment interventions.[48] In spite of the methodological problems, the study by Bell et al. has been very influential in drawing attention to the conceptual issue of human capital within the growth model literature. However, the methodological problems raise doubts as to whether the model of Bell et al is appropriate for actual evaluation purposes. By the same token, their conclusion that reduced income growth can be avoided with large-scale treatment programmes is questionable at best.

A more promising approach is provided by the CGE model study by Jefferis et al. (2008), which presents a detailed study of the (medium-term) macroeconomic impact of HIV/AIDS epidemics and treatment interventions in Botswana. As mentioned above, Jefferis et al. find that treatment may lower the negative GDP growth impact of the Botswana epidemic by 0.4%-0.8%. These estimates are (correctly) based on EPI-DEM population projections to measure morbidity- and mortality-effects. On the negative side, they follow Arndt et al. (discussed above) and introduce a number of additional ad-hoc labour market shocks to characterize the Botswana epidemic, including: (a) a reduction in aggregate productivity growth, (b) a reduction in labour productivity for AIDS patients, and (c) a reduction in labour productivity for people receiving ART– all without an empirical basis to support the assumptions. Hence, although all of the latter effects are important to account for, the ad-hoc specifications lower the credibility of the study.

The specification of ad-hoc characteristics (and the associated loss of credibility) blemishes an otherwise path breaking study. The study by Jefferis et al. (2008) was the first macroeconomic study to employ a proper epidemiological-demographic model for analysing (treatment) interventions; the first to employ a detailed fiscal

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[46] See the discussion in Young (2007); Boucekinne, Desbordes and Latzer (2009) and Kalemli-Ozsan and Turan (2011).

[47] In general, long OLG model time periods (20-30 years) does not allow for proper modelling of HIV/AIDS transmission.

[48] An additional complication relates to the fact that Bell et al. calibrates their treatment cost function on the basis of both treatment and prevention interventions (Bell, Devarajan and Gersbach 2006).

model to measure public treatment and healthcare intervention costs; and the first to use a micro-simulation module for measuring poverty. The study reports that the proposed ART programme will reduce poverty in Botswana by 1.0%-point in 2021. However, given the above discussion, this number is not likely to be accurate. Nevertheless, the methodology is very useful and should be applied as the starting point in future macroeconomic impact assessment studies.

Moreover, there remains a largely untapped potential for model refinement in this area, especially in terms of the measurement of morbidity-related labour force and labour productivity effects, and the macroeconomic impact of changes in human capital accumulation. Evidence is starting to emerge on both absenteeism (reduced number of work days) and presenteeism (reduced productivity when at work) throughout the different stages of disease progression (with and without treatment). Hence, there exists a significant potential for improving the existing methodology for measuring morbidity effects based on EPI-DEM population projections.

The **main lessons** from the above discussion are: (1) HIV/AIDS treatment programmes are likely to have a beneficial macroeconomic impact on per capita income and growth rates, (2) HIV/AIDS treatment programmes may, under extreme circumstances, be able to fully eliminate the negative consequences of HIV/AIDS epidemics, but will, under normal circumstances, only be able to partially negate the negative, and (3) the CGE model methodology would seem to provide a good starting-point for developing a proper macroeconomic simulation model for macroeconomic impact assessment of HIV/AIDS epidemics and both treatment and preventive interventions.

4 Statistical approaches to estimating the impact of HIV/AIDS

The first macroeconomic growth models in the early 1990's indicated that the net impacts of HIV/AIDS on GDP and GDP per capita were negative. This conclusion was, however, disputed by others (e.g. Bloom and Mahal 1997), noting that the existing macroeconomic simulation models could not capture the multitude of effects and rested on assumptions that were difficult to verify. The uncertainty led Bloom and Mahal to conclude that the macroeconomic impact of HIV/AIDS had to be settled as an empirical question.

This section provides an overview of the econometric estimates of the impact of HIV/AIDS, seeking to assess whether this approach can contribute to evaluations and guide policy makers.

4.1 Cross-country estimates of the macroeconomic impact of HIV/AIDS

The lack of detailed longitudinal data at the country level and the interest in analysing universal determinants of growth during the same period meant that cross-country regression was the preferred method of analysis.[49] In brief, cross-country regression analyses regress observed national GDP per capita growth for a group of countries on a range of country characteristics hypothesized to affect growth. Typical growth determinants (labelled "right-hand side variables") are aggregate measures of: capital stock, average level of educational attainment, geography and climate, and institutional strength and characteristics. All identified studies using this approach are summarised in Table 4 in the Appendix.

The aggregate nature of both methodology and data prevents the analysis of specific HIV/AIDS interventions, and implies that cross-country regression can only hope to estimate the macroeconomic impact of HIV/AIDS epidemics. Two approaches to estimating the macroeconomic impact of HIV/AIDS can be identified:

1. The **reduced-form approach**, seeking to estimate the total net effect of HIV/AIDS. This approach was introduced by Bloom and Mahal (1997) and entails modelling HIV/AIDS as a productivity shock in a reduced-form alongside all the other variables hypothesized to affect GDP per capita.[50] Consequently, the average national HIV prevalence rate enters alongside other right-hand side variables in the growth regression, thus estimating the net effect of all direct and indirect effects. The macroeconomic impact of HIV/AIDS is indicated by a statistically significant coefficient of HIV prevalence.

2. The **structural approach**, seeking to estimate the direct and indirect effects of HIV/AIDS that are related to its effect on human capital, typically measured by a composite measure like life expectancy.[51] Specifically, the relationship between the prevalence or incidence of HIV/AIDS and health capital is estimated in a first-step regression. Next, an augmented Solow model is estimated in which the growth of income per head is partly determined by health capital, and where health capital, in turn, is partly determined by the HIV prevalence rate. Consequently, the direct and indirect effects that do not affect population growth and the composite health measure are ignored using this approach.

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[49] Following the influential research by Kormendi and Meguire (1985) and Barro (1991) cross-country regressions were popular and influential during the 1990's, resulting in a vast literature that indentified more than 50 variables to be significantly correlated with economic growth.

[50] Bloom and Mahal (1997) and Papageorgiou and Stoytcheva (2008) employ the reduced-form approach to estimate the total net macroeconomic impact of HIV/AIDS.

[51] Dixon, McDonald and Roberts (2001), McDonald and Roberts (2005) and Tandon (2005) use the structural approach.

Overall, **cross-country regressions find a relatively small macroeconomic impact of HIV/AIDS**. However, there is considerable variation as estimated macroeconomic impacts range from Bloom and Mahal's conclusion that the purported negative macroeconomic impact of HIV/AIDS is "more flash than substance" to Papageorgiou and Stoytcheva's identification of a negative and significant effect of AIDS on GDP per capita for Sub-Saharan Africa.

These differences may to some extent be explained by gradual improvements in data. More specifically, Bloom and Mahal had to rely on one point estimates of national HIV prevalence for each country and included developed countries in their 51-country sample. In contrast, the most recent study by Papageorgiou and Stoytcheva used a panel of 89 countries (all developing countries) covering three five-year periods. In contrast, Papageorgiou and Stoytcheva were able to track the development of HIV/AIDS prevalence and other growth determinants over a 15-year period for a more homogeneous group of countries. Still, taking into account the long latency period from HIV infection to full blown AIDS, the period for which national prevalence estimates are available must be considered relatively short. [52] Furthermore, the indirect effects running through investments in physical and human capital will most likely take even longer to materialize. As a result, it has been argued that the identified relatively moderate macroeconomic impact of HIV/AIDS found using cross-country regressions, could be attributed to the length of the period covered by data (Dixon et al. 2001).

It is, however, also evident that **low inter-study coherence could be related to weaknesses of the methodology**. More specifically, empirical growth economists seeking to estimate the macroeconomic impact of HIV/AIDS face the problem that the theory is neither explicit about what variables belong in the "true" regression nor about how they should be measured. Each growth regression typically contain between five to seven variables – all hypothesized to affect economic growth. Some of these variables typically belong to a more robust set of "usual suspects", [53] whilst the rest are left to the discretion and taste of the researcher(s). In addition, improvements in the availability and quality of data enable researchers to test for

[52] In comparison, Gallup and Sachs (2001) using a similar methodology could rely on data covering a 35-year period (1965 to 1990) to estimate the (negative and statistically significant) relationship between malaria and economic growth.

[53] Applying an extreme bounds analysis, Levine and Renelt (1992) investigate the robustness of the results from linear regression models and they find that very few regressors pass their test.

parameter heterogeneity across regions and countries, which is found to be a potential problem in all the more recent studies.[54]

A closer look at the HIV/AIDS cross-country regressions reveals additional problems. This includes the **questionable choices of (proxy) variables, as well as the simultaneous use of a variable**. Examples of the latter include the level of infrastructural development used both to measure the level of economic growth and to act as a determinant of economic growth (Bonnel, 2000). Another example is the, proposed use of life expectancy at birth and infant mortality as indicators of human capital (McDonald and Dixon, 2005), ignoring that HIV/AIDS is already taken into account in the estimation of national life expectancy and likely to have a relatively small effect on infant mortality.

The **main lessons** from the above discussion are: (i) the aggregate nature of data and the limited options for a structural approach imply that cross-country estimates can only address the macroeconomic impact of HIV/AIDS epidemics and not that of specific HIV/AIDS interventions, (ii) the lack of firm conclusions regarding the macroeconomic impact of HIV/AIDS epidemics can to some extent be attributed to the quality of data and the short time span analysed, (iii) the reduced form approach is, however, also limited by the combination of a fixed set of growth determinants to a very diverse group of countries, and the lack of theoretical guidance in choosing the right variables, (iv) whilst the structural approach deliberately ignores non-health related effects and attempts to squeeze all health related effects into one composite measure. Endogeneity (GDP per capita affecting a country's ability to fight the spread and limit the impact of HIV/AIDS) is potentially also a problem, which is, however, mitigated through the restriction to only include countries at the same, approximate level of development.

By implication both methodologies are unsuited to capture the multidimensional macroeconomic impact of HIV/AIDS epidemics and interventions. Given the methodological nature of the challenges, it is moreover unlikely that future cross-country studies – even if based on better data – will be able to correctly estimate the macroeconomic impact of HIV/AIDS.

4.2 Systematic reviews of cost-effectiveness analyses of the macroeconomic impact of HIV/AIDS

The standard public health answer to the question of how to maximise the health impact of a limited budget is to allocate funds according to cost-effectiveness.

[54] This includes: Dixon et al. (2001), McDonald and Roberts (2005), Tandon (2005) and Papageorgiou and Stoytcheva (2008).

Consequently, studies of cost-effectiveness of different HIV/AIDS interventions have multiplied over the past two decades due to a combination of policy-maker interest and a broader dissemination of the technique.[55] This has enabled researchers to collect and synthesize individual cost-effectiveness analyses (CEAs) in so-called systematic reviews assessing and comparing different studies and types of interventions.

Given the scope of CEA surveys it is, however, immediately evident that this type of study cannot address the macroeconomic impact of HIV/AIDS epidemic. Hence, the question of interest is whether they can provide relevant input to evaluations and policy discussions of the macroeconomic impact of HIV/AIDS interventions.[56]

A systematic review is typically initiated by a comprehensive search for relevant studies followed by a selection process where the identified studies are either screened according to a set of predefined quality criteria and/or subject to standardisation. The objective of the screening and standardisation process is to enable aggregation and comparison of different types of interventions. Subsequently, the relative cost-effectiveness ratios and essential contextual information (about, for example, HIV/AIDS prevalence) can be used as inputs into the decision process.

Table 5 in the Appendix summarizes the systematic reviews of HIV/AIDS interventions identified for this synthesis study. All the reviews included cover more than one type of intervention and include explicit quantitative and cost-based comparisons.

Reliance on systematic reviews of CEA faces several **challenges**. Although it might be possible to provide an idea of the macroeconomic impact of different types of interventions on cost or health related measures, CEAs only include direct effects. In addition, the related problems of delimitating the studies (handling fixed costs, derived/secondary effects and synergies between interventions) raise questions of reliability, validity and transparency, whilst the standardisation of comparable studies – despite international attempts – is constrained by almost universal lack of the necessary information in most CEA studies.

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[55] Cost-effectiveness studies rely on different methodologies including simulation models and statistical treatment-effect methodologies.

[56] Again, the focus on the macroeconomic impact must be emphasised. Systematic reviews of CEAs already inform public health prioritisation exercises, such as the World Bank Health Sector Priorities Review (HSPR), the WHO Choosing Interventions that are Cost-Effective (WHO-CHOICE), and the second edition of the joint Disease Control Priorities Project (DCP2).

These challenges are well recognized, causing all systematic reviews to issue caveats and call for additional research. Temporarily ignoring these caveats, two key observations emerge from the systematic reviews of CEAs: (i) evidence on the cost effectiveness of treatment versus prevention is very limited, and (ii) the majority of prevention interventions appear to be cost-effective, although ranking varies from study to study.

Overall, the **CEA evidence on anti-retroviral treatment (ART) compared to preventive interventions is limited**. This could be attributed to the fact that ART only became accessible towards the end of the 1990's. But if, as found by Stover and Bollinger (2002), evidence is missing and wanted at a strategic level, why do more recent systematic reviews not compare interventions directed at prevention with those oriented towards treatment?

One explanation, provided by the comprehensive POLICY project[57] is that the level and allocation among prevention and treatment is taken to depend on "the country's own particular priorities". By implication, the POLICY project refrained from addressing the overall allocation between treatment and prevention, essentially because it was considered to be a political decision. Ignoring the observation that a political decision does not rule out information and knowledge, the highly political nature of the balance between prevention and treatment is also apparent in Boelaert et al.' s (2002) description of the reactions to the review by Creese et al. Faced with a study that suggested more emphasis on prevention, the executive directors of The Global Fund, WHO and UNAIDS all stressed that: "prevention and treatment must go hand in hand" and that "it is wrong to accept that we have to choose between prevention and care, doing both is easily affordable."

Another explanation could be that preventive interventions are perceived to be "too different" from those focusing on treatment. Although the (arguably debatable) use of Disability Adjusted Life Years (DALYs) as a macroeconomic impact measure allows for direct comparisons between prevention and treatment interventions, it is, of course, true that the administration of ART is different from, say, peer education of prostitutes. It is, however, not evident that this difference is smaller/larger than the difference between two preventive interventions such as voluntary counselling and testing and male circumcision. Measuring the size (and importance) of the differences is, in other words, not possible. Canning (2006) moreover analyse the claim that CEAs overstate the returns to prevention whilst understating the returns

[57] The POLICY project which was funded by USAID, sought to improve the basis for policy decisions related to family planning/reproductive health (FP/RH), HIV, and maternal health in developing countries. The project was implemented in two phases (1995–2000 and 2000–2006), and resulted in a number of influential publications.

to treatment, finding it "not likely" unless new evidence of large positive (and hitherto unmeasured) externalities from treatment is found.

The absence of direct comparisons between treatment and prevention must be attributed to an implicit or explicit acknowledgement of the highly political nature of this allocation. Recently, the preventive dimensions of treatment (lowering the infectivity of the infected and providing incentives to seek testing and counselling) have received considerable attention.[58] The key message is essentially that the difference between treatment and prevention has "narrowed" and that important synergies will occur by following a "combination prevention" approach. Whether this is equivalent to the considerable positive externalities needed to tip the CEA balance between prevention and treatment, however, remains to be seen, as systematic reviews have yet to address this.

The extent to which cost-effectiveness analysis can provide guidance to policy makers about the appropriate mix of prevention strategies is limited. Although all systematic reviews find that preventive interventions in general are cost-effective, evidence is missing for several important types of intervention, including surveillance, abstinence, school-based interventions and mass media campaigns (Galárraga et al., 2009). A subsequent review of the available RCT evidence on the effectiveness of preventive interventions (Padian et al. 2010) moreover finds that 90% of HIV prevention trials find no significant effect of the interventions.

Hence, adopting stringent and evidence-based criteria, the call for more resources to preventive interventions is – looking at the available CEA-based evidence – not significantly better founded than the call for more resources to treatment. This conclusion should, however, be tempered by the fact that systematic reviews are but one among several inputs that inform the allocation of HIV/AIDS resources.

In summary, one can identify a number of reservations regarding the use of systematic reviews of CEAs as a basis for policy decisions. First, there is the **problem of scale and scalability of the interventions**. This relates to a generally recognized[59] lack of knowledge about how costs and impact of HIV/AIDS interventions vary with scale. Is it, for example, possible that economies of scale exist for some levels of coverage as suggested by Guinness et al. (2007)? Or will the costs of the program vary within the same country as suggested by Marseille et al.

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[58] See, for example, Moatti and Eboko (2010).

[59] The lack of knowledge about the relationship between scale and cost is mentioned in most of the systematic reviews (Creese et al. 2002, Walker 2003, Galárraga et al. 2009 and Hogan et al. 2005) and in a number of opinion articles (Kumaranayake et al. 2000, Marseille et al. 2002, Scotland et al. 2003).

(2007)? Most studies ignore these issues, implicitly assuming that interventions are either fixed in size or that cost functions are linear and interventions scalable.

This relates to a second and more fundamental concern, namely that unmeasured or unacknowledged constraints prevent scaling up coverage of HIV/AIDS interventions. Galárraga et al. mention the example of the distribution of male condoms, which continues to be among the most widely used preventive interventions. Yet, there is no evidence on whether existing interventions can be scaled up to achieve higher utilisation of condoms. Hence, it could very well be that the interventions required to reach the non-users are fundamentally different from those currently used. However banal it might seem, a similar, and equally relevant, concern is that the scalability of an intervention in the short to medium term will be restricted by the availability and quality of the supporting "hard and soft" health infrastructure.

The issue of scaling-up is especially pertinent for the ability of the cost-effectiveness methodology to provide proper macroeconomic impact assessments of HIV/AIDS intervention programmes. The CEA have a partial equilibrium nature in the sense that they do not account for macroeconomic spill over effects (e.g. the macroeconomic impact of health-system costs on savings and capital accumulation) or pecuniary externalities (e.g. the macroeconomic impact of HIV/AIDS on relative wage levels in the economy).

Next, there is the problem that the **set of interventions that are subjected to a CEA most likely is biased and incomplete**. Interventions like mass media campaigns and youth interventions are, for example, characterized by broad coverage, easy transferability of a key output (knowledge), implementation in conjunction with or following other interventions, and a (potentially too) short evaluation horizon, rendering CEA difficult and leading to a clear gap in evidence related to the cost-effectiveness of these interventions (Walker, 2003 and Ross, 2010).

Moreover, researchers (and funding agencies) have a tendency to focus on the efficacy and cost effectiveness of novel interventions like male circumcision, vaccines and microbicides at the expense of the already existing (but not tested) interventions like condoms and informational campaigns (Peters et al. 2010). In addition, it is easier to establish an "uncontaminated" control group when evaluating the biomedical interventions as the intervention remains person-specific and evaluators cannot succumb to the moral imperative to provide a diluted version of the intervention to the control group (Padian et al. 2010). As a result, the novel interventions are potentially overrepresented and might also have a higher probability of reporting a significant, positive result in the more recent systematic surveys – not representing the full range of interventions.

Hence, even if a review of CEA satisfactorily addresses the issues of delimitation and standardisation and produce a set of comparable interventions, several challenges to external validity remain. Consequently, systematic reviews of CEAs cannot be used for the assessment of the macroeconomic impact of HIV/AIDS interventions, just as their reliability is problematic when it comes to guiding overall policy prioritisations between different types of interventions.

5 Conclusion

The objective of this study was to present the available methodological options for assessing the macroeconomic impact of HIV/AIDS epidemics and interventions, in order to facilitate a better understanding of the strengths and weaknesses of the different methodologies and existing evidence. Overall, the methodologies used to assess the macroeconomic impact of HIV/AIDS and HIV/AIDS interventions can be grouped into the simulation-based approaches and the statistical approaches.

The review of the simulation-based approaches identified two dominant methodologies: Computable General Equilibrium (CGE) models and applied growth models. While each is associated with different strengths and weaknesses, it was demonstrated that the CGE model methodology has a number of advantages, which are not shared by applied growth models. First, the methodology allows for stabilizing/coping mechanisms including changes in relative prices, re-allocation of workers across multiple production sectors, and changes in international trade patterns. In this way, the CGE model framework captures key natural stabilizing mechanisms, which provide any given economy with the ability to absorb large-scale (HIV/AIDS) shocks. Second, the CGE model framework is specifically designed to measure policy-relevant indicators of interest to evaluation studies, including (1) detailed intervention-specific healthcare costs, (2) detailed analyses of financing options for interventions, and (3) other policy-relevant outcome measures including poverty and welfare indicators.

A weakness of the CGE model approach is that the models – in contrast to the Ramsey and OLG models – do not take account of intertemporal decision-making.[60] Moreover, complexity and data-intensity has traditionally been considered as the main disadvantages of the CGE model methodology. This is, however, changing. It is still true that construction of CGE models (as any economic model) requires specialist knowledge, but data availability is no longer as severe a constraint as earlier. Social Accounting Matrix (SAM) data sets are now available for most (developing) countries, making the CGE model methodology as feasible as other approaches to macroeconomic evaluation of HIV/AIDS.

The critical measurement of mortality- and morbidity-effects – used to measure labour market shocks, which are subsequently used as inputs in the macroeconomic simulation models – has typically relied on epidemiological-demographic population projections. Epidemiological-demographic models have, however, also been refined over the past two decades and more sophisticated models with a focus on treatment and prevention interventions are beginning to emerge. Nevertheless, existing epidemiological-demographic models continue to have important limitations, especially with respect to prevention interventions. No proper macroeconomic assessment of prevention programmes has, so far, been undertaken. Hence, the need for methodological improvements directed at the inclusion of preventive interventions within epidemiological-demographic models, represents a considerable challenge for future macroeconomic assessment studies.

The review of the statistical cross-country approach to macroeconomic evaluation of HIV/AIDS identified two methodologies, including a reduced-form and a structural approach. However, the review also revealed several weaknesses of both approaches. First, data-constraints mean that the approach can only evaluate the macroeconomic impact of HIV/AIDS epidemics. Second, the macro-econometric approach is not well suited to capture the complexity and multidimensional impact of HIV/AIDS. This problem is magnified by a lack of theoretical guidance in choosing the right explanatory variables for the (reduced-form) growth regressions and for the ('structural') intermediate human capital regressions. While data-constraints are likely to become less important – especially with respect to country-specific time series data – the problem of capturing the complexity of HIV/AIDS epidemics (and interventions) are not likely to change over time. In sum, the

[60] The majority of Ramsey and OLG studies are applied to the study of the South African epidemic, while only a single (OLG) study has analysed other Sub-Saharan African epidemics. This is most likely due to data requirements of the sophisticated OLG and Ramsey model methodologies, but may also reflect an underlying sentiment that the fundamental principle of intertemporal decision making (with time horizons of 20+ years) may not be a reasonable representation of economic behaviour in low-income economies fraught with market failure.

statistical cross-country methodology is not currently (and is not likely to become) a feasible alternative tool for macroeconomic evaluation of HIV/AIDS.

Last, a large (and growing) number of cost-effectiveness assessments (CEA) of HIV/AIDS interventions have been undertaken. A number of systematic reviews have demonstrated the diverse nature of CEA evaluation studies, differing with respect to e.g. impact indicator, type of epidemic, type of intervention, socio-economic environment, and population group. Furthermore, CEA studies may be focused on evaluating either single or multiple interventions, and on measuring either marginal or scaled-up effects. Hence, the sheer number of different methodologies makes it very difficult to summarize the results of CEA studies in this area. While the methodology may be appropriate for capturing the financial impact of interventions for specific agents, e.g. health-system units or treated individuals, it is not appropriate for assessing the macroeconomic impact of overall intervention strategies in affected Sub-Saharan African countries. The scale and scope of HIV/AIDS epidemics in this region means that there are significant macroeconomic spill over effects, which cannot possibly be captured by synthesis analyses of CEA studies. Hence, the CEA methodology should not be applied for macroeconomic evaluation of HIV/AIDS.

In sum, the literature on the macroeconomic impact of HIV/AIDS epidemics and HIV/AIDS interventions is a methodologically diverse field, characterized by distinct conceptual and policy evaluation approaches. Although the existing CGE model studies remain deficient in some areas, the basic methodology represents a good starting point for developing a proper macroeconomic evaluation tool for HIV/AIDS epidemics and interventions. Furthermore, a largely untapped potential for model refinement exists in this area. An obvious low-hanging fruit involves improvements to the existing methodology for measuring morbidity-related labour market effects, where new evidence on absenteeism and presenteeism, throughout the different stages of disease progression, can be brought to bear. Another case in point involves the need for developing a new epidemiological-demographic model framework which at the same time accounts for disease progression (based on underlying CD4 counts) and allows for analysing prevention interventions. These methodological advances would go a long way towards providing a proper basis for macroeconomic impact assessment of both treatment and (critically) of prevention interventions. The study also illustrates that current methodologies can provide input to the policy discussion about the most efficient way to fight the disease, and form the basis for better and more systematic future assessments.

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Appendix 2: Tables

Table 1. Macroeconomic studies of the HIV/AIDS epidemic in South Africa[1]

	Methodology	Period	GDP	ΔGDP	GPD per cap	ΔGDP per cap	Other
Haacker (2002)	Solow model (comparative-static analysis)	NA			Closed-economy (0%; ÷4%) Open-economy (÷4%; ÷10%)		
Young (2005)	Solow model	1995-2145			2025 (+10%) 2050 (0%) 2075 (÷9%) 2100 (÷8%)		Consumption per capita (permanent) +5.6% (Fertility effect: +7.3%)
Bell, Devarajan, and Gersbach (2006)	OLG model	1990-2080 (30 year periods)	2050 (÷45%; ÷75%)				
Johansson (2007)	Ramsey model	2000-2055					
Roe and Smith (2008)	Ramsey model	1993-2053	2053 (÷62%)	2053 (÷1.90%)	2053 (÷3%)	2053 (+0.16%)	
Ferreira, Perreira, and Dos Santos (2011)	OLG model (equilibrium analysis)	NA			New equilibrium (÷18%)		
Arndt and Lewis (2000)	CGE model	1997-2010	2010 (÷17%)		2010 (÷8%)		
Arndt and Lewis[2] (2001)	CGE model	1997-2010	2010 (÷20%)		2010 (÷8%)		
Thurlow et al. (2009)	CGE model (Avg. growth rates)	2002-2025		KwaZulu-Natal (÷1.60%) Oth. South Africa (÷1.44%)		KwaZulu-Natal (÷0.51%) Oth. South Africa (÷0.65%)	

Footnotes: [1]The working paper study by Ferreia and Pessoa (2003) was excluded due methodological problems; [2]Arndt and Lewis (2001) provides a sensitivity analysis of the full-employment assumption underlying the CGE model results in Arndt and Lewis (2000). (Similar to methodology in the twin Solow growth model studies by Cuddington (1993b, 1993a)).

Table 2. Macroeconomic studies of HIV/AIDS epidemics in SSA countries excluding South Africa [1]

	Methodology	Country	Period	GDP	ΔGDP	GPD per cap	ΔGDP per cap
Cuddington (1993a)	Solow model	Tanzania	1985-2010	2010 (÷15%; ÷25%)	Avg. ΔGDP (÷0.6%; ÷1.1%)	2010 (0%; ÷11%)	Avg. ΔGDP per cap (0.0%; ÷0.5%)
Cuddington (1993b)	Solow model	Tanzania	1985-2010	2010 (÷11%; ÷28%)	Avg. ΔGDP (÷0.6%; ÷1.2%)	2010 (0%; ÷10%)	Avg. ΔGDP per cap (+0.1%; ÷0.5%)
Cuddington and Hancock (1994)	Solow model	Malawi	1985-2010		Avg. ΔGDP (÷0.2%; ÷1.5%)		Avg. ΔGDP per cap (0%; ÷0.3%)
Robalino, Voetberg, and Picazo (2002)	Solow model (with intertemporal utility maximization)	Kenya	2000-2020	2020 (÷33%; ÷47%);		2020 (÷3%; ÷24%)	
Ventelou et al. (2008)	Endogenous Solow model	Angola, Benin, Cameroon, Central African Republic, Ivory Coast, and Zimbabwe	1985-2010	2010 Angola (÷13%) Benin (÷4%) Cameroon (÷17%) Central African Republic (÷14%) Ivory Coast (÷13%) Zimbabwe (÷26%)			
Ferreira, Pessoa and Dos Santos (2011)	OLG model (equilibrium analysis)	Botswana, Zimbabwe, Lesotho, and Swaziland	NA	New equilibrium Swaziland (÷42%) Botswana (÷33%) Lesotho (÷30%) Zimbabwe (÷29%)			
Arndt (2006)	CGE model	Mozambique	1998-2010	2010 (÷20%)	Avg. ΔGDP (÷1.0%) 2010 (÷4.3%)		
Jefferis et al. (2008)	CGE model	Botswana	2003-2021		2003-2021 (÷1.5%; ÷2.0%)		2003-2021 (÷0.5%; ÷1.0%)

Footnote: [1]The study by Cuesta (2010) was excluded due to methodological problems.

Table 3. Macroeconomic studies of HIV/AIDS treatment intervention programmes[1]

	Methodology	Country	Period	GDP	ΔGDP	GPD per cap	ΔGDP per cap	Other
Young (2005)	Solow model	South Africa	1995-2145					Sustainable ART Expenditures: 10,000 USD/patient
Bell, Devarajan, and Gersbach (2006)	OLG model	South Africa	1990-2080					Intervention cost to maintain steady-state income growth path 1990 (4.5% of GDP) 2020 (3.6% of GDP) 2050 (2.2% of GDP) 2080 (1.2% of GDP)
Johansson (2007)	Ramsey model	South Africa	2000-2055					Government budget savings from treatment programme (10% of 2000 GDP; NPV terms)
Ferreira, Pessoa and Dos Santos (2011)	OLG model (equilibrium analysis)	South Africa	NA			Full treatment (÷6%) No treatment (÷18%)		
Jefferis et al. (2008)	CGE model	Botswana	2003-2021		2003-2021 (+0.4%; +0.8%)			2021 Poverty Headcount (÷1.0%)

Footnote: [1]The studies by Ventelou et al. (2008) and Cuesta (2010) were excluded due to methodological problems.

Table 4. Cross-Country Regression Studies

Authors	Data	Focus and results
Bloom and Mahal (1997)	Sample of 51 countries where HIV prevalence data were available in the early 1990's. Essentially covering a period from 1980-1992.	AIDS prevalence is modelled as a productivity shock entering in an endogenous growth regression alongside variables representing conditional convergence, level of schooling, investment in schooling and population growth. Reverse causality is addressed through the inclusion of additional equation allowing for the possibility of the growth rate in GDP to influence HIV prevalence. Bloom and Mahal find little support for the argument that AIDS slows the growth rate of income per capita.
Bonnel (2000)	Panel of 80 LDCs during the 1990-1997 period	System of three equations. HIV/AIDS is assumed to reduce per capita growth rate through a reduction in labour and capital, and HIV/AIDS is also assumed to cause a downward shift in productivity through the erosion of institutional capacity and capability. Bonnel finds a significant effect of HIV prevalence squared on education, domestic savings and growth rate in GDP per capita (under some specifications)
Dixon, McDonald and Roberts (2001)	Panel of 41 SSA countries over the period 1960 to 1998.	System of two equations. The first estimates the effect of HIV prevalence upon Life expectancy, which subsequently enters a calibrated Solow model (growth regression assessing the macroeconomic impact of physical and human capital on per capita growth). Dixon et al. find no significant effect for the full sample but evidence of considerable parameter heterogeneity.
McDonald and Roberts (2005)	Panel of 112 countries over the period from 1960 to 1998.	System of two dynamic equations. One estimates the macroeconomic impact of HIV/AIDS and Malaria on "Health Capital", which is proxied by life expectancy at birth and infant mortality. Health capital also enters into a structural growth equation based on the augmented (taking account of both the quantity and quality of labour) Solow model. McDonald and Roberts find significant negative growth effects of HIV/AIDS through the infant mortality proxy for health capital. The robustness analysis, however, also indicate substantial differences across regions.
Tandon (2005)	Panel of 94 LDCs over the period from 1960 to 1998.	System of two equations. An aggregate production function (based on an augmented Solow model) and a health production function, where health capital is proxied by life expectancy at birth. Focusing on the Asian developing countries, Tandon finds a significant negative global effect of HIV/AIDS prevalence on Life Expectancy and a negative, but insignificant effect in Asia.

Table 4. Cross-Country Regression Studies

Authors	Data	Focus and results
Papageorgiou and Stoytcheva (2008)	Panel of 89 countries over a 15 year period from 1986 to 2000. In addition, AIDS cases per country can be grouped according to age (four groups)	AIDS prevalence is modelled as a productivity shock in an augmented Solow model. The potential endogeneity of HIV/AIDS prevalence is addressed through an IV specification, using lagged AIDS prevalence as instrumental variable. Papageorgiu and Stoytcheva find a negative and significant effect of AIDS for SSA but not for other regions. Using the age-disaggregated data a significant negative effect is found only for the 16-34 years age-group. Overall, the analysis indicates that the negative impact of AIDS on per capita income is very small.

Table 5. Systematic reviews of cost-effectiveness analyses of HIV/AIDS interventions

Study	Scope	Number of studies	Type of studies
Creese et al. (2002)	Systematic review of cost-effectiveness of preventive and treatment interventions in Africa.	24 studies published from 1988-2000.	Majority of studies were cost effectiveness analyses published in peer-reviewed journals.
Walker (2003)	Systematic review of cost-effectiveness of preventive interventions in low and middle income countries	38 studies published from 1984-2001	Many of the reviewed studies were project reports, perhaps explaining a general lack of methodological rigour and information on costs. Two of the 38 studies were RCTs.
Ross (2010)	Survey of effectiveness of behaviour change preventive interventions in both developing and developed countries.	9 studies published from 2003-2010	All nine studies are RCTs. However, given differences in study setting and design a meta-analysis was deemed inappropriate. Instead, an overview of results is provided
Galarraga et al. (2010)	Systematic review of cost-effectiveness of preventive interventions in low and middle income countries	21 studies published from 2005-2008	Cost-effectiveness analyses published in peer reviewed journals.

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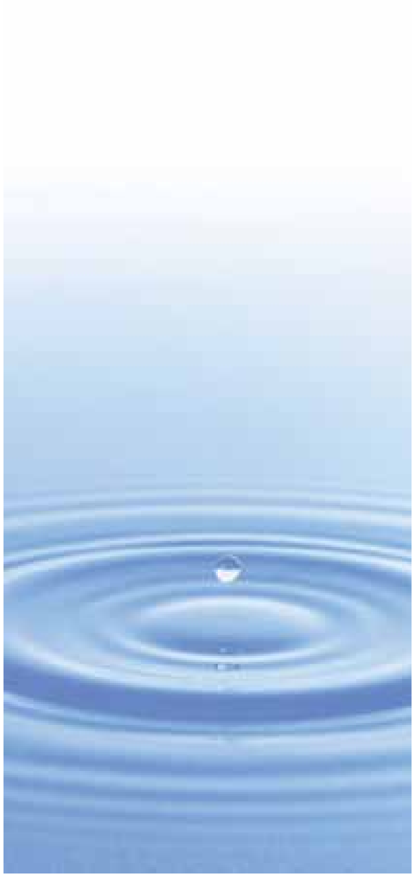

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