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Graduate School of Public and Development Management

University of Witwatersrand, Johannesburg

Master's of Management in Public and Development Management

IMPACT OF HIV/AIDS ON ECONOMIC GROWTH IN RWANDA

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A research report submitted to the faculty of Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Management (in the field of Public and Development Management).

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ABSTRACT

Impact assessment is widely used in the field of socio-economic development. Socio-economic impact of HIV/AIDS has taken on similar cross-cutting studies mostly in poverty, gender and environment disciplines by applying various quantitative techniques tools including econometric modelling.

An extensive literature review was carried out and reveals, in many cases, a strong socio-economic impact of HIV/AIDS on the economic output in the long run.

Drawing on existing methodologies, two models are developed: Spectrum Policy modeler has been applied to determine the HIV/AIDS epidemiologic impact. An econometric model that integrates the determinants variables of the HIV/AIDS Epidemiology and the Gross Domestic Product (GDP) and simulates different scenarios which represent a variety of HIV/AIDS levels corresponding to hypothesised behaviours.

This econometric model demonstrates a limited impact of HIV/AIDS on GDP in the context of extended use of antiretroviral therapy combined with a strong preventive policy which would likely curb the HIV in short term to mid-term.

It also highlights the impact of other essential determinant factors on GDP, which are included in the model that decision-makers should act upon in order to stimulate the economic growth.

DECLARATION

I, Michel Kabalisa, declare that this research report is my own unaided work. It is submitted in partial fulfilment of the requirements of the degree of Master of Management (in the field of Public and Development Management) in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

_____

Michel Kabalisa

_____day of _____, _____

DEDICATION

This work is dedicated to my wife Beata Busasa for her encouragement, patience and support, my father for his inspiration and the tone he set for me.

ACKNOWLEDGEMENTS

I acknowledge and thank my supervisor Mr David Solomon, for his guidance, insightful ideas, encouragement and confidence; Dr Carola Gruen / School of Economic & Business Sciences, for her comments and critical review in the preparation of this dissertation.

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The Econometric Analysis were performed using MICROFIT 4.0 for WINDOWS
Interactive Econometric Analysis by Prof M. Hashem Pesaran and Dr Bahram Pesaran
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CHAPTER 1. INTRODUCTION

This research intends to assess the socio-economic impact of HIV/AIDS on the gross domestic product (GDP) in Rwanda from 1980 to 2015 and the implications on the development perspective in that time span.

The first chapter is an overview of the research methodology designing. It essentially defines the problem, explains the importance of the subject, key questions to investigate, boundaries and some background (facts and figures) in the context of socio-political unrest.

In Chapter 2, the literature review relates economic growth factors to HIV/AIDS in a socio-economic perspective. Comparing various arguments or descriptive materials helps to come to grip with a clear understanding of the interaction between economic output and HIV in various countries and specifically in Rwanda.

Chapter three illustrates two theoretical sub-methodologies (epidemiologic and econometric) and subsequent assumptions frameworks. The epidemiologic impact of HIV/AIDS depicts the population and HIV/AIDS determinant interrelations. The subsequent econometric modeling describes the relationships between HIV/AIDS, demographic, and socio-economic factors in a interdependent way.

Lastly, for a purpose of clarity in the text, most of the projections are presented separately in appendices. but in sequence according to the chapters structure. Their numbering begins with the same number of the chapter they belong to.

1.1 Problem statement

Adult mortality and the relative high morbidity induced by HIV/AIDS systematically erode the accumulation of human capital. The lost accumulation of wealth and knowledge in terms of lost productivity and potentialities due to HIV/AIDS are not directly measurable. However, the

HIV/AIDS impact on some essential macroeconomic variables can be measured over time with reasonable accuracy.

Until recently some studies did not integrate HIV/AIDS as an endogenous factor to human development in many studies. It was an added-on like poverty and macroeconomics in the Word Bank and International Monetary Fund (IMF) policy models (Dubey, 2004). This has had as a consequence the underestimation of its impact, more particularly in countries with a high HIV prevalence rate.

By using the vicious circles theory, it is also hypothesised the endogenous theory (Vector Retrogression modeling (VAR) or by the Autoregressive Distributed Lag estimation (ARLD)) has an added value in assessing the HIV impact on the GDP more than the neo- classical modeling.

1.2 Purpose of Study

The purpose of this study is to systematically provide measurements of HIV/AIDS effects on the national human capital and subsequently on the GDP over time (1980 to 2015) as well as in capturing other major factors which are involved in the GDP formation.

Two models will be used: an epidemiologic model to simulate various scenarios of HIV impact in regard to the population characteristic trends. Its results will feed into the econometric model to construct. The main human capital variables are then considered in that econometric model as essential explanatory factors of HIV and AIDS impact.

The overall impact of HIV/AIDS on the human capital and the GDP will appear as the residual effects between scenarios with HIV/AIDS and without HIV/AIDS in both the epidemiological model and the per capita real GDP model, say, as a time series systematic error over time.

The scenario “without HIV” presents the population as if it did not experience the HIV.

The other 3 scenarios "with HIV" have the population infected with HIV. All scenarios are truncated by the war and genocide. In this case, HIV/AIDS portrays 3 possibilities: high, low and intermediary scenarios of HIV prevalence respectively, 11.5%, 6.9 % and 9.1% in 2015.

1.3 Significance of the Study

UNDP in Rwanda is formulating its second Common Country Assessment (CCA) and subsequently the United Nations Development Assistance Framework (UNDAF) will be formulated. The government is reformulating the second PRSP. These strategic planning tools can benefit from the results of this study in many respects.

Moreover, the HIV/AIDS multisectoral strategy itself needs, for the policy implementation, advocacy and awareness purposes, to know the real impact of HIV/AIDS on GDP and other indicators. This study is specifically concerned with the impact assessment, which can also provide milestones against which progress in various policies/programmes implementation, would be measured and would give feedback to both prevention and mitigation decision processes.

Also, with regard to the Millennium Development Goals (MDGs) the HIV/AIDS impact would undoubtedly delay the timely achievement of many objectives. This study will provide useful information for MDGs monitoring and evaluation in relation to with HIV/AIDS.

This study will also contribute, even though indirectly, to understanding the tragic consequences of the wars and genocide. How many people - approximately - lost their lives due to a man-made disaster? It brings incontestable historical facts to support its authenticity and credibility.

1.4 Research Questions and Structure

A- Questions

Given certain assumptions on population determinants in Rwandan socio-economic and political context with regard to the HIV prevalence trend, what is the impact of the HIV/AIDS through various channels (or mechanisms) of transmission on the human capital up to (2015)?

The main question is "WHAT IS THE EFFECT OF HIV/AIDS ON GROSS DOMESTIC PRODUCT …"?

The impact of HIV/AIDS on the GDP is via the population variable. Subsequent questions describe the interaction between the population and HIV/AIDS.

A What is the epidemiological impact of HIV/AIDS on the population (with and without war and genocide)?

A1- What is the HIV/AIDS impact on the adult population in respect to its various characteristics? (Gender, age, residence, occupation (labour force).

A2- What is the HIV/AIDS impact on the young population with respect to its various characteristics? (Gender, age)

A3- The new population structure and trend as a consequence of HIV/AIDS and GENOCIDE

A4- What would be the size of Labor force (with and without HIV/AIDS, war and genocide)?

B The socio-health impact of HIV/AIDS

B1 - What is the loss of the human capital to HIV/AIDS in the national economy in terms of life expectancy at birth?

B2 – What is the impact of Tuberculosis and malaria due to HIV/AIDS?

B3- Adult population DEATHS due to AIDS

B4- Family pattern developments mainly due to HIV/AIDS and socio-political unrest in Rwanda

i - Orphanage/minor- headed households
ii - Women-headed Households

B5- The effects of HIV/AIDS on the education sector

C Socio-Economic impact HIV/AIDS

C1 Estimation and Forecasting: How has the GDP been / will evolve under certain hypothesis of the HIV/AIDS prevalence rate trends to be specified (sensitivity analysis)?

Definitions

Gross Domestic Product – (measure of the United States economy adopted in 1991); the total market values of goods and services produced by workers and capital within the United States borders during a given period (usually 1 year).

The GDP comprises three sectors: the agriculture sector, the industry sector and the services sector.

The economic growth, the GDP growth and the economic output will be used interchangeably. The GDP growth is measured by the annual variation in nominal (i.e. at market prices) or real (deflated: outstripped of the inflation) if divided by the General Price Level trend as measured by the General Price Index.

The GDP per capita equates the GDP divided by the national population.

1.5. Delimitations and limitations

What the study will not work out:

The use of Proxies is an acceptable alternative when they can describe fairly the situation as also Sala-i-Martin acknowledges (1991). Given the limited scope of the study and many variables involved in the GDP formation, only key variables will be considered. Also the human capital variables participating to the GDP formation will be systematically reviewed.

From the questions structure, a descriptive and deductive methodology will be more appropriate in many situations. However, interpretive factors where more convincing will be discussed and highlighted.

Similarly, the African dummy will not be fully analysed even though very pertinent to Rwanda. This is beyond the scope of this work. Effects of the Genocide and wars are simply acknowledged as facts.

A historical simulation will fit the outputs of each model up to 2003 and thus, thereafter, it will be used to ex ante forecast for the rest of the time so that we have a time series of 35 years

from 1980. The study covers the whole country and within that lifespan of 35 years from 1980. There 4scenarios which correspond to 4hypothesis of HIV trend: In the scenario1, the HIV rate will be 6.9% in 2015, scenario2, the rate will be 11.5 % in 2015, the scenario 3 the rate is set to 9.1% in 2015 and the last scenario the context is free of HIV (no HIV).

In all cases, the context is of the anti-retroviral therapy intervention from 1999 through 2015 where it is 90% but fast from 2005. The model assumes sex work driven heterosexual epidemics of HIV-1.

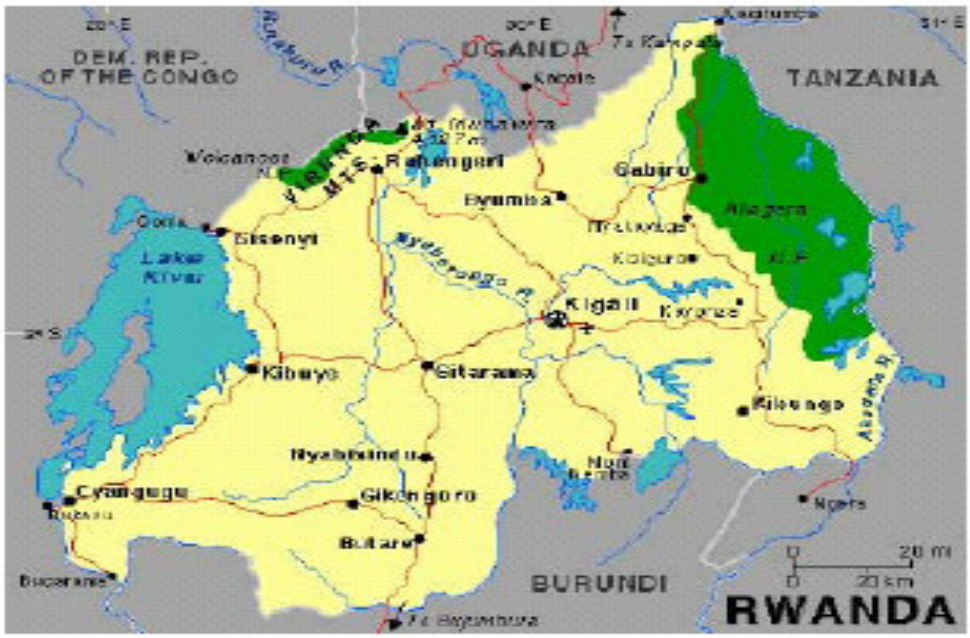
The study does not intend to suggest strategies (what to do, how to do it, and why?) to overcome the socio-economic impact of HIV/AIDS unless incidentally and not systematically. Although the study vastly uses the quantitative methods, critical analysis or some inductive insights will also be provided to interpret facts, trends and the like because HIV/AIDS is essentially embedded in social and behavioural sciences.

The choice of HIV-prevalence time series in various and conflicting data entails some shortcomings. Only UNAIDS and the government latest information option will be used as a reference. This does not preclude the fact that there could be a higher prevalence rate before the war and 1994 genocide which abruptly dropped with mass killings and selected targets.

1.6 Background

Figure1 : Map of Rwanda

Map of Rwanda



Source: Herman Musahara, (2004), Ph.D Dissertation, University of Western Cape.

Rwanda has a size of 26,634 square km. It is landlocked between Burundi, Democratic Republic of Congo, Tanzania and Uganda. The 2002 General Population and Housing Census recorded 8,126 millions inhabitants in August 2002. The Government projections made well before the war and 1994 genocide estimated the size of the population to be 11,219,440 inhabitants as of August 2002.

Gross enrolment in primary schools increased by 63% and reached 105.8% for males and 102.3% for females from 1994/95 to 2001/2002.

In secondary schools, the number of students has more than tripled from 50,100 students to 157,210. In 2001 household survey (EICV)[1], the net enrolment in secondary schools was as low as 7% whereas it was as high as 72.6% in the primary.

At the tertiary level, only 1284 students were in university education in 1981 (inside the country and abroad), the number jumped from 3518 students in 1994/95 to 15,353 students in 2001/2002 (not including students abroad)[2].

[1]Ministry of Economic Planning and Finances (2001) Enquête intégrale de conditions de vie des ménages au Rwanda, Kigali i.e Household Survey on the cost of living.

To contextualize the study, the agriculture sector contributes to about 43 % of the Rwandese GDP and employs about 85% of the active population. The industry represents 21% and the services 36%. Land scarcity is acute: the average of arable land per capita is 0.76ha and 12% of the households while living in rural areas do not have land. 29 % of households have less than 0.20h/household. Gini coefficient was 0.451 in 2001. The GDP (PPP) per capita was USD 950 in 2002.

From 1980 to 2003, the country experienced two sharply different socio-political situations: From 1980 to 1990, the situation was relatively calm but engaged in the Structural Adjustment Programmes (SAPs) period, and later on it was under the Enhanced Structural Adjusted Facility.

From 1990 to 2003 the period was of high tension, wars and genocide in 1994, flows of refugees (old case refugees coming in) and (new refugees fleeing) with a marked international forced emigration.
That decade was characterized by persistent political violence, which resulted in a loss of more than one million of people, and in the destruction of wealth.

There have been controversial HIV seroprevalence assessments. According to Aisnworth and Over (in Allen *et al*., 1987) and Aisnworth and Over (1993:206) using the US Census Bureau data, the estimations of the HIV –positive rate in rural area were about 10% in 1993, and around 33%[3] in urban areas putting Rwanda among the highest infected countries at that time.

In 1997, the National Programme for fighting against HIV/AIDS (*Programme National de Lutte contre le Sida (PNLS)* estimated the rate was 10.8% in rural areas and 11.7%[4] in urban areas, but quickly controversial. UNICEF Rwanda country profile recorded 8.9 % of the adult population as HIV-positive.

---

[2]Ministry of Education, Scientific Research and Technology Project Report: *ASER Planning of 12/02/2002*.

[3]World Bank (1994) Research Observer Volume 9, Number 2 July 1994 page 206.
[4] Progamme National de Lutte contre le Sida (1997), Rapport d'étude de séroprévalence au Rwanda, Novembre 1997.

In 2002, the National AIDS Commission and the Research and Treatment Center (TRAC) carried out a new survey which led to lower estimated rates.

I quote[5]:

> *"The key results of the survey in 2002 were the following: The rates of sero-prevalence varied from 1.2% at a rural site in Butare province to 13% at two sites in Kigali…. The median rate in urban zones was 6.9%, while the median rate in rural zones was 3.0%."*

Many sources do have conflicting data. This question is also beyond this study. For example: 1999 National Human Development Report stated the following: "

> *It is almost striking to note that surveys conducted before 1994 found that the prevalence rate was only 1.1 percent in rural areas, and some 27 percent in urban areas. After the war, another survey was conducted which found that the prevalence rates had gone up in rural areas to between 10 and 11 percent.".*

We should bear in mind that the rural areas should be weighted not only by its population proportion but also by its interaction with urban areas (frequency and proportion of the population in movement). This can sharply differentiate various zones in some areas very close to urban areas even though far from key cities and other which are insulated.

Table 1: Rwanda HIV and AIDS estimates, end 2003

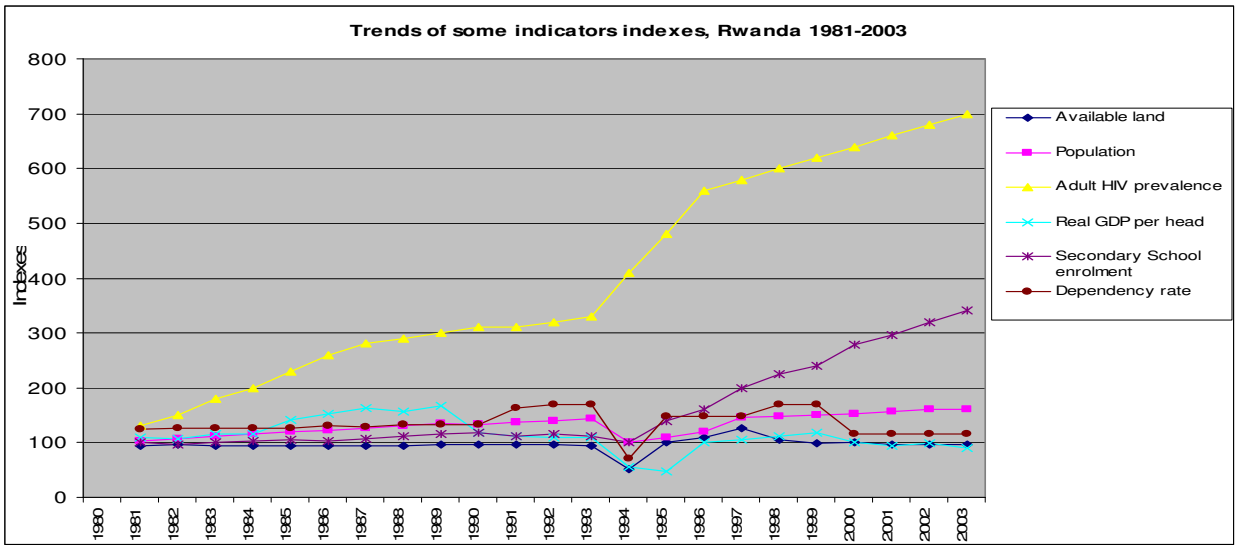
Adult (15-49) HIV prevalence rate	5.1% (range: 3.4%-7.6%)
Adults (15-49) living with HIV	230 000 (range: 150 000-350 000)
Adults and children (0-49) living with HIV	250 000 (range: 170 000-380 000)
Women (15-49) living with HIV	130 000 (range: 86 000-200 000)
AIDS deaths (adults and children) in 2003	22 000 (range: 14 000-36 000)

Source: 2004 Report of the global AIDS epidemic, UNDAIDS, Geneva.

Since these data have been communicated by the government in the absence of other more proving sources and other data I shall use these estimates and interpolate for the previous period.

[5] TRAC publication on : : http://www.tracrwanda.org.rw/
http://www.santetropicale.com/rwanda/web.htm

Figure2: Trends of some indicators indexes, Rwanda 1981-2003



Source: drawn based on my calculations from various sources: http://www.minecofin.ac.rw/statistics, http://www.unfp.org /countryprofil.html, http://www.bnr.ac.rw/statistics, http://www.mineduc.gov.rw/statistics; http://www.unaids.org/wad2004/report.html

Sachs *et al* (2004) enumerates main reasons which maintain Africa in abject poverty trap: very high transport costs and small markets, low productivity agriculture, a very high disease burden, adverse geopolitics, very slow diffusion of technology from abroad. All these obstacles are even more concentrated in Rwanda.

CHAPTER 2: LITERATURE REVIEW

International experience:

Numerous researchers have produced various evidences of HIV/AIDS effects on the economic growth that can be, in many cases, distributed along leading economic thoughts schools thereby reflecting their political economic ideologies stances. Some of these schools are formally summarised in the methodology.

From early 1990s, institutions (World Bank, United Nations, … governments (USA, Ivory Coast,…) and scholars started using the economic approach to understand and measure the socio-economic impact of HIV/AIDS via the impact on Gross Domestic Product (GDP) trend. There have been divergent results as a sample of studies shows below.

Kambou, Devarajan and Over (1993), Cuddington (1993) and Cuddington, Hancock and Rogers (1994) using the General Computable Equilibrium (CGE) found a very limited impact of HIV/AIDS on GDP.

Barro and Sala-i-Martin (1995) used life expectancy at the aggregate level, but not clearly as to whether it represents the health factor or a specific HIV/AIDS factor but rather a social determinant resulting in many other factors at macro level. He reported in overall a huge detrimental effect of the life experience on the GDP.

Arndt C. (2002) found in Mozambique case, that economy will be between 14% and 20% smaller in 2010 due to HIV/AIDS effects.

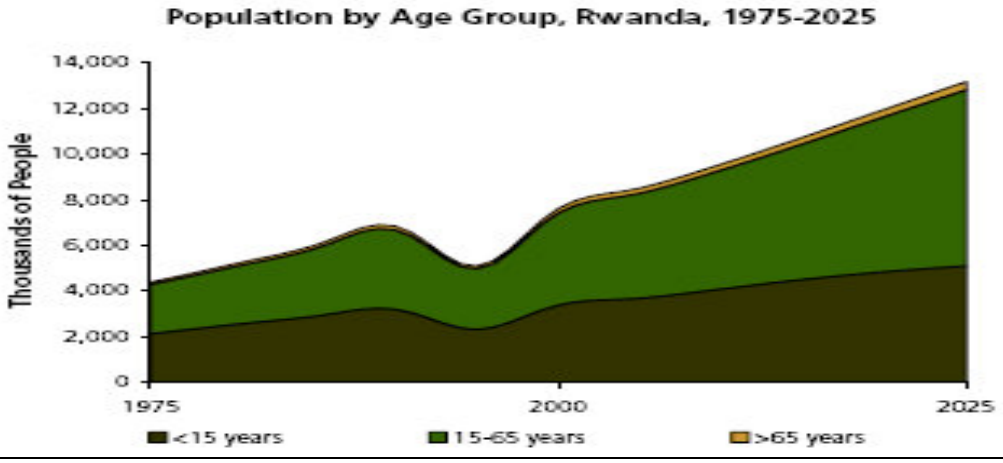
Yang Xie (2003) did not find a significant effect of HIV/AIDS on per capita GDP growth rate in a global (130 countries sample) and regional (43 African countries sample) study.

Masha (2003:304), estimating the HIV/Aids impact in Botswana in 3 scenarios of no-HIV, AIDS without intervention, and AIDS with intervention, found that by 2015, the GDP would be growing at a rate of 4.9% a year under the no-HIV scenario, or at a rate 4.1% under the scenario of with-HIV but with ARV intervention or would grow at the rate of 2.9% if there is no

intervention in the context of HIV. This underscores the impact of ARV when the HIV/AIDS is generalised.

2.1 Socio-Demographic variables and HIV/AIDS

Figure 3: Population Age Group in Rwanda,1975-2025



source: http://earthtrends.wri.org/pdf_library/country_profiles/

The population growth rate trend is exponential until in 2025. In the 1990s the war and 1994 genocide cut an unknown number of population estimated to closely one million (according to the Government of Rwanda: 934,000). The characteristics of the population in the context of generalised HIV/AIDS arise as a constraining factor due to the negative imbalances they carry in the whole economy. In spite of these heavy losses, the population growth rate is still alarming (2.2%-2.7%) per annum (doubling population time is about 25 years).

Early marriages might be one of the strategies to alter the exposure to risk of infection. All in all, infected and affected families will see their fertility declining due to the increasing mortality, morbidity by AIDS and poverty thereby offsetting the relative increase of fertility (Futures Groups, 2001). However, a sudden and short baby boom was expected after this aftermath.

Moreover rural uneducated families have many children per women. A high birth rate has been a common a strategy for mitigating the effects of high mortality, even before the HIV/AIDS pandemic. Theoretically, families may respond with an acceleration of births in the context of HIV/AIDS in the expectation of increasing a higher rate of survival.

A high mortality will jeopardise the productive factor -the labour force- which is a key factor on the GDP formation. The labour force is either skilled or unskilled depending essentially on the quality and level of education, training and experience.

A Unskilled labour and HIV/AIDS

To contextualize the study, the largest part of the unskilled labor is occupied in agriculture which contributes to about 42% of the GDP of Rwanda. This sector employs about 85 % of the active population whose majority is unskilled (in 2003). The agricultural activity is not a choice as such for many farmers, but is the only activity they can do for survival reasons because of their lack of skills. On top of that, land is so scarce in Rwanda that 29% of households have less than 0.2hectare. The poorest people are likely to be landless while living in rural areas.

In the context of overpopulation and a largely agricultural subsistence economy, the scarcity of "human capital: (educated workers) places many impediments on the growth of the economy. There is heavy pressure on the supply of land not in its distribution pattern but its relative scarcity in the context of the high fertility rate (5.3 children per woman).

Furthermore, there is also a portion of urban unskilled population. Urban and rural unskilled labour has the lowest level of education and less experience in sophisticated urban activities. As uneducated population, it is characterized by early marriages, high fertility (high number of children per women) and it is also in the lowest income strata living precariously in urban areas or rural areas. Those who do not access secondary schools mostly fall again in illiteracy and become unskilled, especially in rural areas.

Using the Lewis Model of development, theorists argue that the replacement of the unskilled labourers who die of AIDS has no opportunity cost, since the deficit is replaced from immense unemployed pool of labour. From that perspective, apart from the loss of human life, there is a positive economic impact, a net gain with the diminishing cost of that inactive and costly unemployed population. The Lewis model provides a relative good description of the dual economy predominant in Rwanda and in many other poor countries. Specifically, this model could indeed explain some obstacles of the rural economy without land. The opportunity cost

of leaving the agriculture for a portion of the rural population (e.g. the landless) will tend inevitably to become negligible in the long run.

Lewis formulated it as follows:

> *" the underdeveloped economy consists of two sectors : (1) a traditional, overpopulated rural subsistence sector characterized by zero marginal labor productivity- …/… it can be withdrawn from agricultural sector without any loss of output- and (2) a high –productivity modern urban industrial sector into which labor from subsistence sector is gradually transferred " (in Todaro, 1994:74)*[6] .

Formally it is known in this way: the output function in modern economy is as follows:
Total Product (modern economy) = F (Labour (modern economy), (knowledge), capital (fixed) t (fixed)), $\partial F/\partial L>0$, $\partial F/\partial K>0$
Total Product (Food) = F (Labour (agriculture), (knowledge), capital (fixed), time (fixed)),

However, the problem is somewhat different; their contribution value is not meaningless or negatives either:

- First, some of farmers have accumulated a wealth of indigenous knowledge through experimentation and borrowing ideas but do not have land;
- Second, the demand for labour is very variable throughout the year. In the high season, the pool of unemployed farm workers provide a much needed additional manpower to catch up with the rainy season;
- Third, there are almost no alternatives. Families with HIV/AIDS patients or who have experienced deaths of adults have less capacity to hire labour. The demand of labor is yearly very cyclical. They can be used on different tasks for which they might be not replaceable.

Households affected by death, especially prime-age death, or prime-age chronic illness (like HIV/AIDS persistent opportunistic diseases) are different from other families, they end up in various economic traps. Also the urban unskilled population was found highly infected with HIV (13% in 2002) and with a relatively high Sexually Transmitted Diseases infection rate

[6] Todaro P.M. (1994) Economic Development Fifth Edition, Longman, New York University.

(Biryogo Health Center, 1996), (Gikondo, 1996) (PNLS, 1998), and (US Census Bureau, 2000). This population is also found in urban poverty pockets. Unskilled workforce constitutes the majority of the active population.

DasGupta, *et al* (1999) use the Vicious Circle Theory to explain situations of deep poverty trap for generations with the high pressure of the population growth on natural resources and subsequent agriculture productivity decline. In order to compensate this decline of productivity, families have to increase the labour volume while the latter is hindered by the rural HIV/AIDS progression in the most active population portion.

Ghana Ministry of Health Report (2001) estimated the number of workdays lost to illness for a person with HIV/AIDS from as few as 30 to as many as 240 days in a year. Even healthy workers may need more time off from work to attend funerals of relatives and co-workers.

The unemployment of the pyramidal populations combined with new threats of HIV/AIDS exacerbate the spiral of the vicious circle of unemployment- enclavity --poverty-diseases (malaria/HIV/AIDS opportunistic diseases)-mortality- high fertility but declining- low economic growth and environment degradation. These combinations become a trap which is persistently self reinforcing. HIV leads to poverty which very likely also leads to HIV/AIDS and vice versa particularly if there is no treatment.

Furthermore, Boserup's predictions of increasing productivity in the context of land scarcity still prove difficult or wrong at least in Africa.

The Rwandan population-natural resources perspective makes the migration to cities very attractive. The young population has more motivation to migrate to towns than the elderly and represents no less than 45% of the entire population, even though the risk of being trapped into urban poverty is so high. If the HIV pandemic is not curved, the rural area will be more exposed because of their lack of access to prevention services, their low level of education, and the very low income. PNLS (1997) found that the males' education was negatively correlated with HIV prevalence which means that very likely the urban unskilled people are more vulnerable than the skilled population.

In the framework of UN Millennium Development Goals (MDGs), Sachs *et al* (2004) propose a big push to get rid of this poverty trap with a strong international support to poorest countries like Rwanda. His argument is in spite of strong commitment many poor countries do not get out of abject poverty; their progress does not sustain or they are simply embroiled in various endemic problems (governance capacity, poverty, malaria and HIV/AIDS,…).

However, even to reach these MDGs themselves is far from enough. The push should be maintained by a strong GDP growth and its fair distribution among the population.
It could be too optimistic to believe that it will be managed in, say, less than one generation time because of the proportion in some categories of population who would necessarily rely only on a permanent public assistance. The HIV/AIDS infected and affected people would be disproportionately in this marginal category.

B Skilled labour.

Skilled labour is an active population relatively educated and/or trained. People who have been, at least, in secondary schools for some years, and have gained a certain experience and operate in formal settings with a reasonable or high productivity. They mainly reside in urban areas. They contribute approximately to 52 % of the GDP while they only represent around less than 15 % (2003). This GDP does not include here the volume of informal economy (non waged households activities especially family caring, non recorded dealers,…).

Skilled labour is the backbone of the human capital formation. Human capital investment accrues with the quality of education, time (experience) and effort (fitness and willingness) and very likely starts decreasing after having reached the optimum because of physiological factors (ageing). It thus becomes more productive with more education and experience. Davenport (1999) analyses people not as factors of production, but rather as investors in business, paying in human capital and expecting a return on their investment which falls into 4 main categories:

- Financial rewards (salary, retirement plans, health and welfare benefits,…);
- Growth opportunities (advancement, addition to human capital in terms of education and formal training and informal learning, leadership opportunities,…);

- Intrinsic fulfillment (creativity, social relations, variety, values gratification, challenges,…);
- Recognition (professional, public and community recognition, appreciation, awards,..).

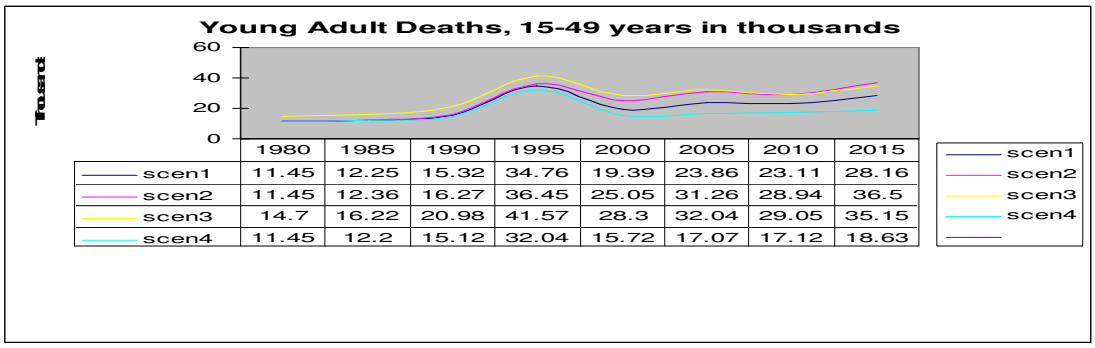
The human capital is pervasively affected by HIV/AIDS. The major source of economic slowdown due to HIV/AIDS stems from the declining productivity, reduced population growth and the lost human capital accumulation and subsequent reduced physical capital but with a degree of uncertainty in combination of these factors.

Allen and others (1991) and Ainsworth and Over (1993) had found in a national survey carried out in 1987, a strong positive correlation between the socioeconomic status of male partners (income, education, occupation) and the women HIV positive rate. In other words, women partnering/dating with men ranked as having high socio-economic status tend to be found in the category of the highest HIV positive rate group. Both men and women are also more likely to belong to the same socio-economic status by alliances, income strata, education level, residence,…

As PNLS (1997) found that the males' education was negatively correlated with the HIV prevalence, this entails a behaviour change among educated males even though still limited. The educated people in Rwanda are relatively young and still active. Their prime age death causes a great loss to the entire society.

There are two types of cost for such loss: direct cost which is the direct output cost from the farmer's loss of work and the loss to society members who relied on this income and by the knowledge and skills s/he could not pass on to the future generation and this memory lost is costly to society (Cohen, 2002).

Table no2: **Adult population DEATHS due to AIDS**



Source: Based on results from the Epidemiologic Modeling (Spectrum)

Every curve describes a scenario. In scenario1 (HIV positive rate =6.09%) there will be a loss of 28,160 of young deaths whereas in noHIV scenario (scenario4), only 18,630 young deaths will occur. The difference is due to the deaths related to AIDS which amount to 9,520 annual young deaths.

At national level, the implications of such loss could be limited in terms of number of deaths, but not necessarily in their various and distinctive contributions as potentially most productive group (if young and more skilled labour for instance).

Scenario1 and scenarios 4 can be described by the following equation: scen1= -0.4504 X^2 + 6.2142X + 4.5579 and Scen4 (No HIV) = -0.8181 X^2 + 8.429X represent respectively annual young adult deaths in the category of 15-49 years old. Scenario1 depicts the HIV trend reaching the rate of 6.09% by 2015 whereas scenario4 is the NO HIV scenario. These curves are concave since the coefficients of X^2 are respectively negative (-0.4504) and (-0.8181). It means the number of HIV deaths decrease over time in the scenario1. This result is in the strong hypothesis of antiretroviral therapy included in this epidemiological perspective. This hypothesis corresponds to political and international mobilization through the global fund for TBC, malaria and HIV/AIDS and other various grants in that field, which have made possible the antiretroviral therapy through free access policy.

If HIV infection continues to rise and reaches 9.1% by 2015, the HIV deaths would total 35,150. The deaths would reach 35,150 young deaths if the HIV infections continue to rise and reach 9.1% by 2015.

Furthermore, the HIV positive rate before the 1994 aftermath was not too high to adversely and early impact on the GDP. In 1994 genocide, war and hard conditions in refugees and internal displaced camps, a significant proportion of HIV infected people died, and consequently accounted for other deaths causes, thereby, limiting the future HIV impact.

2.2 The socio-health factors with HIV/AIDS

Socio-health factors such as poverty diseases are one of the most important causal factors in the demographic transition from a pattern of, high fertility, high mortality and low economic growth, to the pattern of low fertility, low mortality, and high economic growth.
HIV/AIDS consequences of increasing the mortality trend (when unexpected) with the risks of outweighing the advantage of controlling the fertility can reverse the demographic transition.

As the infant mortality and fertility rates decline, if there are better socio health factors, the average age of the population tends to rise, thereby, increasing the active population proportion in the entire population. These demographic changes by lowering the dependency rate overall boost per capita GNP, savings rates, and thus the economic growth. Socio-health services and products improvement also tend to limit the HIV spread (example: extended use of condom decreases the fertility. Small families member tend to get higher income compared to large families ones and may be more healthy to delay the transition from HIV to AIDS and to the exit stage (death).

The active population mortality and morbidity due to HIV/AIDS can be controlled through the socio-health factors such as strong Sexually Transmission Diseases (STIs), universal antiretroviral approach, generalised Mother –to –Child-Transmission (MTCT) coupled with non breastfeeding more than other groups, better access to the health services and products,…

The Commission for Macro-economics and Health has estimated to 2.2 million Africans who died of AIDS in 1999 costed to the continent 'an astounding 35.1% of GNP.'[7] This estimation is likely the result of pessimistic scenario but can reasonably apply to certain limited geographical areas.

Only about 24 % of the population can expect to consult a doctor while 18% will likely consult a traditional healer; 76 % of the cases do not get access to health services because of the cost recovery which is too high for them, while 40% live far away from the health centers (PRSP Review, June 2003). This situation gives room to HIV spread especially the vertical transmission (from mother to child). Also the transition from HIV to AIDS is shortened by lack of treatment of opportunistic diseases. It results in a high mortality which leads to low life expectancy.

Also the World Bank (WB) (2000) and International Monetary Fund (IMF) (2003) illustrate how the improvements in health conditions lead to higher productivity and enhance the ability of workers to increase their income. However, they still recommend the commodification of the same services in the context of provision of basics needs (amenities), primary health services and the preference to generics in many cases.

The Programme of Mother-Transmission-to-Children (PMTCT) is constrained by delivery at home. Only 26.5% of pregnant women deliver in a health institution in 2001 because of the relative high cost recovering for poor services quality, and the distance (88 per cent of women have to walk for more than one hour to reach a health facility).

The early HIV-positive trend was imbalanced male-dominated but as time went on, women have become more infected. According to the US Census Bureau (2000), 20-29 years old age group of pregnant women had a HIV positive rate of 18% as of 1996. The same sources conceded that pregnant women HIV positive trend in Kigali has very likely reached a plateau while in rural areas it is still increasing.

[7] Jeffrey Sachs and others, 'Macroeconomics and Health: Investing in Health for Economic Development,' Report of the Commission on Macroeconomics and Health to the Director-General of the World Health Organization, 20 December 2001.

UNDP and CNLS (2004:33) in a behavioural study enumerate many risky social cultural practices, among them, *gukuna*[8], but do not mention non-circumcision. Rwanda is part of the East African community which does not practice the circumcision. Only urban areas have started practicing it due to the Muslim community influence. Very few male adults are circumcised, rural and urban alike.

Barnett and Whiteside (1998) discussed whether circumcision could not limit HIV susceptibility. Avert, (2005) presented a promising study in Brazil (2005) on its trial findings from the Gauteng Province examining the potential link between male circumcision and a lower risk of HIV acquisition. "Circumcision prevented 6 to 7 out of 10 potential HIV infections," says researcher Bertran Auvert, MD, MPH, professor of public health at the University of Versailles-Saint Quentin in France.[9]
The authors conclude that male circumcision may be an important way to reduce HIV transmission to males in Sub-Saharan Africa, especially "at a time when no vaccine or microbicides are currently available and when delivering antiretroviral treatments under WHO guidelines will have only a small impact on the spread of HIV."

In another study in USA Castellsagué X et al (2005) found similar results through women who had a circumcised partner were significantly less likely than those who had an uncircumcised partner to test positive for chlamydia antibodies; other factors negatively associated with testing positive for Chlamydia[10].

Also, evidence has proved that the sexual transmitted infections (STIs) are fertile to HIV infection. According to studies from Ivory Cost and Tanzania a strong biologic plausibility is

[8] Gukuna, is roughly (traditional women practice) a sort of physical elongation exercise of external sexual lips at the very beginning of teenage.
[9] http://www.cbsnews.com/stories/2005/07/26/health/webmd/main711923.shtml: The study included 3,128 uncircumcised young men aged 18 to 24 in a rural area outside of Johannesburg, South Africa. The men were randomly assigned either to undergo the procedure or remain uncircumcised. All the men were heterosexual.

By about 1½ years later, 51 men who had not been circumcised had been infected with HIV, compared with only 18 who had the procedure, the study showed.
The findings were presented at a meeting of the International AIDS Society.
-Castellsagué X et al., (2005) Chlamydia trachomatis infection in female partners of circumcised and uncircumcised adult men, [10] *American Journal of Epidemiology,* 2005, 162(9):907-916. retrieved on: http://www.guttmacher.org/pubs/journals/3116005.html

supported by empiric studies documenting that *Trichomonas* may increase the HIV transmission by two- to threefold.

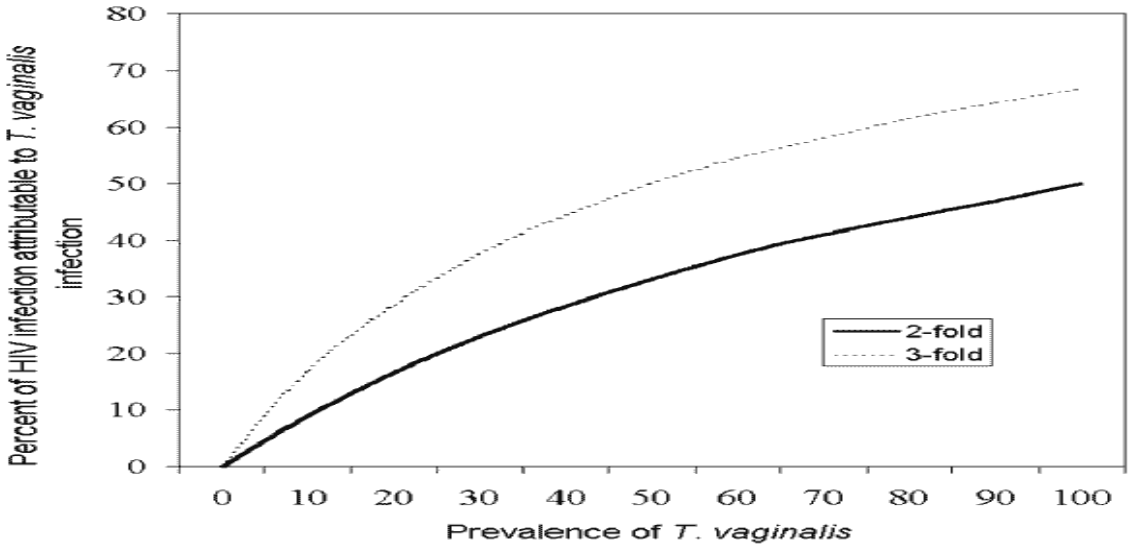
Since STIs such *Trichomanas vaginalis* have proved to be cofactors of HIV infection there an *increased* risk of HIV transmission by a sizable population by the fact that Trichomonas is so common in ante-natal clinics attendance. Slums have shown a high incidence of STIs (Biryogo, Gikondo, Butare,…). They are at the same time known as urban poverty pockets areas.

Trials in Tanzania have demonstrated the benefit of reduced HIV incidence in communities receiving aggressive STD control intervention[11].

As the figure illustrates, if *Trichomonas* amplifies HIV transmission by twofold and the prevalence of *T. vaginalis* in a community is 25%, one fifth (20%) of HIV transmission in that population would be attributable to *Trichomonas*.

Hypothetical level of HIV transmission attributable to *Trichomonas vaginalis* at varying prevalences of *Trichomonas* infection and assuming that *T. vaginalis* infection amplifies HIV infection by two- or three-fold is as follows.

Figure4: Percentage of HIV with respect to the prevalence of Trichomonas Vaginalis



[11]http://www.cdc.gov/ncidod/eid/vol7no6/sorvillo.htm#41

This graph highlights how important the prevention of HIV must take into account the STIs prevention and treatment like the Mwanza success story. Promiscuity and violence are prone to spread the STIs.

Violent sexual behaviour is extremely risky to both parties, because it is characterised by the lack of protective precautions, which might be used in consensual sex. This kind of violence has left remnant behaviour. It persistently happens even though it is hidden, socially and officially repressed. Both parties involved rarely acknowledge it, especially the victim, thereby limiting the effects of deterrence.[12] Stigma prevents some patients from attending clinics for STI treatments and prevention.

The political sexual violence that was experienced as part of the genocide had more far-reaching consequences than social sexual violence in that it is openly generalised, politically motivated, supported and systematically organised. Thus it is more destructive because it is not only a psychological war to traumatise the adversary but also to totally exterminate it by intentionally spreading HIV as part of the final solution in the genocide. Unfortunately, it was also spread among Hutu women for other political reasons mainly by the same group. Political violence has therefore been a strong HIV vector.

Recently, many economists have been modelling institutional issues by using the so-called Latin-America, Asian or African-dummies. The results are still controversial but useful in describing real problems which can have even catastrophic impact in some situations.

Cost of living and HIV/AIDS

The chronic malnutrition rate is 42% at the national level (Demographic and health Survey (DHS) 2001, PRSP Progress Report 2003 page 71). The proportion of the population under the poverty line (cut off US$1) is 60%.
The transition speed to AIDS stage and the terminal phase also depend on the level of welfare of the population. The healthiest people tend to resist to opportunistic diseases and other illnesses at least for a number of years and the existing antiretroviral medication is more

effective in better-off people with a certain level of an appropriate diet and other physiological needs. There are some limited areas (which is the lowest altitude, South-East and East) which are subject to cyclical food insecurity. Food insecurity is an aggravating factor for People Living with HIV (PLWH). Productivity is also positively influenced by good health conditions, and adversely affected by poor health conditions. Food insecurity, and therefore susceptibility to AIDS progression is one of the important characteristics of poorest households, especially PLWH.

Impact of Antiretroviral (ARV) Treatment

The impact of ARV on HIV/AIDS will essentially depend on how Volunteer Counseling and Testing (VCT) is evolving and the capacity of deploying the ARV programme nationwide by various stakeholders involved. Many people are still confused on the existence of any medication in regard to HIV/AIDS and what this kind of treatment can do and cannot. Clearly it is a multi sectorial approach to overcome several invisible barriers.

On the very beginning, there is an accumulated demand of ARV which can't be satisfied in short term even if people were ready to go through the process. It can be assumed that as it rolls out in the middle term there could be a very high demand but also more readiness from the ARV providers (declining learning curve experience based on yields scale economy) which will thus sharply curb the demand. The latter will remain high for some years and thereafter would abruptly fall.

However, there are limitations to VCT on both sides (providers and the population), health centers system capacity, and the ARV sides effects. A residual group will never use ARV for the reasons mentioned above. ARV is quite new and very few studies have tried to comprehend its effect on HIV/AIDS behaviour change and the AIDS mitigation impact. University of Cape Town studies on ARV have estimated to an increase in average of about 10years or so for the PLWHA life compared to the group not on ARV protocol treatment. PLWHA start taking ARV at expected stage which is CD4<200 counts.

There is an inequitable distribution of human and financial resources between the rural and urban health areas. In urban areas predominantly poor health centers have less means to handle VCT compared to hospitals apart from Kicukoro center. The workers do have more

access to health services in general with RAMA (parapublic medical insurance Agency) than the population in general. This insurance coverage is very limited in terms of national health services access. However the health sector institutions and health mutual networks are trying to fill the gap with the support of new interventions by Médecins Sans Frontières (MSF), Clinton Foundation, UNICEF, USAID Healthcare specialists,… that exist only in mainly urban areas.

There is also inequity between spending on levels of care.

Only about 24 % of population can expect to consult a Doctor (PRSP review June 2003) while 18% will likely consult a traditional healer. 76 % of people who do not get access to health services it is because the cost is to high for them while 40% live far away from the centers.

HIV/AIDS is a major cause of hospital admissions (70% at CHK[13] and, at primary level, health workers' morale is being affected as they become overburdened by HIV-related illness.

Prevention of mother-to-child transmission (PMTCT) programmes have also been constrained by poor infrastructure, an absolute shortage of human resources in quality (less skilled), quantity and the programme management continuity because of the high turnover of staff due to the very low compensation more particularly by the cost recovery system and the distance.

But also the PMTC still encounters a problem of awareness. It confronts the problem of information, education and communication (IEC) and the Access to Voluntary Counseling and Testing (VCT). Fifty percent of women reported to be ready for VCT (in 2004). Also only 26.5 % (in 2001) of pregnant women delivered in health institutions. These 2 factors combined are too limiting to PMTCT.

Obviously the urban areas will benefit form ARV coverage more rapidly. There is also the possibility of limiting the stigma effects by confidentiality in cities. This is challenging in rural areas where they cannot afford to go far away from their respective health centers, and are hence exposed to the disapproval of the community in which they live.

[13] CHUK:Centre Hospitalier Universitaire de Kigali.

Having started in 1999, access to Antiretroviral Therapy (ARV) is still small, around 6% in 2003. Of approximately 263, 400 infected people in 2005, about 35,000 would need ARV by 2006.

The graphic tells how the ARV falls short behind the fast need (Appendices). Although the problem of the high cost relative to income is always invoked, two other issues seem to be crucial, that are the limited use of health institution and the low level VCT. The health centers are not highly used as expected for many reasons among others, the cost recovery, the lack of products, the staff's limited expertise, the high turnover and the distance. Availability of appropriate infrastructure for ARV programme is a serious problem, as is the problem of VCT, which has to be emphasised in particular for women. It is important to curb the mother transmission to child (MTC) through a more focused information, education and more appropriate communication strategy. PMTCT by reducing the infant mortality contributes to elevate the life expectancy.

2. 2. 1 Tuberculosis (T.B.) and Malaria Impact due to HIV

Tuberculosis is one of the most frequent HIV opportunistic diseases if it is not well treated. It is latent in most 50% cases. A strong stigma is associated with it because, it is highly contagious and fatal if not well treated. For people in good health conditions, the probability of developing such illness is too low and the treatment is more efficient. Its incidence with HIV positive people is estimated at more or less 8% while it is for others is only 2.4%. Using these assumptions, we can estimate the impact of this differential incidence due to immunity failure of 5.6% (8-2.4%).

TB ruins the productivity with long absences it entails. The cost of patients caring is also high. As the country is situated in intertropical region, the most frequent disease is Malaria which plays a leading role in the Sub-Saharan Africa high mortality including that of Rwanda.

Sachs (2001) and Sala-i-Martin (2003) put it as one of the most pressing public health issues and also one of the major causes of low growth in Africa. Malaria mortality and morbidity do not appear as a consequence of HIV/AIDS in many cases even though their interaction is evident. PLWH are also more victims of this endemic disease because of the immunity failure due to HIV/AIDS, but the incidence is not yet enough researched at least locally. Estimation

of malaria cases due to HIV poses many problems of how to differentiate it from the malaria which would occur in absence of HIV.

Therefore, Malaria mortality and morbidity do not appear as a consequence of HIV/AIDS in many cases while their interaction is acknowledged. Hence, neither will it be accounted for while its partial impact is due to HIV/AIDS. For example, the economic impediment caused by endemic malaria is estimated at a loss of 1-1.3% in growth per annum (Sachs: 1997).

Table3: Three scenarios Tuberculosis trend in Rwanda

	1980	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Scen 1	7.37	7.7	8.05	8.42	8.86	9.33	9.82	10.41	10.93	11.54	12.57	13.24
Scen 2	7.37	7.7	8.03	8.42	8.86	9.32	9.82	10.41	10.92	11.52	12.55	13.22
Scen 3	7.37	7.84	8.34	8.86	9.41	9.99	10.6	11.27	11.98	12.73	14.1	14.96
Scen 4	6.43	6.63	6.84	7.04	7.26	7.49	7.73	8	8.28	8.58	8.89	9.19
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Scen 1	13.92	15.14	14.98	11.76	11.8	13.02	15.09	16.42	17.62	18.76	19.97	21.57
Scen 2	13.89	15.11	17.56	14.25	14.3	15.65	18.08	19.6	20.63	21.66	22.73	24.36
Scen 3	15.83	17.52	18.34	14.92	14.73	15.51	17.68	18.91	19.95	20.9	21.88	22.9
Scen 4	9.49	9.79	9.99	7.23	7.74	8.35	9.5	10.11	10.62	11.07	11.53	12
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Scen 1	21.06	22.54	23.46	24.47	25.43	26.42	25.93	27.61	29.1	30.96	32.12	33.18
Scen 2	23.28	24.79	26.25	27.81	29.45	31.2	31.16	33.76	36.5	39.79	42.83	46.06
Scen 3	21.89	23.18	24.39	25.69	27.05	28.34	28.01	30.14	32.39	35.14	37.63	40.25
Scen 4	12.48	12.97	13.4	13.85	14.29	14.63	14.11	14.76	15.47	16.37	17.09	17.78

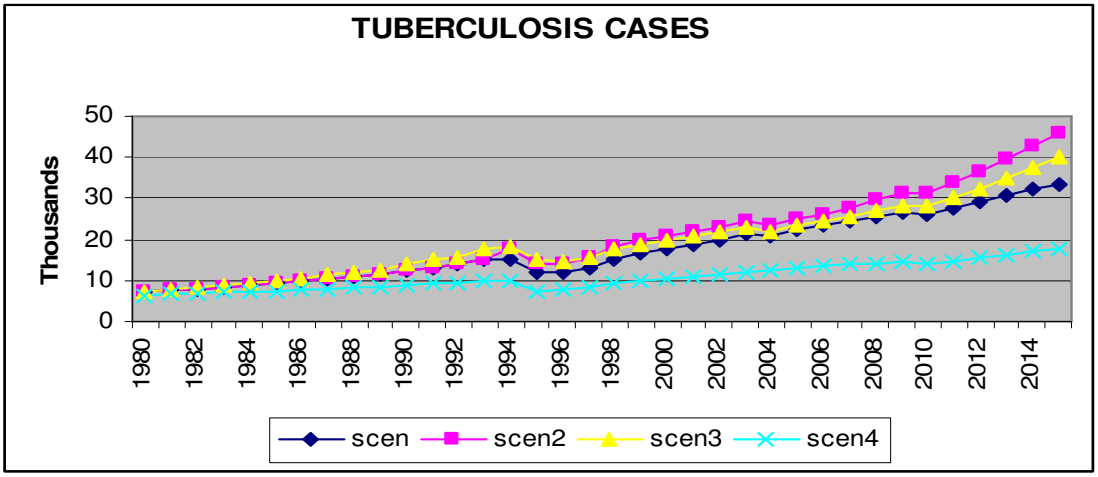
Source: From Spectrum modelling

By 2010, TBC cases will be about 26,000 if HIV rate is as low as in the scenario1 whereas there could fall to only 14,110 cases in the absence of HIV.

In 2015, TBC cases will almost double just because of the HIV if the scenario 1 is the most likely one. In other scenarios 2 and 3, (if HIV changes the trend and rises) the number is even more than double from end of 2006. These TBC are relatively reduced by the ARV treatment conditions.

PLWH are prone to fall sick of both tuberculosis and malaria. This complicates the treatment and delays the recovery, thereby, aggravating the loss in terms of productivity and cost for caring. Scenario4 NOHIV is slow; the number of TBC will double in almost 18 years to reach 17,780 cases in 2015.

Figure5: Number of Tuberculosis Cases in thousands



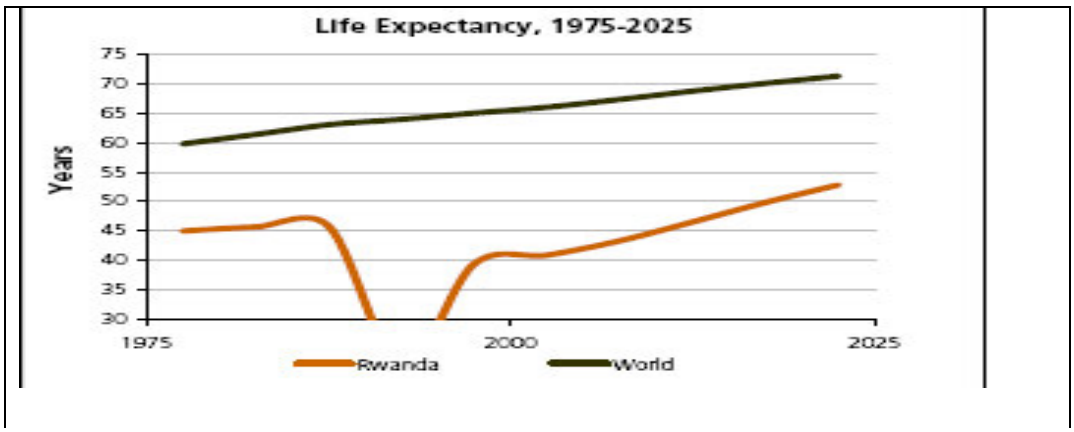
Source: extracted from based spectrum model based on author's calculations,
Scenarios: Scen1:HIV=6,9%, Scen2: HIV=11.5%, Scen3:HIV=9.1%, Scen4: NO HIV

2.2 .2 Life expectancy and HIV/AIDS

Bloom et al (2001) indicated that one year of increased life expectancy leads to 4% increase in output. Lifetime is shortened by death for many HIV-Positive very likely before 49 years if not treated. This contributes to slowdown the life expectancy. In 2010, the life expectancy should be61.5years if there was no HIV. In the most optimistic case (scenario1) it will be 56.67 years. The loss in 2015 in terms of constant decline of life expectance at birth will be about 5.82 years in the first scenario and 9.22 years on the scenario of the HIV positive rate of 11.5% Conversely the loss in terms of the economic output due to the decline of life expectancy at birth would then be high since savings depend on span of time. Shortened life expectancy impedes long term savings that are fundamental to economic growth via investment.

While health care competes resources away from other goods consumption and production, it prolongs life expectancy which in turn leads to higher capital accumulation. McPherson et *al* (2000), applied to Zambia a retrogression model with Life expectancy at birth (LEAB) as a proxy for HIV consequences; the results indicate that a 1% loss in LEAB implies 0.68% loss in GDP growth.[14] In normal circumstances, the probability of dying in the range of young adult age is the lowest possible even for poor people in that lifetime.

Figure 5 : Life Expectancy, 1975-2025



Source : http://earthtrends.wri.org/pdf_library/country_profiles/Pop_cou_646.pdf

The low and disruption in the life expectancy at birth curve are to be related to poverty and recently in 1990s to the war and 1994 genocide. It dropped because of the generalised violence and genocide to the large extent. PLWH/AIDS trend has sharply declined too, describing their death due to the political violence.

This decline of the probability of attaining adulthood cuts the Returns on Investment (ROI) in the human capital (the ROI requires several years and the later, the better). Only formal settings workers, hold the social security coverage (in the state corporatist tradition).Life insurance is rather very recent and too costly thus inaccessible. The 1990s period has adversely impacted on households in many ways not only families were lost or broken but also many survivors and aggressors underwent deep change due to many reasons: deprivation or unexpected wealth but also new behaviours have emerged as a result of fear, distrust, social capital disruption which in turn contribute to HIV/AIDS spread.

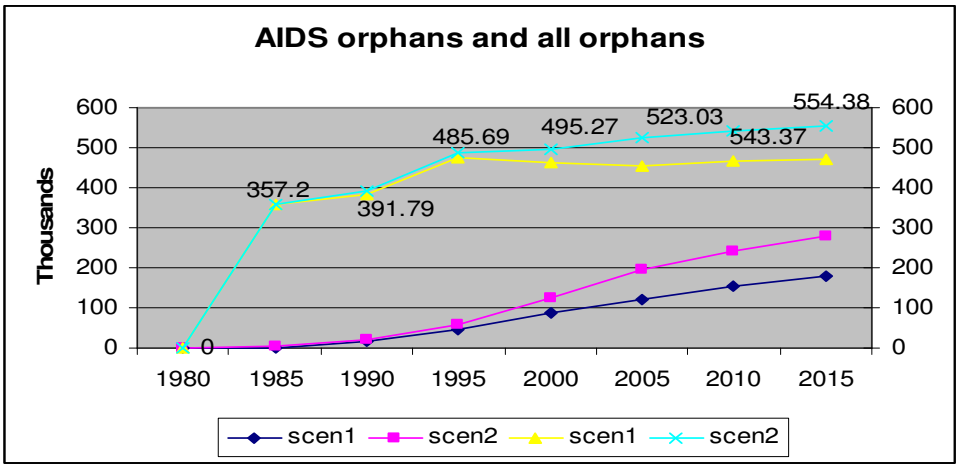
[14] Malcolm McPherson, Deborah Hoover and Donald Snodgrass, 'The Impact on Economic Growth in Africa of Rising Costs and Labor Productivity Losses Associated with HIV/AIDS,' JFK School of Government, Harvard, August 2000, p. 53.

2. 2. 3 New population structure as a consequence of HIV/AIDS and GENOCIDE

A – Orphans and HIV/AIDS in Rwanda

By 2005, an estimated 205,000 children had lost one or both parents to AIDS, representing 38 per cent of 545,000 orphans who are children between the ages of 0 to 14 years. Today there is second generation born in the street.

Figure 6: AIDS orphans and all orphans



Source: based on my Spectrum modeling and calculations

AIDS orphans curves (scenario1 and scenario2) do not show their figures in the graphic. For all orphans scenarios indicate the numbers of all orphans (for example 543,070 in 2010). In 2015 with a level of HIV of 11.5% (scen2) the number of all orphans would reach 554,380 of which about 300,000 would be AIDS orphans. The differential would narrow over time. The number of orphans was severely aggravated by political violence. The number of non-AIDS orphans is declining and could be outnumbered by the AIDS orphans in the long run if HIV persists at the same pace. Being among the poorest of an already poor population, orphans are highly vulnerable to HIV/AIDS. As a result of their circumstances, they lack social reference and protection.

Many of them have started their own household and fight for survival. Social protection is becoming too limited; social networks through which support was traditionally channeled are disintegrating or have broken because of high demands on them in the context of endemic poverty. The plight of AIDS orphans is additionally worsened because they do not have the same support as do the non HIV infected children who were orphaned due to genocide.

Their status commonly leads to stigma and social exclusion. About 101,000 children are heading some 42,000 households (UNICEF Rwanda) and between 7,000 and 8000 street children (in 2001) are mainly orphans.

B- Family pattern developments with HIV/AIDS in Rwanda

HIV is fundamentally transmitted through heterosexual intercourses relations. Women-headed families represent roughly one third of all families. Cohabitation and celibacy is an ever-increasing response. New household patterns are arising partly due to socio-political instability and HIV /AIDS impact. Moreover, HIV/AIDS tend to exacerbate them. Minor-Headed Households (some households in jails in connection with to the genocide accusations) due to the political violence are no longer insignificant.

Cohabitation

Widow

Cohabitation is a very vague and highly temporary relationship and is open to many other networked relationships. Widows tend to be the biggest proportion of cohabitant group. Young childless widows get remarried more frequently and rapidly than the widowed mothers. Widowed, are likely to succumb to the cohabitation as the last resort which tend to be long while singles people would probably leave it soon for marriage.

Widow/widowed by entering in such relationships they increase the risk of getting infected because they are not set to last because they are not bound by any firm obligation.

Although cohabitation is an important contributing factor to HIV transmission, it can also end up in marriage for a number of couples or it reverts to their previous status of separated, widow/widowed, divorced and singleness. In this relationship men tend to take the lead and decide its outcome. That kind of imbalanced relationship is favourable to HIV transmission in that females may expect much more than men from the relationship and would overlook the risk.

Therefore, widows are exposed to the risk of infection for longer period than men and very likely will remain legally unmarried for their lives. Their number is at their disadvantage even

though some are relatively young particularly widows.[15] This group is likely highly exposed in that it has less bargaining power and has been dispossessed in many respects. Females are 10 times more than males (31433) against 317067 females.

Separated and divorced

These sub-groups can also be engaged in cohabitation, but divorced men have high probabilities to get remarried. Separated people are in transition to other types of relation. This situation increases chances of being engaged in risky behaviour related to HIV. Divorced women may remarry far less than widowed mothers at the same age.

HIV transmission among the cohabitation group is likely to be propagated to other groups since in many cases members are also in a transition to other types of relations.

Polygamy

The polygamous families have relatively joint conditional probabilities higher then normal families of being infected by HIV. They are concentrated in urban areas; that compounds the risk. However this group is still small and is limited as a result of the constitution disposition, which prohibits it.

Street children

Today there is a second generation of the street children due to various factors. The generation is the first born in the street out of any formal support institution. They can't access PMTC programme or any other medical treatment now based on cost recovery system. This new group of minors has lost ties with the society. Most of them are orphans; the majority is abducted to drugs. They are under many serious threats including HIV/AIDS infection. Such situation is extremely risky vis-à-vis HIV/AIDS for the entire group of street children. They are difficult to reach even though living in cities because their exclusion, deviant behaviour and the lack of the appropriate institution to reintegrate them in society.

Table4: Population Distribution by area and legal status, Rwanda Aug. 2002

[15] Some people took advantage of confusion to declare that their partner was killed in the genocide while has succumbed to AIDS.

	Rural Areas			Urban Areas		
	Males	females	total	males	females	total
Total	**1895284**	**2353768**	**4249052**	**409688**	**436419**	**846107**
Single	906960	917669	1824629	229496	199479	428975
common law	261045	290550	551595	45146	47627	92773
monogamic marriages	534290	580170	1114460	97787	95558	193345
polygamous	43394	-	43394	3090	-	3090
1 st wife in marriage	-	40820	40820	-	2327	2327
2 nd wife in marriage	-	50701	50701	-	3289	3289
3th wife in marriage	-	7485	7485	-	445	445
Divorced ou separated	10660	43664	54324	1998	8007	10005
widow/widowed	31433	317067	348500	5731	53354	59085
not specified	107502	105642	213144	26440	26333	52773

Source: based on the Rwanda Census, August 2002

2. 2. 4 The effect of HIV/AIDS on the education sector

Education is of particular importance in economic growth and development, and it employs the biggest component of civil servant, whilst it comprises the highest skilled labour of the society and constantly continues to produce and update itself. Knowledge lifecycle is shortening higher than ever requiring life-long learning (Redling, 2002). In the globalising world, knowledge is the most competitive advantage. Undoubtedly it is strategic to prevent it from collapsing to HIV/AIDS.

HIV/AIDS poses a serious threat to the education sector on both the demand and the supply sides. Conversely the education sector holds an important role in addressing HIV/AIDS issues and it is cost effective to use it (World Bank: HIV/AIDS and Education). The recent privatization of education has increased individual access to education systems but has also aggravated the segregation of students according to income levels. The shift from quality of education and resources from public system to the private system is clearly proceeding very rapidly, as a result of a push towards " Structural Adjustment " and also, the influx of refugees coming back home from various countries. Many of them were more prepared to invest in the private education system.

Intuitively, the education sector has an HIV/AIDS rate higher than the average of the 15-49 population group. Firstly, schools are located urban areas, and the staff is likely to be more mobile than other civil servants living far from their normal residence. They are linked to more

social networks and are likely to be sexually active in these networks. Teachers have a respected status in rural areas and a relatively high socio- economic status. On average, their sexual activity with attendants AIDS/HIV infection is likely to be more widespread across social and economic classes.

The education sector is labor intensive but it has been fragilised by heavy losses of students and educators on one hand, and the capital (investment and operating) reduced in the adjustment process on the other. At all levels, skilled staff is insufficient and not enough qualified. In primary schools, 18.8% of teachers are not qualified. The ratio primary student teacher is 59% which is already far from the standard.

Drawing on Shaffer's grid (1996) the potential problems due to HIV/AIDS in education sector policy and their specific consequences are highlighted. HIV/AIDS arises economic, demographic and equity issues throughout the education sector and they can be summarized as follows:

Table 5: Including HIV/AIDS in Education Sector Support

Issue	Potential Problem posed by HIV/AIDS	Consequences
Demographics	Decline in project student numbers (demand)	The absolute numbers will not really decline but rather distorted cohorts and constant reassessing by planners will be needed. Long studies could be more impacted. Studies choices would be distorted. Short studies could be preferred posing problem of education development. Human capital formation limited in the long run. Abnormal Mortality rises
	Increased staff HIV/AIDS (supply)	Replacements more often difficult to meet; Desencetivise other staff. Quality of education likely suffers. Abnormal and morbidity Mortality rise
Economics	Student can't afford schooling	Informalisation to increase, Marginalization, susceptibility to HIV/AIDs increased; Labour force exposed to more unemployment; Future shortage of skilled labour; Economic performance impacted.
	Education budget under threat	Quality decreases, HIV Prevention avoided. Accrued Risk; Future shortage of skilled labour, economic performance impacted in almost sectors.

Equity	Student with special needs because of:	
	Poverty and HIV	HIV Risk and inequality accelerates; Marginalization, risk of social disease and associated unrest , Possible spiral effects on society. Development goals compromised
	Orphanhood	Consume other Households budget Or increase government transfers HIV risk,
	HIV infection	Need for ARV, counseling services Drop out, Risk of infecting other students.
	Gender –female in relation to HIV/AIDS	Social practices increase the HIV risk. Education compromised, status trapped in lowest strata

Source: adapted from Sheldon Schaeffer, Education Sector AIDS Brief, Academy of Educational Development, page 5

HIV impact on primary and secondary schools population

As at 2005, HIV/AIDS would have killed 32800 primary school age children if HIV trend was reflected by the scenario1 whereas the secondary school population lost 63500 potential students. In 2010 primary school age children lost to HIV will total 117,200 while the secondary school will be losing around 83,900.

In 2015, Secondary schools age children who can be already on market labour given the secondary school low rate will record a difference of 105,100 persons when compared to the scenario of no HIV (scen4).

HIV/AIDS impact in primary schools should be lower than in the secondary and the tertiary levels where unwanted pregnancies are relatively frequent and sometime involve both students and educators.

Table6: Children of secondary and primary school age, in thousands

	Children of secondary school age In thousands				Children of primary school age In thousands			
	scen 1	scen2	scen 3	scen 4	scen 1	scen2	scen 3	scen 4
1980	707,2	707,2	707,2	707,2	864,9	864,9	864,9	864,9
1985	810,12	810,1	807,5	807,5	1,047,1	1,047,5	1,053,2	1,053,7
1990	987,5	987,7	987,8	988,2	1,302,6	1,303,2	1,339,4	1,344,3
1995	846,8	847,6	875,8	880,2	1,311,3	1,310,6	1,353,1	1,369,6
2000	1,225,7	1,225,5	1,258,2	1,269,4	1,320,6	1,318	1,366,8	1,395,0

2005	1,319,9	1,318,3	1,357,2	1,383,4	1,293,8	1,284,3	1,288,4	1,336,6
2010	1,678,2	1,667,9	1,714,3	1,762,5	2,058,6	2,038,4	2,102,4	2,175,8
2015	2,036,4	2,017,6	2,070,9	2,141,5	2,134,7	2,104,4	2,198,8	2,299,6

Source: calculations from Spectrum model.

There is compelling evidence to demonstrate that, in many African countries, teachers are dying faster than they can be replaced (de Waal 2002).

However, this is not the case in Rwanda. In order to deal with HIV/AIDS mortality, and other incapacities, the number of teachers tends to be slightly higher than effectively needed. The replacement of the absentees due to HIV/AIDS, other related diseases and the subsequent time involved in the planning and redeployment processes, it is likely to be less than 1% of each school.

Again, the HIV positive rates of rural schools are likely to be lower than should be recorded by urban schools. In fact, the short but frequent interactions of rural scholars and teachers with their counterparts in urban areas results in a convergence of rural HIV infection rates towards the urban HIV rates. This is particularly true for students of secondary and tertiary. This should also apply to correct the national weighted average rate by recalculating the proportion of the weight of urban population proportion. The urban proportion is increased by the number of people in daily movement by taking into account in-going and outgoing movements of people at the main entrances of towns. The urban areas are points of convergence of various networks.

2. 3 Socio-Economic factors with HIV/AIDS

Barro and Sala-i-Martin (1995) in evaluating the impact of health on growth used life expectancy as a proxy at the aggregate level and concluded with a very positive association but not clearly as to whether it represents only the health factor or it also links to other factors at the macro level.

Controversially, de Waal (2003:5) and Nattras (2003), using the neo-classical model, concluded with an unexpected deduction that the per capita GDP will rise over long term because of HIV/AIDS. For them, the fast reduction in population and hence in the workforce

will be more than in the GDP, thereby, increasing the GDP per capita. People will become better-off, on a per capita basis.

This conclusion would be possible only if HIV/AIDS was rapidly fatal in the short term when people die leaving their all wealth free. This is not the case; AIDS tends to deplete wealth even if accumulated on a relative long period. The health cost is too high for both the government (15% of the total public health expenditures in 2002)[16] and families. Cleary, Boulle, Di McIntyre, and Coetzee (2004) estimated at ten years more of survival if AIDS patients undergo an Anti-Retroviral (ARV) Therapy.

The survival function of HIV/AIDS patients (progression from HIV infection to AIDS disease) has a logistic form and goes up to 20 years. When ARV is combined with a highly appropriate treatment people can gain 10 years or more. In many cases, patients are incapacitated to work for long years while developing constantly opportunistic diseases.
Furthermore, the choices and behaviour of HIV-positive people could be strongly affected by their health status. HIV positive people may form a different meaning of the future and this may affect their related intertemporal decisions such as decisions to save, to invest, to guard against risks. The life cycle for them would be different from the non-HIV people when they know that sooner or later they will die of AIDS. In many cases, there are some opportunities lost if they have to undergo a prerequisite test of HIV (for example entering in Army, Higher education abroad,… contracting the life insurance,…) and this has detrimental consequences for the future . As Loewenstein, Camerer, C. and Prelec, D *(*1996) in (Loewenstein, (2005)) people are likely to place more stress on the immediate future or the present , and therefore make short-sighted choices when under the influence of powerful drives or emotion.[17] That is the caveat of the mechanics of the neo-classic model which is not realistic (linearity, many omitted variables). GDP formation is embedded in institutions which are disorganised by AIDS deaths. This model does not fully capture many intangible resources which are critical to productivity for the competitiveness advantage.

Empirical evidence of this phenomenon is, however, mixed. In a study in Zambia, Mc Pherson (2000) found a strong positive relationship between life expectancy and GDP and a negative

[16] UNAIDS 2004, Health National Accounts
[17] Loewenstein, G., Camerer, C. and Prelec, D. (2005), Neuroeconomics: Neuroscience can inform Economics, Journal of Economic Literature, march 2005 Vol XLII, Number one, page 219

relationship between GDP and the dependence rate. Bonnel (2000) also found a strong negative relationship association between adult HIV prevalence and per capita GDP growth in a study of 60 developing countries.

Unlike Bonnel and Mc Pherson , Yang Xie (2003) in a study of 43-African country sample group and 130-country group using another modified endogenous version with a system of equations where GDP and HIV prevalence rate are respectively dependent variables but not recursive, concluded on a very little impact, not statistically significant.

However, it is intuitively plausible that HIV/AIDS hinders the GDP growth through the negative effect on labour quality and quantity, the decline of the savings rate and the slow and reluctant response of institutions to the new environment of the pandemic. The accumulation and growth factor are then seriously limited if the progression of the disease is exponential.

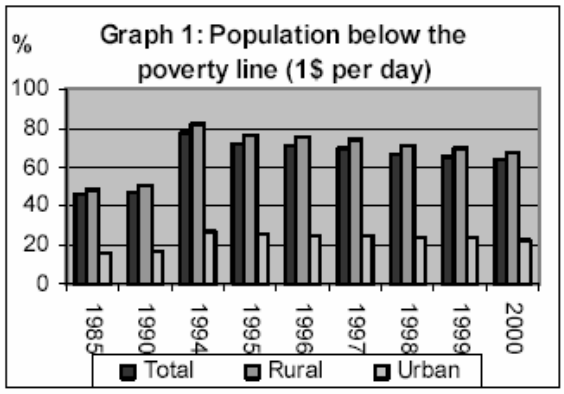
2.3.1 GDP, land and HIV/AIDS

From 1985 to 2000, the proportion of the population below the poverty line($1/day/person) has increased in rural and urban areas as well with particular acuity in the rural areas (from 43% in 1985 to 62-63% in 2000). Again, 1963, 1973, 1993-1995 were lost in the throes of wars and genocide, whereby, deepening the poverty for the whole country.

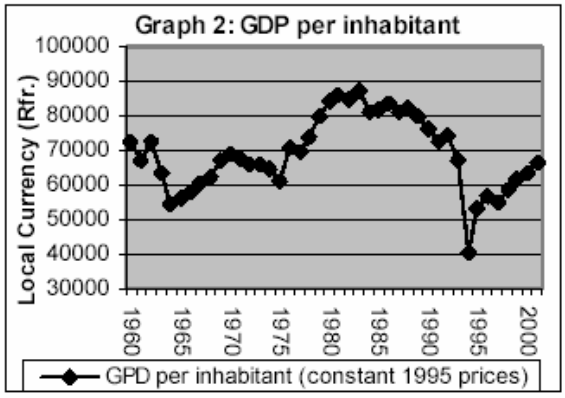
However, from 1995 the urban population proportion below the cut off line of $1 keeps reducing whereas the rural zone was stagnant until 2000.

The Rwandan GDP per capita can be estimated by a negative linear regression or a concave quadratic. In 1983 it was about US$900. It shrank to US$162, after 22 years. The GDP curve shows 3 broken points (years: 1963, 1973 and 1994) which are significantly recognized as a time of political unrest.

Figure6: Population below the poverty line (1$ per day) **Figure7: GDP per inhabitant**



Source: Minecofin, 2001, A



Source: World Bank. 2003.

The agriculture sector accounts for around 43% of the GDP but uses 85% of the population workforce. The predominance of subsistence agriculture and the overpopulation factors augment the pressure on its existing scarcity problem, while there is still a high fertility rate (5.42 children per women in 2003).

Donovan, Bailey, Mpyisi ., and Weber (2003) found that in rural Rwanda the long disease (opportunistic diseases, persistent malaria,…) and/or mortality in households have a more deleterious effect on some crops than on others. Crops which are more labour intensive like potatoes and maize are more strongly affected. The labour intensivity of these crops is increased, and labour is re-allocated from cash crops to substance. Peasants have moved away from coffee because of the low profitability given the price paid to producers.

Also limited access to secondary education (less than 12%) diverts the youth to agriculture and further increases labour intensivity thereby, reducing the productivity.

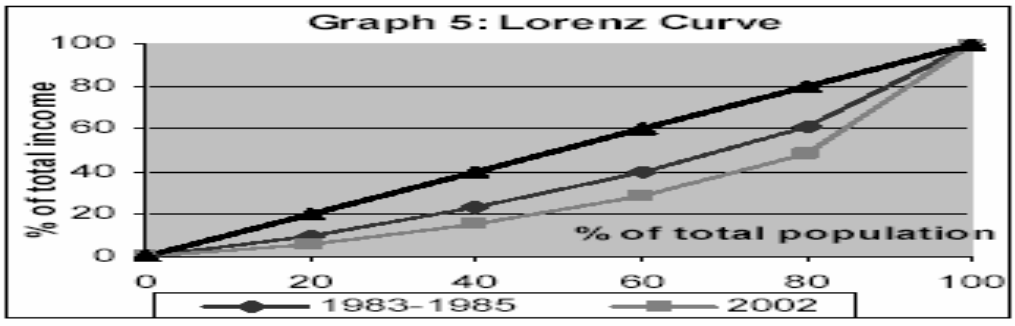
Therefore, the Cobb-Douglas production function is not appropriate to measure the output since the returns to scale can't sum up constantly to 1. They are likely declining because of poor productivity in the agriculture sector. In this case, the returns would be less than one. The agriculture proportion in the GDP will likely continue their downward movement, thereby, aggravating the rural-urban incomes divide not only in terms of the households numbers but also the level of income. Farmers do not control any market portion; they do not have enough bargaining power on the price setting neither for their production nor the products they demand. For them the two markets are completely disconnected by the difference in price levels without any control or facilitation mechanism.

There is a relatively high population density and the population is scattered almost everywhere, thereby, making the land management for various activities (including farming) almost impossible. This does not help modernizing and extension of rural activities and access to social infrastructure.

The villagisation policy and the land reform have become controversial. They did not receive enough support from donors community apart from the emergency resettlements. It aims at bringing the population out of marshlands, encouraging settling into villages out of the farming activities areas and also zoning similar activities.

In spite of the alignment of the government objectives on the main donors concerns through the Brookings Report recommendations (2000) commissioned by the UN, the lack of funding which hindered the implementation of the resettlement programme meant the low priority given to the land issue or the unresolved contention around the land policy.

The persistent poverty divide between rural and urban areas has contributed to aggravating the inequality. Wealth is unevenly distributed and the trend could even be worse. Before the 1994 genocide, Ainsworth and Ower (1993) found a high HIV positive rate of pregnant women associated with the high income, and education of their male partners. Figure8:



Source: Minecofin, 2001, A; Minecofin, 2002, B.

The diagonal in the Lorenz curve is a theorical perfect line of equality. If the income inequality arises the diagonal becomes more convex and the intercept between percent of income axis and % of total population represents the income share owned by that percent of the population. The extreme inequality would make the income axis orthogonal to population axis under the diagonal (around the 100th percent of the population point) meaning 99% of

the population will loose their income while the very last one percent (100th) has taken the all income.

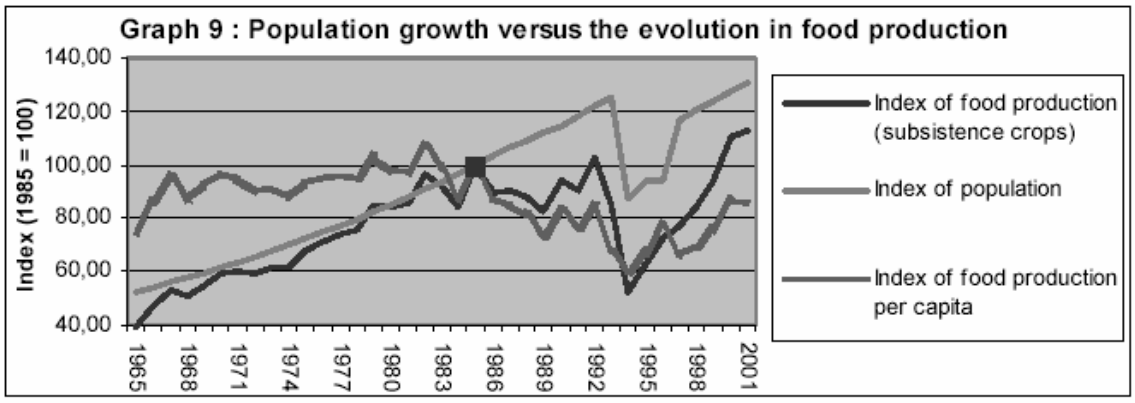
Although the increasing income inequality is going together with the HIV spread, it is not clear which causes what. The simple positive correlation could come from other factors also related to each other. Evidently, the mutual causation is also into play to certain degree. Policies which deepen the income inequality fragilise the population making them more vulnerable and susceptible to HIV via many channels which negatively impact on income: the limitation of social transfers, access to health and education services among others. However, it should be highlighted that the poorest are not necessarily the most infected so far.

Ansom and Marysee (2003) assert that violence took root in endemic poverty and increased inequality. However, they did not provide links between designated victims category characteristics and the better-off status or possible alliances between them. There was no existence of any specific relationship between wealthy population and victims category albeit, indeed, the growing inequality and flawed institutions at that right period.

HIV/AIDS and poverty would rightly contribute to inequality, over time, making the Lorenz curve more convex if more inequality occurred. Gini Coefficient was 0.289 in 1985; it increased to 0.451 by 2000. In 1982 ten highest percentages had 20% of the rural revenues and rose up to 42 % in 1992. The quarter of the highest revenues families lives in urban areas. Economic growth with profound inequality has negative effects on poverty which is fertile to HIV spread.

Furthermore, Ansom and Marysee (2003) single out the Malthusian threat, at work very possibly, in the whole process in either 1990s violence or after 1994 genocide, where large slaughter freed some more land or lying fallow and pushed forward the natural resources constraints horizon, indeed, just for few years. The deficit in food production persists from 1985 and would go deepening if demographic determinants remain unchanged.

Figure 9: Population growth versus the evolution in food production



Source: Calculations from: World Bank, 2003.

2.3.2. Investment, debt, aid, exchange rates and HIV/AIDS

Savvides (1992) asserts that the incentives to invest are weakened by the debt servicing compulsion. The debt is perceived as a tax on investment for the in debtor country.

Less investment corresponds to low labour opportunities creation which leads to very low economic growth. Investment in Rwanda is always rather sluggish between 12 % and 18 % of GDP. Only the rehabilitation and the reconstruction after 1994 have boosted it thanks to more international aid. From 1996 to 1999, it was between 20 % and 25%.

Exchange rates and interest rates have strongly and negatively affected investment.

In the context of uncertainties, investment tends to migrate. In December 2003, the exchange rate was RWF538/$ while in 1980, it was RWF92.9/$.

In order to limit the inflation, depreciation and avoid devaluations effects, households increase the dollarisation of their savings and invest in construction and transfer their funds abroad. Boyce and Ndikumana (2002) demonstrated how Sub-Saharan Africa is a net creditor vis –à-vis the advanced countries.[18] Households with high income tend to invest more than others categories of population

Aid

[18] James Boyce and Leonce Ndikumana established that a core group of 30 Sub-sahara African Countries, with a foreign debt of $178 billions, suffered a quarter century of capital flight by elites totaling more than $285 billions including imputed interest earnings, leaving Sub-Saharan Africa a net creditor vis-à-vis the rest of the world.

Aid reinforces the culture of dependence (Devarajan et al 1997). Rajan and Zingales (1998) depict aid as hurting the growth and weakening institutions. However, Rwanda can't fund its budget without any external support. The investment budget is not sustained without aid and debt. It entails a strong vulnerability to the external shocks. But also aid and debt bring a lot of politics in the economic management sphere.

Turning to the use of debt it is unpredictable. UNCTAD writes (2004) the likelihood of achieving debt sustainability under different scenarios in 2020 was 57 % (PRSP formulation: too unrealistic assumptions) and 10 %(prediction based on historical economic growth), conclude IMF and WB. A high proportion of the debt is part of the public investment. Its return is unpredictable.
Theoretically, the present net value of the debt = $\sum$ (Annual Revenue (t)-Service Debt (t))/ (1+i) ^ (t), t>0, i is the central bank interest rate, t the time.

To reach the HIPIC completion date, after a number of consecutive years of Poverty Reduction and Growth Facility (PRGF) implementation, while reimbursing the external debt, the government disinvested in social welfare (cost recovery of education and health services,…). Rwandan debt service as a % of export earnings for the period 1995-97 was 17.8%.

Once the debt is forgiven at the HIPIC completion date, the dilemma is how to access new loans without falling again into new unsustainable debts since grants are not only unpredictable and under conditions most of the time, but also insufficient.
To strategically deal with debt, UNCTAD (2004) recommends a complete debt write-off, as a "Moral imperative", on the belief it will guarantee resources to help meet the MDGs in Africa.
However, if previous debts proved unrealistic, mismanaged, there is high likelihood to continue to be so. Write-off can send a wrong signal as to persistently support wrongdoings and thereby discouraging good payers.

Sawada (1994) and Rockerbie (1994) show that the external debt obligations have a significant negative effect on economic growth. Concerning the debt, there has been convergent views on how this debt was odious in holding victims of debt redirected in wars and genocide though it has to be repaid by victims.

There exists an interesting emerging international convergence towards the aid effectiveness through the procedures harmonization, increased predictability and mutual accountability (Déclaration de Paris).

2.3.3 Impact of Institutions (African-dummies) of HIV/AIDS

During the 1980s, the Structural Adjustment Programme (SAP) was introduced in Rwanda.It aimed at liberalising the economy by deregulating it in halting public subsidies, introducing the cost recovery mechanisms for access to the public goods and to more or less use the market incentives in most of activities and downsizing of the public civil servant structure. It is the "End of the Public Culture" which is being replaced by the "Corrosion of the Character" to paraphrase Sennet (1999).

The Permanent Income Hypothesis is strongly affected by structural adjustments. Individuals adopt either a forward-looking or adaptive behaviour. There should be a strong psychological effect of SAP due to uncertainties on job carrier and thus increased vulnerability. Also, the shock to income and consumption can impact beyond the concerned people over time and shape new mental models like disloyalty, selfishness, corruption which erode the public ethics, and the social capital. In this situation, the life-cycle model is no longer a sustaining behavioural strategy; it is disrupted. Sennet (1999) illustrates the corrosion of the character in the context of the new capitalism. He simply put it as follows: "No long term is a principle which corrodes trust, loyalty and mutual commitment"[19] .

If there is no longer trust, the social capital, the common interest, solidarity cut across the public interest and can make government inefficient and divisive around the "*cliques"* and Lack of confidence undermines public affairs, discourages the investment and tends to end up in generalised political conflicts.[20]

[19] Sennett, R. (1999) Corrosion of the character : the personal consequences of work in the New capitalism Norton &Company, New York

[20] Burundi, Ivory Coast, Liberia, Republic of Democratic of Congo, Rwanda, Sierra Leone, Sudan,...

Political violence first targets opposed high statuses both educated and working in formal settings or entrepreneurs running their own business. However, it is difficult to extract their specific contribution on the poor economic performance.

Ansom and Marysee (2003)[21] elaborated on the constant rising of income inequality and pretended that this was one of the trigger of harsh violence in early 1990s. However, it is still to prove how an increasing income inequality in a country where the leadership is male - predominated brings to generalised women raping. Apart from few women co-opted on board, women do not control any political constituency. Politics has fuelled the distribution and the incidence of the HIV/AIDS. It is a fact that the corruption and opacity tend to end up in generalised institutional collapse and subsequently in the political violence.

Rodrik (2003)[22] puts impact of policies quality and their implementation capacity of institutions in dummies variables. He asserts that they tend to concentrate on their extremes in many cases.

The stigma effects of disempowered people by politics, socio-economic institutions and markets drivers:

Human Development is " providing the basic amenities "of shelter, sanitation and clean water ,and improving social infrastructure to guarantee education, training, health care, and population services, ensuring equal access of the poor to legal assistance, credit, and financial services and employment opportunities" (Reed). Poor countries cannot provide all these basic amenities. Lack of basic amenities is a trigger for HIV/AIDS spread.

When these amenities are absent for a long period in a substantial proportion of the population, desperation results in which leads to violence. Violence will lead to sexual violence and therefore an escalation in AIDS statistics. When people become desperate they can get involved in whatever transactions (including the sex where they exchange it for goods, services or money), to such an extent that the perceptions of the risk, socio-cultural

[21] [21] Ansom A. and Marysse S. (2003): Evolution and characteristics of poverty and inequality in Rwanda: coincidence of violence and structural constraints, page 8.

[22] Rodrik (2003) Raoul Prebisch Lectures, UNCTAD, Geneva.

and/or psychological barriers begin to break. The mental process seems to liberate a kind of last and crude energy of renewed motives.

Such new behaviour sustains until something stronger happens. This can be unexpected new resources, exhausting disease, suicidal behaviour (real or the like) or a strong re-interpretation of the situation after some events (example: Amnesty International, 2002)[23]. Three options seem to emerge from this strange behaviour:

First, there is a positive re-interpretation, which brings about a positive attitudes transformation. Arguably many PLWH adopt such behaviour once they know their status.
At this level, this psychological rejuvenation very possibly, could re-energise physical health. An Example of this phenomenon is some conversions to new denominations or revisiting their old ones (Skhosana 2001). Some adults and young people embrace and /or experience new faith (enlightenment of some sort) especially the Millennium Religions or some Catholic fundamental groups like (*Mouvement Marial*),[24]…, which propose direct link with almighty, a guaranty of another life in the afterlife but through necessary way the death and then straight into the heaven[25] in response to HIV/AIDS nightmare. In a way, it is an answer to "death, where is your victory?"

Those who adopt a suicidal behaviour seem to either become anti-social in many ways; characterized by alcohol and drug abuse; they tend to be degenerate such that normal interaction with others becomes a constant irritation. Conversely, they can attempt forced or a strange socialisation or psychological experiments that are taboo or impossible.
The last group is those unstable changing very erratically from one extreme to another from time to time.
These last groups are not only highly vulnerable to the HIV risk but also are prone to be propagator of it.
Concerning rape spread, it was used as a supervised physical and psychological destruction weapon during the genocide against Tutsi (e.g see traumatizing Tutsi woman with her baby remains in Nyamata Memorial Catholic Church). For example, it is estimated that at least a

[23] Amnesty international in Interview with females genocide survivors 2002
[24] Christian Forum around devoting prays to Saint Mary, mother of Jesus
[25] The sublimation helps to survive in providing a new raison d'être which has truly or supposedly) a meaning.

quarter of a million women were raped during the genocide in about 100 days (at least 3000 women per day). Many survivors face significant health complications, including HIV/AIDS, children born out of rape with HIV/AIDS, sexually transmitted infections (STI) that increase the likelihood of HIV transmission, as well as emotional trauma and severe social isolation. In addition, a large number of widows and orphans from the genocide are among Rwanda's most impoverished and vulnerable populations that are at higher risk of HIV/AIDS.[26]

Later, within the camps inside and out of Rwanda, it was both an uncontrolled sexual violence and a political orchestrated intention of reproduction and not to kill or to coldly traumatise. Whilst life in camps went promiscuously, the Hutist[27] government into exile pushed people into what it called "deaths replacement" by forced pregnancies.

Conflicts promote promiscuity and sexuality through heterosexual contacts, mainly due to hostily activities, displacements and social economic collapse. The full control (social, economic and military) combined with uncontrolled war emotion of the same side result in gender based violence ending up in systematic rape and sexual abuse[28]. This increases HIV/AIDS and unwanted pregnancies and subsequent high infant mortality due to HIV/AIDS. As Mcquinn (2000) aptly put it "much of rape's potency as a weapon in war or peace derives from societal acquiescence "*ceceka n'ishyano*" (it's a shame, just forget it").

A- Social capital disruption and HIV/AIDS

Long and open conflicts have also negative consequences on social capital even though some survival practices reinforce other social sub-networks like ethnicity, regionalism, etc...

Fukuyama (1997) and Dasgupta (1999) recognize that some networks have negative effects. The political mobilization diverted the social capital for its own purpose ending up as generalized glue forces for the violence promotion.

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[26] USAID/RWANDA Integrated Strategic Plan 2004-2009, page 9.

[27] However the fact was not to be necessarily Hutu (1- there was no evidence of such claim by a truly representative hutu entity and, 2- opposed hutu were also targeted) rather to defend the pure prohutu ideology as opposed to any alternative political agenda within Rwanda.

[28] Japanese Forces in South Korea, British Army in Kenya in Masai land

Violence facilitates the fast destruction of positive values, attitudes and encourages the forced population movement with the subsequent promiscuity. HIV is positively correlated with the population concentrations particularly in the hazardous conditions.

There is an intergenerational institutional memory if the critical mass can every time maintain the generations' web together. The high mortality and morbidity of active people due to HIV/AIDS tend to destroy such mechanisms in putting on strains the rest of the population for coping with fewer members.

B. HIV and socio cultural factors

Depravation and deprivation

In Liberia (2001), talking about the clitoridectory an old man describes the situation like this:

> *"It has lost real meaning and should be done away with. Moreover, it does not stop promiscuity, rather the opposite, look around,see what is happening?"*

Depravation and deprivation are positively related to high risk of exposure to HIV infection.
In the context of endemic poverty, the strong interrelations between deprivation and depravation are due to many other intermediary factors such as rampant family authority bleaches, gender issues, residence and values crisis in modern and global behaviour pattern already adopted in the country.

Inadequacy of information: For 59.1% of people in country representative survey people in 2003 conceded that the communication on HIV/AIDS was inappropriate[29].
Depravation is not necessarily embedded in local African culture or any other sub-culture or faith as such. Rather, it progressively erodes accepted positive values of some sub-strata of the population without becoming a normative behaviour.
However at a certain point in time, it can be a virtual attractive model since it is more visible in the highest strata of the society which is already part of the global society at a local level. This

[29] CNLS and UNDP (2003) Etude des comportements face au risque du VIH/SIDA, Kigali

category has a high income, dense connections through various channels (travels, use of multimedia and it lives in urban areas).

Gender and HIV/AIDS

The gender and residence factors (being urban girl) are still biased by less autonomy in choosing the residence even for the skilled ones with sufficient income. This has HIV/AIDS risk implications. Newly arrived in urban areas, girls have poor social networks, find new values pattern and have to bargain more than men in almost everything (new job, contract extension, tendering, government services,...). It has been commented how such bargains end up playing around sexual harassment.

Even though HIV/AIDS is strongly related to gender bias as one of the major cause (prima facie), it can be argued that it still also lies with the fact that the society is more likely permissive allowing new risky behaviour for both men and women. This is grounded in the so-called modern individual rights agency (social experimentation such as radical individualism, universalism of rights, human quest of utopia (e.g. extra-marital sex, … pervasive cohabitation,…, lifetime singleness[30],….). This is broader than the gender battlefield[31].

In the weakened social and public institutions environment, the individual rights of the dominant culture invade fastly the other cultures much easier particularly in moulding new mentalities by means of new global values through various mass media (TV, radio, newspapers, mobiles phones and internet) which tend to alienate people. To sum up global ideological values which promote individualism and hedonism have provided a fertile ground to social diseases and HIV/AIDS included.

These are conflicting demands on culture. Culture is being questioned, contested in many respects rightly or not (e.g. about its gender perspective, family values,…) and at the same time, it is pressed to provide the same society with a solid foundation for the family, the

[30] 1Corinthians 7: 9:" But if they cannot control themselves, they should marry, for it is better to marry than to burn with passion.".

[31] Morocco is a known touristic destination for more Muslim males than Muslim females. HIV in Arab countries is highly associated with the fact of having lived abroad particularly not Arab countries and the society does not allow permissive attitudes towards females. If physiological effects controlled, women Muslim in those countries have lesser HIV prevalence.

community values repository and the mental model. In the meantime, it is also becoming fuzzy. Such culture in mutation would likely be of very limited help to sustain a strong positive behavioural change needed for multilayered, fragmented, contradictory aspects of the self.

However, the openness to other cultures can help to instil new life skills indispensable in the fight against HIV/AIDS.

2.4 Summarising Conclusion

HIV/AIDS affects demographics characteristics by changing the structure: the mortality and morbidity distort the workforce composition and the family structure by aggravating the orphanage. The labour composition changes depending on the age distribution, the HIV/AIDS infection rate among age categories and gender. The young death result in short life expectancy as one the consequence of generalised HIV/AIDS and adversely impact on the economy by destroying the human capital in the prime age.

The education as an intensive labour sector is on of the sector which might be fragilised by the HIV/AIDS.

Health factors exacerbate the spread of HIV/AIDS through various channels: non circumcision, PMTCT, STIs,… especially Trichomonas Vaginalis while tuberculosis and malaria cases grow steadily because of it and have an incredible impact on the public health system and the entire economy.

HIV/AIDS include issues related to social and political conditions, the status of women and other marginalised groups in society (widows, street children, minors heading families,…).

Also fundamental macroeconomics (investment, aid, debt, land, international reserves,…) management has large implication on HIV/AIDS spread in combating or aggravating the poverty and inequality. The poverty reduction and human rights (rape, social exclusion,…) interplay with the HIV/AIDS.

Institutions dimension have to be seen as one the major causes of the political unrest and impact profoundly on the economy at large. In many ways, HIV spread takes on the fragile institutions which also have a very limited capacity to mitigate its negative impact.

In fact, Dr Giraldo suggested that the only rational way to stop the spread of the AIDS epidemic in the African continent is by finding solutions to the economic disparities and misery that are rampant.

It can be argued that the link between HIV and cofactors might explain why the epidemic tends to be higher than in countries with better health system regardless the promiscuity issue. The high incidence of STIs and socio cultural practices in the HIV transmission are evidenced in many situations.

CHAPTER 3- RESEARCH METHODOLOGY

To evaluate the economic impact of AIDS, Greener (2002) categorises studies into four clusters:

1. There are qualitative studies based on case studies of particular communities or areas;
2. The human capital approach, which assesses the cost of AIDS by estimations through the foregone earnings or production of AIDS victims.
3. Econometric modeling, where the impact of AIDS is factored into a growth model with estimated parameters;
4. The equilibrium modeling (computable general equilibrium (CGE)), that attempts to identify and quantify the different channels of HIV/AIDS impact through simulation.

This study attempts to apply econometric tools. However, it also combines the quantitative and qualitative approaches by bringing interpretive facts. The HIV/AIDS impact assessment needs to be understood in terms of behavioral, structural relationships and quantity measures. The econometric modeling allows to break or aggregate the abstract facts in behavioural, structural, dataflow and layout essential sub-components by estimation of the parameters. There is a clear difference between essential and nonessential information. Very limited information is used in this methodology as key explanatory facts while providing strong and accurate deductive information of HIV impact on economic sectors.

Moreover, the econometric model describes the whole economy by very few variables and various relationships between them. By defining variables in dependent and exogenous groups, it is much easier to demonstrate interactions and eventually the causations involved, thereby, providing guidance for action. It is almost straightforward when more influential variables on HIV and GDP can be prioritized through the ranking of their effects on each other. Statistical techniques provide accurate information on the impact of variables in interaction on each other.

Arguably, these quantitative methodologies bring an added value in measuring the HIV impact whereas the critical analysis explains and/or gives a background to some omitted or intangibles facts and reasons behind of such impact and processes involved.

Furthermore, drawing policy and strategies for implementation are clearer than in the only qualitative study. As the two approaches have been combined to certain degree, they overcome the weaknesses of each methodology.

3.1. Econometric approaches to measure the impact HIV/ AIDS on GDP

McPherson (2000) challenges the conceptual linear models commonly used to explain the HIV/AIDS scenario. He suggests that HIV explanatory factors should be nonlinear with respect to the GDP growth rates. The interdependence of main factors that intensify the epidemic should be considered as retrogressive with time lag effect and therefore compounding. This brings about the cumulative and spill over effects of HIV/AIDS on the GDP.

3.1.1 Neoclassic models: Open Harrod –Domar, Solow -Lewis growth Models:

HIV/AIDS is integrated in the model through the labour factor which can be skilled or unskilled by taking account for the level of education and experience. It is thus a demographic – economic model trying to capture the demographic trend and its effect on the economy.

However, its usability is limited in its deterministic relationship with other variables such ascapital. Even though it integrates survival probabilities in the context of HIV maturity, for labour prediction, limitations can persist. The model does not fit the reality it describes since many other important aspects (which can't be converted either into the capital or the human capital) do not have a place in the model. It is a partial equilibrium model which simply demonstrates the HIV/AIDS impact on human capital but it downplays other human factors interactions of strong impact. It overlooks or underestimates the interlinks for example the diversity and the level of activity. It does not offer recommendations or guides for action.

An application of this model is Spectrum Policy models funded by USAID and widely used in many developing countries. Cuddington and Hancock (1995) explored the impact of HIV/AIDS in neo-classical model with two sectors, including a link between the age structure and the workforce and productivity through the experience and the job learning. Botswana Institute for Development and Policy Analysis (BIDPA, 2000) used a Solow-type production function to capture effects of HIV/AIDS on the labour force and on aggregate output.

3.1.2 Computable General Equilibrium (CGE)

There are three main modes through which HIV/AIDS has impact on economic growth:
The decline of the active population size, the loss of labor and human capital accumulation effects and the decrease of the productivity by its effects;

Arndt (2002) used the CGE model for Mozambique (2001) in economy-wide approach to evaluate the impact of HIV/AIDS as a cross-cutting problem. It used essential social accounting matrixes data as reflected in national accounts with some estimation. The 3 sectors of the economy (agricultural, industry, services) were split into 19 productive sectors in the case of Mozambique. The number of productive sectors depends on the institutionalisation of the economy through which data are generated, and transformed into knowledgeable information.

The use of GCE also underestimates seriously the HIV/AIDS impact if it is at an advanced stage. A linear relationship between variables limits too much sectoral interactions and the population movement effect from both rural to urban and vice versa.
Many studies have used a version of it, thereby, underestimating the impact calculated for the long term scenarios. This led to using new modeling tools in order to capture the interaction of various factors. In fact, Greener (2002) agues that it is the distribution of AIDS cases (particularly across labor categories) rather than the absolute numbers of AIDS infections that is crucial in determining the impact of AIDS.

Kambou, Devarajan, and Over (1992) applied this model to the Cameroon case. The GCE could, indeed, be used for a short time and eventually medium term but could not be used to forecast HIV/AIDS impact on other variables in the long term because of the compounding

effects of many of variables. The linear interdependency entails that the calculated impact will lag behind the reality over time (increments grow slowly). To overcome this weakness, Mc Pherson (2000) recommends using the retrogression model.

3.1.3 Endogenous models:

Retrogression model

The retrogression model uses the theory of endogenous growth. This theory stipulates an accumulative causation process (Myrdal). The retrogression model integrates key variables of economy: gross domestic product, investment, labour, monetary variables, population characteristics (dependency ratio, life expectancy, …., in interdependent way which can be formulated as a simultaneous system of equations.

This framework has some similarities with Vicious circular and PEDA model. However, it is very different in variables used. Retrogression is embedded in classical macroeconomic reasoning like inflation, exchange rate, money,… integrating the utility theory to describe the rational behaviour.
PEDA is rather population approach-based and uses less average data at national level. Instead it uses microeconomic data i.e. households information.

A - Vicious Circular model (Dasgupta/ Cambridge).

The vicious circular model which presupposes the interdependencies between the Population, Environment, Development, and Agriculture corresponds to endogenous process methodology. It has deeply inspired the Population, Environment, Development and Agriculture (PEDA) Model of UNECA.

PEDA is an interactive computer simulation model demonstrating the likely impact of national policies on the food security situation of the population in a various scenarios of natural resources (water, land, …), population trends scenarios with various technological levels (integrating level of education).

Through the population variable, it also integrates the level of HIV/AIDS spread, fertility, literate life expectancy[32] (PEDA Technical Manual) and gender status.

It also describes sort of traps which can occur on some segment of certain variables (food insecurity, high illiteracy, high fertility, endemic HIV/AIDS …). Masanao Aoki (1998) shows those kind of attractive traps (basins) by the JUMP MARKOVIAN PROCESS how agents operate in endogenous stochastic and dynamic environment (e.g. illiterate, poverty and land degradation) are subject to dynamic external environment (e.g. food insecurity, HIV/AIDS, endemic malaria, and environment degradation).

Mathematically these traps correspond to local extrema (minima or maxima) of a multivariables function. But PEDA resolution of the system does use a simplified jump markovian process with few hierarchical steps.

Turning to traps, Masanao Aoki (1998, p.197),puts it as follows:" *in general, the deterministic dynamics model will correspond to the landscape with many locally stable or metastable, that is, stationary equilibria as well as locally unstable equilibria*".

He argues that these models can work with basins of attractions, barring dynamics with strange attractors since the stationary states are located in basins of attraction, separated by barriers of varying heights. In stochastic dynamics, states do not stay necessarily in one basin, but may move around in different basins of attractions. In this case this simply would correspond, for example, to set the transit probabilities of getting HIV positive, from HIV positive to AIDS disease, or from AIDS disease to terminal phase (to die of AIDS) in markov process. In Bayesian conditional situations (a priori information) the education level or food insecurity status can be added to each state while to take into account of antiretroviral (ARVCOV) is to administrate (ex post information). This provides an analogy to describe traps of people in various critical situations (for example female teenagers moving areas from poorest rural areas to urban promiscuity pockets).

While the vicious circle stipulates that fertility will increase in the context of environment degradation, the case of Rwanda is quite opposite as also suggested by the PEDA model.

[32] Numbers of years a person is expected to live in a literate status from 15 onwards.

The empirical observation is that fertility has been constantly declining while natural resources are shrinking. This model integrates some issues like weakness of institutions from Amartya (1993) when it comes to food distribution process.

The study draws on PEDA and retrogression models in theoretical foundation to the model to apply to the Rwandan case by using the Vector Autoregression and linking education, HIV, land availability, among others.

However, the empirical model formulated for the purpose of this study is specific from the Vector Autoregressive Model in specifying some variables as exogenous and using simultaneous system of equations.

B- Non Structural Models /Vector Auto regressive (VAR)

Non structural model with Vector Auto Regressive model (VAR) are an alternative to multi-equation modeling through the work of Sims (Pindyck 1998). In this modeling, all variables are assumed to be endogenous and provide the largest number of lagged variables to capture the most internal dynamic effect.
It is not necessary to specify variables in terms of endogenous and exogenous variables because setting exogenous variables is restricting the model. There could be reasons to let all variables interact endogenously in order to capture all the dynamic feedback on each other.

However, the limitation to this is for time series data, degrees of freedom quickly decrease as increase lags unless the time series is extended. For a limited number of lagged variables set by Akaike Information Criterion (AIC), the model benefits to use the Ordinary Least Squares as a consistent and efficient estimator.

C- The autoregressive distributed lag (ARDL) approach to cointegration :

ARDL is an endogenous methodology which captures previous compounding effects through many lags (the more lags, the better, but degrees of freedom are inversely related to the number of lags). It is a relatively new method of cointegration. I did not find any other work

applying this approach to HIV/AIDS so far, if any. The cointegration is to match up the degree of non stationary variables in equation in a way that makes the residuals of the equation STATIONARY and to rid this equation of any spurious regression results. If the residuals are stationary, first difference series are not necessary (Pindyck 1998).

ARDL avoids concerns of choices regarding the number of endogenous and exogenous variables (if any) to be included, the treatment of deterministic elements, as well as the order of VAR and the optimal number of lags to be specified.

The ARDL approach involves two steps for estimating the long-run relationship (Pesaran *et al.*, 2001). The first step is to examine the existence of long–run relationship among all variables in the equations under estimation. The second step is to estimate the long-run and the short-run coefficients of the same equation. If there is a long-run relationship in the first step, then the second step is to estimate the long-run relationship and the short-run coefficients of the same equation (Narayan, et al. 2004).

Also ARDL provides a more efficient approach to the structural breaks in the data. This is very pertinent to Rwanda time series data. Another reason for using the ARDL approach is that it is more robust and performs better for small sample sizes such as this study(1980-1981(1lag)- 2003 and annual data) than other cointegration techniques like that of Johansen,…

3.1.4 Other models :

Many econometric models are not so specific; they are close to one of those above with small changes in what researchers believe useful to supplement the model by experience.

3.2 The theoretical Framework Assumptions:

The study uses two theoretical models:
The econometric model assumes that HIV/AIDS will affect the economic mainly economic growth through: the loss of the labour and human capital accumulation effects, the missed physical capital accumulation and the productivity decline effects.

Hence, the epidemiological model will capture the human and labour loss and the epidemiological impact due to HIV/AIDS. The population outputs obtained from the epidemiological model are used as explanatory variables in the Econometric model.

3.2.1 Epidemiological model

The context is of generalised HIV (UNAIDS, 2003 country profile) since HIV infection rate is more than 5%. Fertility is high (5.3 children/woman) in 2005 but declining (UNECA 1999). The risk behaviour vis-à-vis HIV is still persistent making it rising. Poverty and limited access to Anti Retroviral (ARV) therapy accelerate the transit state from HIV to AIDS and subsequently result in early deaths. Care (2003) reported a very low food intake in Rwanda, particularly in families with long illness caregivers. Sharp net emigration between 1994 and 1997due to refugees movements and heavy life losses to war and genocide was also cited as another contributory factor.

For the scenario purposes, the simulation uses high risk behaviour which posits an accelerated HIV infection rate that would reach 11.01 % by 2015. The intermediary risk behaviour will lead to 9.5% by 2015. The optimistic hypothesis assumes the decline of HIV to 6.1% by 2015.

Each situation involves 4 hypothesis (scenarios) corresponding to 4 combined graphics in the same Euclidian space to support the comparisons: the hypothesis of no- HIV, with fast HIV positive trend (up to 11.01 % in 2015) and middle HIV positive trend (up to 9.5 % in 2015) and 6.1 %, the progression is assumed nonlinear (accumulation of interdependent effects).

The assumption of a constantly progressive path of HIV/AIDS presupposes lower rate before the 1994 (UNAIDS, Government). This is in contradiction with Allen and others (1991) and Ainsworth (1993).

This research uses the “Spectrum suite Policy Models”. Its epidemiological methodology can be found in the AIM Tutorial Manual from page 71 to page 84 as referenced.

Detailed technical assumptions to meet in the Spectrum suite Policy Models methodology were extracted on 25May 2005[33]:

The Spectrum suite Policy Models have been developed by Futures Group and the Centre for Development and Population and Research Triangle Institute (1997) and funded by USAID. This set comprises seven -computer sub-programs dealing with the approaches to analysis and presentation of existing information - essentially socio-demographics-and an excel template for a limited economic impact estimation, but customizable, for determining the future consequences of policies and programmes targets.

This software package supports simulations on demographic variables and GDP impact in "with HIV/AIDS" and "without HIV/AIDS" settings. However, in the context of HIV high rate, the GDP impact can be questioned in its linearity and the lack of the interdependency of the socio economic factors as HIV/AIDS and Human capital do.

For that reason, the Spectrum Model simulation on GDP impact should be compared to other concurrent models if the rate of HIV prevalence is too high.
It is downloadable from the website address of the Futures Group as referenced. Many countries have been using it. It is a very popular model simulator.
Two other sub-models connected are EpiModel and Easproject .

The methodological approach was suggested by Chin, Lwanga (1989) and Mann, of (World Health Organization) developed by Sokal and Stover…

Moreover, almost similar formulas can be found in many quantitative demography[34] or epidemiology textbooks.

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[33] http://www.futuresgroup.com/WhatWedoDo.cfm?page=Software&ID=Spectrum.

[34] Pressat, R. (1980): L'Analyse Démographique: Méthodes, Résultats, Applications, 4ème Edition Paris : Presses Universitaires.

3.2.2 Socio-economic and demographic assumptions for the econometric model

GDP and HIV

Nattras assumes that high levels of HIV/AIDS infections are associated with a low GDP in many cases. This portrays a general picture of the HIV/AIDS at a global level and its dramatic impact on Sub-Saharan Africa and specifically Southern Africa (Whiteside, 2001, Barnett and Whiteside (2000). Africa accounts for more than 60% of 13 millions cumulative cases of adults HIV infections worldwide as at mid 1993 (WHO/GPA).

However, this assertion is misleading. Although the highest HIV rates are in the most sub-Saharan African poorest countries, the poorest families are not necessarily the most infected. In Rwanda, like in other many African countries, HIV is more concentrated in urban areas and it has been argued that there was a positive correlation between high incomes of partners with the ante-natal clinic attendees distribution. Even though HIV trend would change in the near future it seems to cut across various income strata (generalized to the entire population) with more concentration in the urban poor households and some high income. Moreover, the poorest population is particularly rural based where the HIV infection is the lowest.

Furthermore, Ainsworth and Over (1994) wrote:

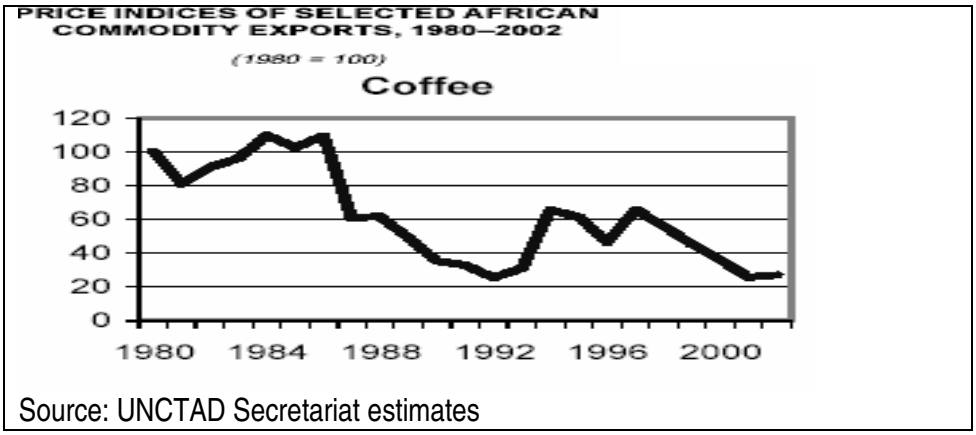
> *" infection rates are higher in urban areas than in rural areas, and studies suggest that they are highest among urban high-income, skilled men and their partners. Macroeconomic models show that the greater the infection rate among educated workers and the greater the propensity to finance medical care out of savings, the more detrimental is the impact of AIDS on the growth of per capita income."*

The income depends on the socio-economic status which is mainly determined by the education levels attained in family. In Uganda, Serwadda and other (1992) found men and women with secondary school have infection rates (20% and 41 %) more than twice as high as men and women with no education (8% and 14%).

Investment, Labour and HIV/AIDS

Investment impacts positively on economic growth. There is a positive correlation between the investment and the GDP. Unlike investment, HIV deteriorates the economic growth more and more at high levels. GDP and Investment change in opposite direction of the HIV.

Savvides (1992) asserts that the incentives to invest are weakened by the debt servicing



Source: UNCTAD Secretariat estimates

compulsion. The debt is perceived as a tax on investment for the in debtor country.

Less investment corresponds to low labour opportunities creation which leads to very low economic growth by virtue of a low level of consumption. The labour productivity depends on the categories of workers. The economic sectors determine the type of labour : unskilled labor operates essentially in subsistence agriculture and in informal settings and has a very low if not declining productivity .

Figure10: Price Indices of Coffe, Rwanda , 1980-2000

In the context of landlessness (or almost), large unskilled labour, high unemployment and under-employment the per capita economic growth will decrease. Unemployment issues and the low productivity labour pull down the economic growth, thereby, offsetting the skilled workforce productivity contribution.

HIV has detrimental effects on the investment by diverting savings to medical treatment and also by loss of specialized labour that can rise the cost of wage of specialised labour.

Furthermore, investment in agriculture is not sustainable on basis of existing international prices of main cash crops: coffee and tea for Rwanda. Productivity in agriculture depends on inputs prices: fertilizers, seeds, labour wages levels and the weather. In such a context, rational behaviour is to divert most of the land to subsistence agriculture which does not allow savings, thereby, laminating investment

Exchange rate, Aid, Debt

A high exchange rate discourages investment, low interest invest stimulates it. The mechanics of devaluation (2times) and daily depreciation of the local currency has tremendously inflated the external debt. AID should stimulate the economic growth via the investment and or social transfers which in turn boost investment through the demand of goods and services of entreprises or savings from households.

However, aid is mostly given on condition of obedience of some sort, thereby, negatively affecting the impact on economic growth by weakening autonomous decision making. This stems from the content of the aid schemes (inappropriateness, conflict of interests, conditions, lack of the management capacity of the recipients, malpractices,…

Aid reinforces the culture of dependence (Devarajan et al 1997). Rajan and Zingales (1998) depict aid as hurting the growth of and weakening institutions.

It has distorted the labour market and led to some management practices that are not necessarily conducive to attract the skilled labour in the public sector. It partially contributed to the demotivation in the public civil service. AID seems to change at a certain level and starts getting a negative effect on economic growth unless strict measures are taken (Rodman 2004).
To a certain extent, debt management poses the same problems. It would be more manageable if government strategically handled it especially in considering that Rwandan debt service as a % of export earnings, 1995-97 was 17.8%.

The debt is also frequently tied up. The lack of Debt and AID the management capacity and corruption tend to derail the debt programming and disbursing both in terms of scheduling and priortisation. Karagol (2003) argues that the rise in the debt reimbursement adversely affects the economic growth. The decline in the GDP negatively impacts on the capacity of the economy to repay the debt. Debt like aid can change its impact direction to a certain degree, after have being positive. This means that the relationship is not linear; it could be

described by a polynomial function because of uncertainties highlighted by Schimdt-Hebbel and Mueller (1990), and Fischer (1991).

Land

Land supposedly brings more wealth in the proportion of its quantity and quality. Conversely, lack of land and or its unequal distribution places a negative impact on the economy, argues Marysee. Thus, the increase of arable land would positively impact on the economic growth. The agriculture production represents about 43% of the GDP (2003) and it is predominated by the households production primarily as a means of subsistence substance. The average size of land per household (0.3ha) is too small and the inputs (techniques, fertilisers,…) are also limited. The best long term economic perspective in this case would be to get out of this sector. There is a need to transfer more active population in other sectors (industry and services) and also by a faster urbanisation, a consistent and coherent villagisation. The rural –urban incomes divide is supported by the GINI concentration and the Lorenz curve trend. For many reasons, Rwanda has no choice but to urbanise as high proportion of the population as possible. The long term population distribution strategy would recommend for every farmer could, for example, to be fully employed while applying modern agricultural techniques. This would require several hectares per farmer.

From 1990s, the subsistence agriculture and livestock production have experienced some cycles due to meteorological changes such as (El Niño) which caused food shortage in some parts of the South-East and East of Rwanda. PLWH are particularly prone to food shortage. They become more vulnerable to opportunistic diseases and reach more quickly the terminal phase.

However, empirical observations do not support the assertion that natural resources abundance leads to wealth, meaning that the real long term growth drivers are not necessarily natural resources. There exist some strong economies with very limited land such as in Belgium, Israel, Singapore and others. The agriculture output proportion tends to narrow for fast growing economies, while other sectors grow bigger.

Health, education, life expectancy and HIV/AIDS

As a proxy to good health services, one nurse or doctor for a few people in the whole is an example of a good health indicator. Fewer and fewer people per nurse should improve health conditions which, in turn, will trigger the GDP via the increased productivity of a healthy popuplation.

The anti-retroviral (ARV) therapy delays the process of falling ill of AIDS opportunistic diseases, thereby, avoiding early deaths due to AIDS. ARV officially began in Rwanda in 1999. It assumes it will cover about 90% of PLWH/A in 2015. There are many reasons that can explain this situation: many people fear and avoid HIV/AIDS tests even if they are seriously ill, some have strong side effects and stop the treatment while others can not manage to go to health centres,…

Life expectancy at birth is directly linked to the quality of health services, socio-economic conditions and education level. Life Expectancy is negatively correlated to the mortality. A high mortality results in low life expectancy. Good health services, better socio-economic conditions and a high level of education tend to improve life expectancy especially if they are fairly distributed between both women and men.

Life expectancy at birth = (2-mortality rate)/2mortality rate[35].
HIV/AIDS by increasing the mortality rate automatically decreases the life expectancy.

Lagged GDP and HIV

Krueger (1991:366) postulated that GDP is affected by the level of the per capita income which means it depends on previous level of per capita GDP. If the behaviour change controlled the high level of the income is positively correlated to HIV infection rate.

- [35] Olivier R. (1970), Techniques Quantitatives de la Planification, Paris, OVATY, page 133.

3.3 The econometric model specification

In this case study, the model specification builds on the vicious circular model (Vicious Circular economic theory (Dasgupta/Cambridge University), which presupposes the interdependencies between the Population, Environment, Development, and Agriculture aspects (PEDA). It is an endogenous model[36].

The real GDP per capita is obtained by dividing the GDP by the population and the price index. The GDP is also divided by the nominal exchange rate in order to get the GDP in dollars. The labour is split into 2 sub-categories unskilled labour and skilled labour. These categories correspond more or less to the kind of activities. Unskilled labour is more popular in the subsistence agriculture and the informal sector.

The debt stock is cumulatively calculated. We need to know the annual amount of debt allocated which is available for immediate use. This is simply be obtained by the difference of the annual debt stock between 2 consecutive years.

Table 7 : Definition of variables

- Yt= GDPR = Real GDP per capita at time t - Yt-1= GDPR at time t-1 (lagged variable) or GDPR(-1) - LABSKLISt=skilled labour at time t, - LABUNSKILt= Unskilled labour at time t - INVESTt: INVESTMENT at time t - HIVt = adult HIV positive rate at time t - AIDt= Official development assistance at time t - CDEBTt=Annual Change at time t -	- LANDt= Landt/POPt= land per capita at time t - NEXCRt= nominal exchange rate RwF/USD at time t - LEABt=Life expectancy at birth at time t - SSENRt: Secondary school enrolment rate at time t - POPURBt= urbanisation rate, at time t - POPNURSt= population per Nurse. At time t - ARVCOVt= It is a dummy variable - ut = error term per equation - vt = error term

[36] Refer to UNECA: UNECA PEDA Model: FSSD Division of the ECA, PEDA Focal Point, P.O. Box 3001, A.A., Ethiopia, Fax. (251) 1 5144 16, E-Mail: Peda.Uneca@Un.Org.

3.4 The behaviour or structural equations

Structural equations are also called behavioral equations because they intend to translate the economic behaviour into statistic relations.

The dependent variable GDP while premised on the vicious circles theory will capture only key variables. The formulation of equation on GDP will use the generalised production function.

It is preferred to use a Production function which is a double-log function. The latter uses the log transformation for linearization of its coefficients, thus, it follows:

GDPRt = Yt = f (INVESTt, HIVt, LABSKILt, LABUNSKILt, NEXCHt, AIDTt, LEABt, LANDt, CDEBTt,Yt-1,)

HIVt= f (Yt, P0PNURS, POPURB, LEABt, SECSENRt, ARVCOVt)

Assuming the dependent variables are linked to predetermined variables by nonlinear relationship (multiplication represented by Π) whereby each variable is powered by a coefficient ai in the first equation and bi in the second equation.

$Y_t = \Pi$ ($Invest_t^{a1}$ $Labskil_t^{a2}$, $Labunskil_t^{a3}$, $Leab_t^{a4}$ $Nexch_t^{a5}$ Aid_t^{a6}, a7 $Cdebt_t$, Y_{t-1}^{a8} , HIV_t^{9} , $Land_t^{a10}$), a1, a2, …ai, … a10, (i=1,2…11).

$HIVt = \Pi$ (Y_t^{b1} , $PoPNurs_t^{b2}$, $PopUrb_t^{b3}$, $Ssenr_t^{b4}$, $Leab_t^{b5}$, $Arv\,\mathrm{cov}_t^{b6}$,), b1, b2,..bi,...b6 (i=1,2 ...5)

It is assumed that from infection by HIV to death by AIDS, 99% of infected people will die before 20 years at logistic function pace. HIVt, AIDSt, LEABt, are outcomes of the epidemiological model via Spectrum in every scenario. LABUNSKILt and LABSKILt will be combined in one output which is the labour force for the epidemiological perspective.

The differentiation of this multiplicative model in an additive one ($\Pi \rightarrow \sum$), the powers become coefficients (slope) of predetermined variables followed by logarithms for each variable and the multiplication is then replaced by the addition (Nerlove M. et al. 1979).
This means that the regression coefficients ai, bi, represent direct elasticities - as explained above- of dependent variables GDPt or Yt and HIV with respect to predetermined variables.

LnYt= Constant+ a1lnINVESTt+ a2lnLABSKILt+ a3lnLABUNSKILt + a4lnLEABt +a5lnNEXCH +a6lnAIDt + a7CDEBTt +a8lnYt-1+a9lnHIVt+a10lnLANDt+ + ut

Ln HIVt= Constant+ b1ln Yt +b2 ln P0PNURSt +b3ln POPURBt+b4ln SSENR t+b5lnLEABt+ b6lnARVCOVt + vt

In every equation there is the stochastic term: ut, vt. They are not all necessarily independent from endogenous variables.

Expected Signs of structural coefficients

Assigning signs to coefficients is fundamentally supported by the economic theory. However, in certain cases, controversial empirical results arise, especially around the AID and the Debt. Since many factors are not only and strictly economic concepts, there are open to various interpretations.

Estimates of slopes coefficients ai, bi, are at the same time elasticities because all variables in the model are specified in logarithmic form. A positive coefficient means that the corresponding predetermined variable has a positive impact on the dependent variable; they change in the same direction. A negative coefficient of independent variable corresponds to negative change in the dependent variable. Coefficient a1 is supposed to be positive meaning a positive relationship between the investment and GDP. More investment should increase the GDP. Conversely, a small increase of investment will get a limited impact on the GDP. It is the percentage change in the dependent variable caused by a1 percent increase (if the sign of the coefficient is positive or decrease (if the coefficient is negative) in the independent variable, holding the other variables in the equation constant.

Intuitively a2 should be higher than a3 since the skilled labour has more productivity than the unskilled labour (a2>a3).

Table 8: Signs of regressors coefficients

a1>0	a2>0	a3>0	a4>0	a5<0	a6>o	a7>	a8>0	a9<0	a10>0
b1<0	b2<0	b3>0	b4<0	b5<0	b6<0				

AID and Debt are highly politicised. They can't be only under normative behaviour scrutiny and left to the economic rationality of a homo economicus. They should be non linear with upward and downward trend, depending on the political environment (some grants and debts are tied to conditionalities). In some cases, the natural environment disasters (drought, floods, wars,…) command aid and debt flows in response to the emergencies. The latter corresponds to breakings in the data.

The proportion of the urban population has been constantly increasing and the HIV positive prevalence rate, too. The urban population is more likely to change the behaviour before the rural area, whereby, HIV rate can be reversed more quickly in the long run if the urban population would increase faster. This is probably underway but the fact that the urban population is still far below compared to the rural population HIV will decline; only once the latter has also initiated the behaviour change in regard to HIV. In this situation b3 would become negative.

Since there is a positive correlation between educated people, high income and urban residence, the same relationship is potentially between them and the HIV positive population. More educated people were more likely to be infected. Education is more concentrated in urban areas, indeed, and this should also be linked to others factors like the level of income, social networks density and adoption of modern values.

Yet, the same educated people have more chances to access education and information in relation to HIV fighting. They would also be more capable of changing their behaviour. They are less exposed to other vectors which facilitate HIV transmission (sexually transmitted diseases, delivering baby at home,…) and also get more positive stimulus to adopt a new

behaviours. It is assumed that educated people will adopt the appropriate behaviour change easier than illiterates, thereby, changing the sign of b4 from positive to negative.

The representation of the model above in the 3-Dimension (perspective) would look like a landscape. The extrema (minima and maxima) would correspond to write the total differential of the system of equations and then to derive it by explanatory variable and equate the differential function to zero and resolve for explanatory variables. The second conditions for searching minima and maxima points apply Hessian matrix conditions. Integrating (multiple integration) the function would give the landscape itself (Masanao 1998:243). This also explains the non linearity relationship of explanatory variables (e.g. life expectancy, debt and urban population factors,…) vis à vis the dependent variables over time. In general, traps would correspond to some local extrema .

Various techniques are proposed to resolve the system of equations.

- Univariate techniques:

- Linear regression: Ordinary Least Squares will be applied as entrance point, as easiest technique but with limitations.

- Autoregression Distributed Lag Approach (ARDL): It is an endogenous methodology which captures previous compounding effects through many lags (the more lags, the better, but degrees of freedom are inversely related to the number of lags).

- Multivariate Analysis:

- Unrestricted Vector Autoregression (VAR):
- Cointegrating VAR:

With VAR, the theoretical demands are also very limited on the structure of the mode. There is no need to specify the endogenous and exogenous variables and the largest number of lags in order to capture the effects that variables would have on each other.

The interdependence between variables is captured by a simultaneous system of equations. Given the uncertainty about the specification it is ruled out to use the full information method likelihood (FIML)[37].

Although there is case of important structural changes (important breakings in 1994 and 1995), the autoregressive model using the second order difference equation can be used to simulate the future by the autocorrelation function thanks to the ARDL methodology and the spectrum analysis. This is particularly appropriate if the GDP forecasting seems to draw a sinusoidal process. Thus it is to resolve second-order difference equation by its characteristic equation in both situations of HIV/AIDS and HIV-free.

The solution could be 2 characteristic roots which are complex and of form of $\lambda 1, \lambda 2 = \alpha \pm \beta i$ [38] but inferior to 1 in order if they (GDP function) converge (stability).

The measure of the effects of each of the variable on the GDP (dependent variable) and their interrelations with HIV/AIDS in the first stance are given by regression coefficients.

Tests to perform:

While estimating the equations, MICROFIT 4.0 is programmed to run many tests automatically among others, following tests:

- R^2 correlation coefficient $\overline{R}^2$ adjusted correlation coefficient ;
- F -tests : This test has an overall significance in jointly testing all variables in the equations
- Augmented Dickey-Fulley (ADF): to test the stationarity of the time series: If ADF test proves the existence of unit root, then the time series is not stationary. Hence, differentiate the logarithmic (in this specific case) time series until reaching the stationarity. It entails: first difference ADF: DADF (-1), Second difference ADF: DADF (-2), and so on.

[37] There is controversy around the so-called African dummy: Nkurunziza J. (2003). It seems the Politics has a key role to explain the most of African low economic performance via the investment, which becomes an endogenous variable even though econometric models used so far fail to demonstrate the full significant link.

[38] i : imaginary number $\in$ set C complex.

If the data in the diagram show that the mean variable is increasing dramatically over time, then series are non stationary (Pindyck 1998). ADF is to test unit root of times series. The problem at hand is to verify if the time series are cointegrated, or not.
For the time series, Durbin- Waston test for serial correlation test would be used only where when there are no lagged variables. Rather use ADF for cointegration analysis of all variables in order to check their stationarity if lagged variables are involved. The non stationarity is particularly of importance for the real GDP per capita, and HIV positive rate. It means, for example, for HIV time series that everyone will be HIV infected die and should die of AIDS in the long run at least in 95% cases.

Applications and Assumptions used for the Demographic projections outputs.

Spectrum epidemiologic modeler will generate the demographic projections in a windows-based programme.

The program uses current information on the population, fertility, mortality, and migration to forecast the future demographic trend of a population group.

Out of 7 modules the study uses only 4 modules for this exercise:
1- DemProj, 2-AIM, 3- Rapid and 4- Easyproject.

Demoproj is the backbone of the program in which generates the population trends.

AIM is the AIDS Impact Module which generates different outputs as implications or consequences of AIDS epidemic. HIV prevalence rate time series are provided (various scenarios by the policy implications through targets setting).

RAPID generates some indicators on economy labor force, GDP,… , education (schooling population, school infrastructure capacity and resources needed) and health. It generates labour force trend, schooling statistics, and health statistics depending on inputs.

Easyproject provides an automatic link to the UN Population statistics database which stores time-series of countries population statistics to automatically populate Easyproject as population initialisation.

The following information is necessary as inputs to produce Rwandan projections:
Total fertility rate to retrieve from US census bureau and UNFP website. HIV prevalence rates time series per scenarios "no HIV "and "with HIV".

The population projection bases are retrieved from UN Population database using the hyperlink of the Spectrum Policy. The disaggregated inputs and outputs can be found in Spectrum Policy modeller in the separate windows. The access is by queries like in other database systems with graphic features; it promptly gives either tables or graphics or jointly graphic with table. Data are collected through various sources and for each variable from 1980 to 2003.

As explained above, in order to calculate the socio-economic impact of HIV/AIDS on GDP, some demographic outputs are fed into Microfit version 4.0 as inputs.

The outputs are equations and various subsequent tests on coefficients and the model to validate the quality of relationships between variables.

3.5 Model estimation, data collection and Procedure

Data are collected according to 2 systems: the epidemiologic data protocol for spectrum policy models which produce the outputs used later as demographic variables for the econometric model.

The Microfit Version 4.0 Software is interactive econometric modeling software which resolves the econometric model based on the Tutorial Manual[39].

[39] Refer to: Pesaran H. and Pesaran B. (1998) Working with Microfit 4.0 Interactive Econometric Analysis , Oxford University Press.

1- Procedure- SPECTRUM

Model estimation

Collection of Data inputs

Processing data:

- In Spectrum and export to EXCEL continue processing

Preliminary data analysis and graphics

Estimation/Testing/Forecasting: End Spectrum.

2-Procedure: Start MICROFIT

Model estimation

Collection of Data inputs

Processing data:

Econometric Model :

Univariate techniques:

- Linear regression : ordinary least squares (OLS)
- Autoregression Distributed Lag Approach (ARDL)

Multivariate Analysis :

- Unrestricted Vector Autoregression (VAR)
- Cointegrating VAR

Preliminary data analysis and graphics

Estimation/Testing/Forecasting. Data are organised in the logic of vectors.

CHAPTER 4- PRESENTATION OF RESEARCH RESULTS

4.1 HIV/AIDS Epidemiological impact projections:

The accounting of lost population can be easily captured through the difference between the projections made by US Census and Central Bank of Rwanda (BNR) on one side and the Rwandan General Census carried out in August 2002 previous census data in Rwanda on other side for comparison.

Population structure

For all scenarios, the population would have tremendously increased in the absence of the 1994 genocide. HIV/AIDS had claimed 191,700 cumulative AIDS deaths as at 2005. It will have killed 400700 by 2015.

The fertility rate continues to sharply decline and was 5.28 in 2005. Still, the population structure is young with large base of pyramid structure.

Unexpectedly, the dependency ratio has been declining from around 1993 because of the same trend in decreasing fertility rates and the mass killings of young population. Child dependents were about 4millions in mid 1993; they have reached the same number in 2003, ten years later. The group of 5-14years old in 1994 accounted for 2.5millions of people. It got back to the same number in 2006.

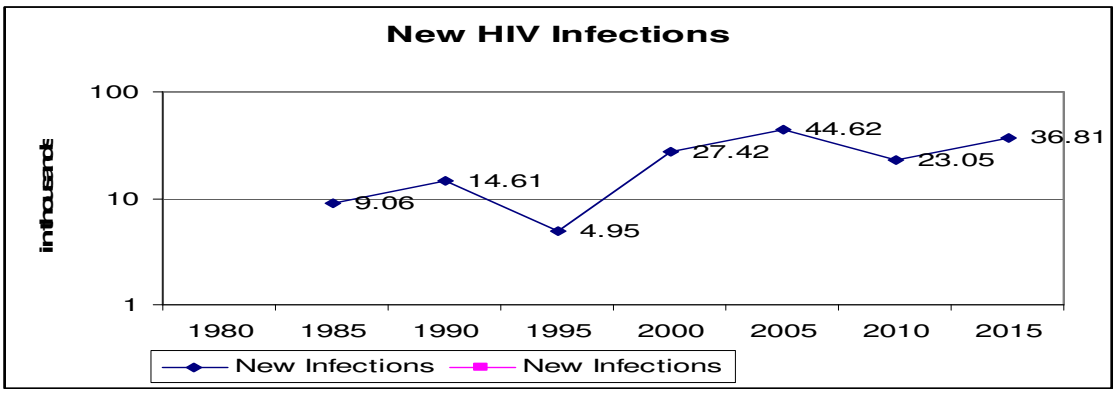
More young people became orphans due to violence, war and genocide rather than HIV/AIDS. From1994-1998, the population characteristics have followed an abnormal trend. The war and genocide have broken the vital events time series that are sound from 1999 onwards.

Concerning the scenario1 with HIV positive prevalence of 6.09% (2015) the population would be 12.58 millions by 20015 whereas the same population no subject to HIV would have been 13,31 millions corresponding to a net difference of 730 000 persons.

Epidemiologic outputs suggest that HIV would start reversing around 2008. AIDS Deaths also will diminish over time due to a combination of the proposed ARV treatment and a likely decline in number of the infections from 2008 onwards. The effects on the fertility rate are very limited not significant. The fertility decline is not fundamentally due to HIV/AIDS.

New HIV infections curve once smoothed shows a relative decline which continues in 2015 and afterwards. The highest number of annual increase in HIV infections is 44,620 people in 2007. The new infections trend is decreasing from 2008 onwards.

Figure11: New HIV infections



Source: Spectrum output.

4.2- Socio- healthy impact of HIV/AIDS

This study seeks to inform the policy debates and advocacy and the updating of the multisectorial planning and monitoring framework which is in use currently in various sectoral responses to HIV/AIDS in the Rwanda.

ARV, PMTC and infant breastfeeding require the nutrition standards beyond social expectations for more than 50%of all households. The food deficit is quasi permanent for poor families. Poverty mapping is well defined in this context in utilising the criteria of having enough food or not. ARV strategy would be highly constrained by food insecurity. There is a structural shortage of food for a high proportion of the population.

*The chronicle malnutrition rate is 42% at national level (*DHS 2001, PRSP Progress Report 2003:71). The proportion of the population under the poverty datum line (cut off US$1) is 60%. The socio-economic conditions in Rwanda are so weak that they accelerate the weakness of people suffering from HIV/AIDS especially the children.

Society does not allow people to cry when hungry. Social values do not allow for open talk of hunger problems surrounding families. People who succumb to the hunger spectrum can be trapped in vicious circles including HIV/AIDS –poverty- illiterate chains. Moreover, internal institutional processes can make the situation even worse by delaying the access of international assistance.

The progress towards the Millennium Development Goal (MDGs) target:" Reduce by two thirds the mortality rate among children under five" will be seriously undermined by HIV although it would not have been achieved even if there was no HIV. In 1990 the under five mortality rate was 195.88‰ in the scenario1, it will be 117.97‰ whereas it would be 85.31‰ if there was no HIV by 2015.

HIV/AIDS is also more concentrated in pockets of more vulnerable strata with abject poverty particularly in urban areas. HIV/AIDS seems to be concentrated on extremes of the population structure. This situation is likely to be transitional converging towards the average income strata from high and very low incomes.

Also the HIV, TBC and malaria when combined they have shown a strong negative impact on life expectancy. The latter is detrimental to the economic growth. Unlike the epidemiological results, the econometric outputs (OLS) highlight the life expectancy at birth high impact on the GDP.

4.3 Socio-Economic impact of HIV/AIDS

The econometric modelling outputs provide very significant results (scen.1).

The constant GDP per capita below is produced in the situation of both genocide and HIV/AIDS. The economy collapsed in 1994 due to the capital flight, devaluation and destruction exchange rate deterioration and subsequent climbing exchange rates.
The domestic prices and the exchange rates influenced a galloping inflation rate which accelerated rampant depreciation, the devaluation of the currency in the 1994 and the bursting of the external debt. It stabilized around 1997. The country was not subject to a high and generalized constant inflation. Nevertheless imports have been a challenge to the country which has structural deficit of the balance of payment.
The production of coffee and the tea (1st export product) seriously collapsed as a reaction to the low producer price especially the coffee and farmers who began growing bananas as a new cash crop.

Households who have a HIV positive adult member with frequent illness status or who have lost one or two active members tend to neglect or simply to stop producing intensive cash crops replacing it by shifting to the less intensive agriculture production of short cycle crops such as beans and potatoes.

When the agriculture output does not perform well because of natural disasters or lack of basic inputs (fertilizers, insufficient and poor quality of labour.,…), there is an immediate shock on the overall output.
Plotting the economic output in 1980 constant dollars, the constant GDP curve is shrinking, almost asymptotic to $ 50 level. This reflects partly the exchange rate fall of the national currency and various devaluations and a small fraction of the long term value but almost constant depreciation of the national currency afterwards. The structural export price package becomes endogenously pegged to the international price system setting.

The GDP trend is highly and positively correlated to coffee and tea price. They are also shrinking in the long run once set in constant unity ($, €,…) and can be estimated by a linear regression with negative coefficient (their slope is negative). From 1980 to 2015, HIV and AIDS would have a quadratic concave form.
Although, there is a clear negative HIV/AIDS impact on the economic growth, the fundamental causes of this declining have to be found elsewhere and very likely in unsettled

political unrest. Strong shocks have long term impact as reflected in the appendices. A sample of these generalized impulse responses are depicted in the Appendices

There are also short run shocks for which a short term error corrector model can quickly correct the model in very short time span (to come back to the stability).

NB LGDPR (i.e L stands for log or ln, thus lnGDP and R for real).

Example: Appendice I.1: The error correction model (ecm) in ARDL approach was estimated in econometric model as a residual effects. It gave this equation.

ecm = LGDPR + 3.0165*LHIV + .15189*LINVEST -2.4818*LSKIL -1.1814*LUNSKIL + 1.5853*LLAND + 2.1373*INPT.

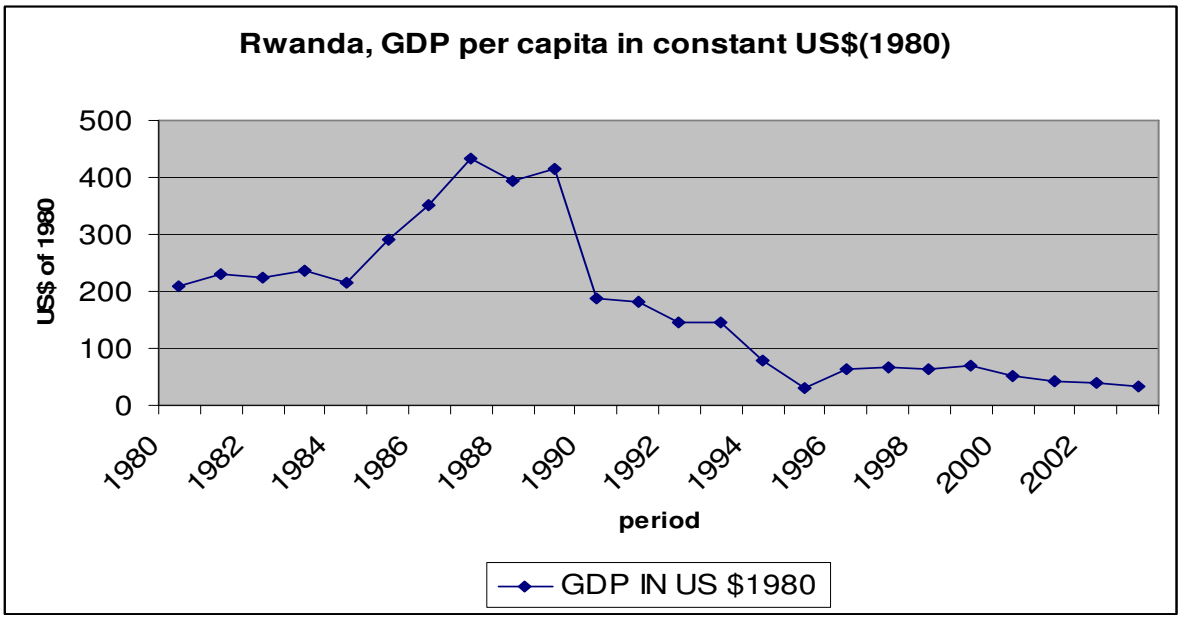
Table 9: The error correction model (ecm) in ARDL approach

regressor	**coefficient**	**Standard Error**	**T-ratio[Prob]**
ecm(-1)	-.59907	.24797	2.4158[.028]

Since the coefficient is negative the correction is in the upward movement (increase) towards zero (equilibrium). As data are annualized, only 21months is needed for the model to settle back to the right track. In effect, if 12months correspond to 59.907%, then 100% = (12monthsx100%)/59.907=21months in order to correct the model. The shock is supposed to be reabsorbed in 21months time.

The GDP curve has been structurally disrupted and punctuated by political motives from 1960. ARDL approach is more suited to endogeneise such broken curves (Pesaran).

Figure12: GDP per capita in constant US$ of 1980, Rwanda, 1980-2002



Sources: Calculations based on BNR data (Central Bank of Rwanda).

Table 10: Log GDP per capita (real) estimated function (scen1,HIV=6,08% in 2015)

Residuals and Fitted Values of Regression

****

Based on OLS regression of LGDPR on:

INPT LINVEST LHIV LLABHIV LLANDHIV

LAID LLEABHIV LCDEBT LNEXCH DLGDPR

23 observations used for estimation from 1981 to 2003

****

Observation	Actual	Fitted	Residual
1981	5.4381	5.3983	.039775
1982	5.4072	5.5381	-.13093
1983	5.4931	5.5532	-.060160
1984	5.4889	5.5136	-.024614
1985	5.6836	5.5749	.10863
1986	5.7683	5.7334	.034907
1987	5.8319	5.8026	.029268
1988	5.7869	5.8167	-.029767
1989	5.8493	5.8777	-.028398
1990	5.4972	5.3982	.098992
1991	5.4510	5.4679	-.016814
1992	5.4337	5.4118	.021936
1993	5.4250	5.4842	-.059278

1994	4.7536	4.7411	.012469
1995	4.6052	4.6728	-.067668
1996	5.3471	5.3761	-.029005
1997	5.3799	5.4430	-.063098
1998	5.4467	5.2700	.17669
1999	5.5134	5.4074	.10604
2000	5.3566	5.3562	.4175E-3
2001	5.2832	5.3896	-.10642
2002	5.3181	5.3193	-.0012144
2003	5.2364	5.2482	-.011762

Source: Microfit : econometric output

4.4 Data analysis of Obtained Results:

4.4.1 Historic Simulation (1980-2003):

Econometric output: Estimated Equations: Ordinary Least Squares Estimation (OLS)

****

Table 11: Dependent variable is LGDPR

23 observations used for estimation from 1981 to 2003

****

Regressor	Coefficient	Standard Error	T-Ratio [Prob]
INPT	3.3552	1.9870	1.6886[.117]
LLNVEST	.21270	.18205	1.1684[.265]
LHIV	-.10262	.27209	-.37717[.713]
LSKIL	.54215	.46128	1.1753[.263]
LUNSKIL	.16985	.31081	.54646[.595]
LNEXCH	-.34556	.090553	-3.8161[.002]
LAID	-.33477	.087530	-3.8246[.002]
LLAND	.10114	.27394	.36920[.718]
LLEAB	-.034178	.27731	-.12325[.904]
CDEBT	-.0065064	.0012714	-5.1176[.000]
LLAGGDP	.28952	.13755	2.1049[.050]

****

R-Squared	.97904	R-Bar-Squared	.96158
S.E. of Regression	.057516	F-stat. F(10, 12)	56.0585[.000]

```
Mean of Dependent Variable    5.4259   S.D. of Dependent Variable      .29342
Residual Sum of Squares      .039696   Equation Log-likelihood        40.5273
Akaike Info. Criterion       29.5273   Schwarz Bayesian Criterion     23.2821
DW-statistic                 2.0040
*******************************************************************************
                        Diagnostic Tests
*******************************************************************************
*    Test Statistics  *       LM Version       *        F Version         *
*******************************************************************************
*                     *                        *                          *
* A:Serial Correlation*CHSQ(   1)=   .11457[.735]*F(   1,  11)=  .055069[.819]*
*                     *                        *                          *
* B:Functional Form   *CHSQ(   1)=   1.4901[.222]*F(   1,  11)=   .76205[.401]*
*                     *                        *                          *
* C:Normality         *CHSQ(   2)=   .78411[.676]*      Not applicable      *
*                     *                        *                          *
* D:Heteroscedasticity*CHSQ(   1)=   2.6478[.104]*F(   1,  21)=   2.7321[.113]*
```

Key Regression Statistics:

RSquarred = 97904 and R-Bar-Squared = .96158

F(10, 12)   56.0585[.000]

The high value of R2 shows that the overall goodness of fit of the models is satisfactory. The F-statistics measuring the joint significance of all regressors in the model is statistically significant at the 1 per cent level.

Diagnostic Test Statistics:

Serial Correlation F(1, 11)= .055069[.819]*

Functional Form F(1, 11)=   .76205[.401]*

Heteroscedasticity F(1, 126) = 4.1105 (0.045)

Meaning of the coefficients: For 1% of change in the independent variable (predetermined) the dependent variable (here it is GDP) will also change in the proportion of coefficient. For instance: The increase of 1% of the exchange rate will result in decline of .34556%.

The diagnostic test results show that the model passes the tests for functional form, serial correlation (there is no tracking effect of one variable on the other, and the heteroscedasticity (`the variance residuals is constant).

Therefore the result indicates that there is no serial correlation and heteroscedasticity in the model at 5% of significance level. This model has shown to be robust against residual autocorrelation by applying the Ordinary Least Squares Estimation (OLS) .

Only Aid, Debt, Exchange rate and lagged GDP (previous GDP) coefficient are statistically significant at 5% to explain their stated relationship with the GDP. Unexpectedly the influence of debt on GDP is too limited.
According to this OLS model, only the variables which are statistically significant to explain the GDP trend with less than 5% error are AID, Exchange rates and the previous level of the income GDP. The remaining variables (HIV, Land size per capita, Labor (skilled and unskilled), LLEAB and Investment might have also a relationship with the GDP but the confidence level is too low. Nevertheless the signs of these variables are quite expected in all cases apart from the Life Expectancy at birth (LLEAB).

The skilled labour coefficient demonstrates a very big elasticity vis-à-vis the GDP but the level confidence is also not significant. The skilled labour factor, the aid and the exchange rate are critical to the GDP formation. The implications are that the GDP would be very sensitive to their variation as inputs more than in the case of other factors having small bi coefficients (ex. change in the debt and the life expectancy).

However, the Least Squares Estimation (OLS) has rejected many coefficients of explanatory variables at 5% while indicating expected sign of relationship between the Gross Domestic Product and the regressors (predetermined variables). The impact level of the impact of land size per capita, the labour (skilled and unskilled), the life expectancy at birth and the investment on the GDP is not clearly measured by the Ordinary Least Squares (OLS) since the relationship does not provide an acceptable level of confidence (less than 5% of error or at least 10%).
Also the level of education is serially correlated with the labour. Hence, it is not appropriate to take both the labour and the variable LSSENR in the same OLS model.

Therefore, the model output confirms what it has hypothesized concerning the relationship between GDP (dependent variable) and the explanatory variables (the HIV, Aid, Debt, Land size per capita, Labor (skilled and unskilled), and Investment). According to the OLS

approach, HIV, Aid, Exchange rates, the Life Expectancy and the Debt have a negative impact on the GDP. Conversely Investment, Labor, Land, and the previous GDP have a positive relationship with the GDP. This means if the latter increase, then the GDP will also increase. If they decline the GDP will fall.

Also unexpected is the negative sign of the coefficient of the LLEAB variable. The meaning of such a situation is that if the life expectancy at birth increases then the GDP will fall. This is not a normal behaviour. However, different reasons in Rwanda could indeed trigger the GDP long-term trend to be negative while the life expectancy is increasing. One could conjecture that there other major factors which offset the life expectancy positive effects on the GDP.

The strong negative impact of the exchange rates and that of the aid confirm the political control of the most influential variables. This demonstrates the difficulties of the governments to strictly apply only the economic reasoning on them thereby limiting the predictive capacity of the model.

Table 12: Ordinary Least Squares Estimation

****

Dependent variable is LHIV

24 observations used for estimation from 1980 to 2003

****

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
INPT	9.1068	1.2505	7.2827[.000]
LLEAB	-1.0224	.076131	-13.4292[.000]
LP0PNURS	-.50037	.10478	-4.7754[.000]
LPOPURB	1.9937	.11223	17.7645[.000]
LSSENR	-.33636	.11464	-2.9342[.009]
LAGGDP	.9208E-4	.2525E-3	.36463[.720]
S1	-.020463	.033817	-.60513[.553]

****

R-Squared	.99117	R-Bar-Squared	.98806
S.E. of Regression	.080851	F-stat. F(6, 17)	318.1200[.000]
Mean of Dependent Variable	4.5330	S.D. of Dependent Variable	.73980

Residual Sum of Squares	.11113	Equation Log-likelihood	30.4472
Akaike Info. Criterion	23.4472	Schwarz Bayesian Criterion	19.3241
DW-statistic	1.5475		

S1 is a dummy variable for ARVCOV which takes into account the context of using antiretroviral or not. If ARVCOV is distributed, then S1=1, otherwise S1=0.

The high value of R2 shows that the model is satisfactorily fitting the data. The F-statistics measuring the joint significance of all regressors in the model is statistically significant at the 1 per cent level. However, the Durbin-Watson statistics is less than 1,68 meaning it is inconclusive.

All the signs of the coefficient bi are expected. HIV positive rate change in the same direction that the following independent variables: the proportion of the urban population (LPOPURB) and the level of the GDP.

The relationship between HIV and the previous level of the GDP (lagged variable) is not statistically significant at required level (5%) even though it exists. The rest of independent variables have a statistically significant relationship with the HIV. The life expectancy at birth, the second school enrolment rate (LSSNER) and the number of population per nurse change are in opposite direction of the HIV. This would mean that the life expectancy at birth improves where HIV is either too low or sharply diminishing. The high level of education limits the HIV spread. The urbanization is a serious cause of HIV spread and the more contributive factor to HIV spread.

If the number of nurses is low, the HIV will take advantage of it. Conversely the medical coverage rate will help combat the HIV.

The antiretroviral therapy ARCOV or (dummy variable: S1) provides a favourable context of limiting the HIV pandemic. More coverage by this treatment would have benefic effects in the fight against HIV.

OLS shows that HIV, Debt, AID and nominal exchange debt (NEXCH) have in most of the cases a negative impact on the GDP. Investment, land, land, and labour (skilled and unskilled) have a positive impact on GDP. Life expectancy has an unexpected sign.

4.4.2 Forecasting:

The multivariate dynamic forecasts for the level of LGDPR (scen4 (HIV=0%) using VAR, the contegrating vector. The order of VAR=1 and r =5

Three forecasting scenarios:

1. GDPNOHIV: scenario without HIV using VAR modeling; NOHIV is called scenario4: (Over-identified model).
2. GDP (HIV=6, 09%) : scenario 1: as estimated in the chapter 3, it is an Over-identified model.
3. GDPR*: This model was recalibrated by VAR Model in order to Exactly-identify the model.

Table 13: GDP scenarios

Period	GDPNOHIV	GDP (HIV=6.09%)	GDPR*
2004	5.2711	5.2562	5.3709
2005	5.1682	5.1041	5.4254
2006	5.1062	5.0587	5.3049
2007	5.1023	5.1104	5.3482
2008	5.0826	5.0345	5.2956
2009	5.0539	5.0125	5.2301
2010	5.0332	5.0371	5.2378
2011	5.0141	4.9989	5.316
2012	4.9927	4.9657	5.3424
2013	4.9714	4.9666	5.3195
2014	4.9508	4.9411	5.3195
2015	4.9301	4.9123	5.3221

Source: MICROFIT.4.0 calculations

* GDPR is an exactly-identified model using the cointegrating vectors selected on the basis of the Cointegration with unrestricted intercepts and no trends in the VAR. This cointegration test for the long- run is based on the Trace of the Stochastic Matrix.

While operating Microfit 4.9 (Order of VAR =p= 2); (p is the number of lags for endogenous variables), and the chosen r =5 (r is the number of lags for exogenous variables) .

NB: L which precedes every variable means data are in logarithmic form. L stands for natural logarithms. LGDPR is the dependent variable; the following variables are cointegrated variables: LHIV, LINVEST LSKIL, LUNSKIL, and LLAND, LAID.
Using VAR for HIV forecasting based on the exactly-identified model, the output is as follows: List of variables included in the cointegrating vector are LHIV LSSENR LPOPURB LPOPNURS LGDPR LLEAB ARVCOV. These are the most important variables which directly influence on the HIV.

HIV has increased less and less from 2004 but at slow pace and should start reversing in 2008 sharply and consistently beyond 2015 in this model.

Augmented Dickey-Fuller Tests:

For all variables the Unit root tests have been calculated by running Augmented Dickey-Fuller Tests (ADF test) .The outputs are in appendices. The null hypothesis of unit root test for the logarithmic values of every variable has been tested.
Criteria for decision: Irrespective of the order of the augmentation chosen for ADF test, the absolute values of ADF statistics (values in column under Test Statistic) are well below their asymptotic 95%critical values of the test given at the foot the table example (last appendice : augmented Dickey-Fuller statistic = -3.6921).
For example (for r=1, ADF (1) = | -2.9161 | < -3.6921.
Therefore it not possible to reject the null hypothesis of a unit root (H_O:Φ=1 refer to Tutorial Microfit 4.0) in the log variables (GDPR, HIV,…) at the 5% significance level. Thus, we accept the null of Hypothesis i.e. the variable GDPR has a unit root.

Thus, all variables are not stable (stationary) unless first differenced which permits to use the vector autoregression (VAR) modeling. There is evidence of a statistical significance of residual serial correlation in the GDP equation because of volatility of 1980s due to brutal devaluation and in 1990's as result of unstable period.

The historic simulation for 1980-2003 and the forecasting (2004-2015) are enough to accurately provide the data which have broken due to the fact of large variability of conflicting status to certain extent.

The GDP growth is weak (less than 6% a year). The poor proportion can't be even halved in 2015, by such a weak economic progress unless institutional and economic fundamental changes happen in the meantime. These perquisites are critical to HIV/AIDS-poverty paradigm.

-B- Autoregressive Distributed Lag Approach (ARDL).

The economic interpretation of cointegration is that if two or more variables are linked to form an equilibrium relationship spanning the long run, even though the series themselves in the short run may deviate from the equilibrium, they will move closer together in the long run equilibrium (Harris and Sollis 2003, p.34).

Autoregressive Distributed Lag Estimates ARDL (1, 1, 0, 0, 1, and 1) selected based on Schwarz Bayesian Criterion

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Table 14: Dependent variable is LHIV

23 observations used for estimation from 1981 to 2003

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Regressor	Coefficient (bi)	Standard Error	T-Ratio [Prob]
LHIV (-1)	**1.1194**	**.080715**	**13.8684[.000]**
LGDPR	-.090922	.059289	-1.5335[.147]
LGDPR (-1)	**.11283**	**.050413**	**2.2382[.042]**
LPOPNURS	-.0030187	.027063	-.11154[.913]
LPOPURB	**-.57346**	**.22014**	**-2.6049[.021]**
LSSENR	-.023897	.20985	-.11388[.911]
LSSENR (-1)	**.44853**	**.15621**	**2.8714[.012]**
ARVCOV	.0083000	.018179	.45657[.655]
ARVCOV (-1)	-.12637	.063646	-1.9855[.067]

****

R-Squared	.99746	R-Bar-Squared	.99601
S.E. of Regression	.043973	F-stat. F (8, 14)	688.1719[.000]

Mean of Dependent Variable 4.5919 S.D. of Dependent Variable .69649
Residual Sum of Squares .027070 Equation Log-likelihood 44.9297
Akaike Info. Criterion 35.9297 Schwarz Bayesian Criterion 30.8200
DW-statistic 2.7652 Durbin's h-statistic -1.9901[.047]

Variables which are highlighted have statistically a significant long run relationship with the dependent variable LHIV at 95% level of confidence. HIV is, indeed, in long term relation with LGDPR (-1), LSSENR (-1) ARVCOV (-1) which means that HIV has a long –run relationship with the previous level more than the same year level of the GDP, the education level and the previous level of the anti-retroviral therapy coverage .

There is a cumulative effect of these variables on HIV/AIDS if they have a long run relationship. It also highlights the factor that these variables are endogenously playing a role in the HIV/AIDS spread.

The positive correlation between HIV and the previous level of education (secondary schools and higher education) is confirmed by the strong and positive coefficient (.44853).

Also the previous high level of the per capita GDP is positively linked to HIV **(.**11283) but 4 times lesser than the education level.

These ARDL model outputs sound more logic and congruent with the hypothesis in predicting the relative high level of infection rate among the more educated and wealthy people. This result is also confirmed by the fact that the urban area has registered the highest HIV rate.

ARDL approach finds that in the past the HIV has a mutual positive relationship with the education but over time the education will help change the behaviour and will curve the HIV trend.

The econometric outputs predict that in 2008 the HIV trend will be reversed. This is also congruent with the fact that the urban population is expected to be the firs to change the behaviour and hence will see, in the long run, its HIV infection rate diminish over time.

Therefore, GDP, Education and Urbanization have a non linear relationship with the HIV changing over time.

C- Vector auto regression (VAR) modeling

The following discussions are based on the Appendices I.3 and 4.

The VAR methodology has used the Estimated Cointegrated Vectors in Johansen Estimation (Normalized in Brackets): Cointegration with unrestricted intercepts and no trends in the VAR. There are 22 observations from 1982 to 2003. Order of VAR = 2, chosen r =5.

List of variables included in the cointegrating vector are:

LGDPR LHIV LINVEST LSKIL LUNSKIL LLAND LAID.

The LGPR is the dependent variable and the period is 23 years (n=23), k: number of variables (6) and the degrees of freedom=n-k-1= (2003-1980)-6-1=16.

Putting the LGPR as the dependent variable, the VAR model above is exactly-identified with these predetermined variables in the table with which it has a long run relationship. There are 6 other possible coefficients for each coefficient. In those 6possible coefficients some are higher than the critical value of t- ratio=1.33.

The VAR model has identified these variables (in the first column) as the major factors in the GDP formation. The selection criteria of the appropriate values of ai (coefficients in the first GDP equation) is to consider values above 1.33, the critical value of t-ratio and preferably the highest normalized values for each variable. HIV has been found as one of the key variables.

Concerning the HIV, the fundamental variables in the exactly identified VAR model are: LSSENR LPOPURB LPOPNURS LGDPR LLEAB ARVCOV. Again, the GDP is included in the equation. This mutual interdependence between HIV and GDP postulated earlier proved to be important although they are not substantially the most important factor to explain each other.

In some vectors, unexpected relationships exist due very probably to the fact that on one hand the data are broken and to the non linear relationship which can be supported by possible multiple extrema on the other hand. This makes data inconclusive but proving the relationship at least.

4.5 Empirical observation:

As described by Pougan (1995), "People *who lose their job are not only deprived of income, but also more likely to have marital problems, less contacts with family and friends and feel socially disqualified".*

Infected people tend to abandon their career at certain point in time even before getting to the exit stage.

Statistics at national level provide the overall trend of underlying factors but fails to weigh these realities. Information at sectoral, organisational and households level are weak to capture and provide such complex and detailed HIV implications in relation to their economic impact in order to comprehend certain HIV/AIDS consequences.

Deaths are not weighted, but it is a fact of life that some people by their skills, experience and overall quality fairly contribute far more than others. There are others who just constitute a cost for a society. Accounting those extremes in case of AIDS death by the same system will not capture the right productivity lost to HIV. At national level Composite indexes do not capture these differences.

The cost of HIV is likely to have been underestimated by trying to monetise most of its impact. AIDS orphans or widowed mothers can experience particular difficulties along the life due to early abandonment. For example the rate of suicide due to HIV related issues could be high since society is intolerant of PLWHA especially in the context of no ARV treatment. The stigma is not well understood and hence not correctly weighted.

Poverty and HIV go hand in hand but the extent to which this relationship is accounted for is not yet exhaustive. It is not yet fully researched so as to know which causes what. Human sexual behaviour is difficult to measure as it lies in culture, shared values, habits and opportunities in the same country or region which makes it difficult to determine what exacerbates its transmissibility.

More women are infected and affected by HIV/AIDS. The GDP is a poor accounting system to capture the contribution to the GDP made by women in their home care services. HIV/AIDS

intensively requires caring services. Women have at least 2hours of more of work than men per day in normal situations.

This accounts in average for at least 25% of national working time budget more than men. Women are greater in number than men and generally have a longer life span than men in normal conditions. This complicates the opportunity cost lost to HIV/AIDS at national level. However, their overall compensation is presumably less than that obtained that obtained by men.

4.6 Results and Discussion

HIV is generalised and goes far beyond the health factors. It has a very systematic and significant long run relationship with these variables level of education (LSSENR), the proportion of the urban population, (LPOPURB), the number of population per nurse (LPOPNURS), the Gross Domestic Porduct (LGDPR), the life expectancy at birth (LLEAB) and the context of HIV(antiretroviral treatment) (ARVCOV).

The epidemiologic model has produced a clear impact of HIV on the population, the life expectancy at birth, the dependency rate, the orphanage and TB cases as given in appendices.

In 2010 the population will be about 10 980 millions if the HV prevalence rate is moderate and can be reflected by scenario1 (6.09% by 2015) whereas in the context of HIV-free the population will be 11.49 millions. The difference (11490-10980= 510,000 inhabitants) is the loss of the population to AIDS.

Education level represented by the secondary school enrolment rate (LSSENR) relationship with HIV has been confirmed by the fact that the coefficient bi =.44853 is significant to the level of at least 95%. In HIV infected population, the proportion of educated people was higher than less educated. The correlation between the two variables was positive. This result was obtained by ARDL approach which is in more accordance with the endogenous properties.

The OLS found (bi = -.33636) meaning if the secondary school rate increases, the HIV will likely decline. The advantage of ARDL states that in the long run the education will be negatively correlated to HIV (bi=-.23897) but with very low probability while in the past it was positively linked to HIV positive status with a level of confidence of no more 5% error.

The augmentation of the proportion of the urban population will be likely associated with the fall in the HIV rate. This is probably true if we consider that more urban people are educated. Policies aimed at HIV/AIDS fighting have more chances to succeed in the urban areas (ARDL approach results) dealing with people having a high level of education.

The proportion of the urban population ARVCOV HIV has a strong effect, indeed, on the GDP, through the variables with which it.

High previous level of income is positively linked to HIV positive rate increase. The argument that high income category was likely more infected by HIV holds. Education, level of income and geographic distribution are hardly totally independent .This would explain in part, the serial correlation found in regressions. More educated people are relatively better off and tend to live in urban areas. Conversely, most of the poor are country-based and have a low level of education and are less infected with HIV.

PoPNUR: The number of population per Nurse is a proxy to capture the health services access. If we have a high number of nurses, health care will be easier and less expensive. More patients could be timely treated .Opportunistic diseases will be easily treated. HIV/AIDS lifetime can be longer than in the region with fairly poor health system or simply improved.
Less income will be devoted to health. The high number of nurses would be fairly distributed in the countryside.
If there are more nurses then health services would be more affordable and effective to patient due to competition. Deliveries in the health center could increase, thereby, limiting the transmission of HIV to babies born of mothers HIV positive.
Sexually Transmitted Infections could be minimized, thereby, limiting, chances of susceptibility to HIV. VCTs will be more accessible. Therefore the increase in number of nurses will get a positive influence on the health system. This could contribute not only to

HIV reduction but also to more VCTs thus mitigating AIDS effects by controlling opportunistic diseases, whereby, survival probabilities under ARV can be augmented.

Autoregressive Distributed Lag Estimates ARDL (1, 1, 0, 0, 1, 1) selected based on Schwarz Bayesian Criterion.

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Table 16: Dependent variable is LHIV

23 observations used for estimation from 1981 to 2003

****

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LHIV(-1)	**1.1194**	**.080715**	**13.8684[.000]**
LGDPR	-.090922	.059289	-1.5335[.147]
LGDPR(-1)	**.11283**	**.050413**	**2.2382[.042]**
LPOPNURS	-.0030187	.027063	-.11154[.913]
LPOPURB	**-.57346**	**.22014**	**-2.6049[.021]**
LSSENR	-.023897	.20985	-.11388[.911]
LSSENR(-1)	**.44853**	**.15621**	**2.8714[.012]**
ARVCOV	.0083000	.018179	.45657[.655]
ARVCOV(-1)	-.12637	.063646	-1.9855[.067]
**********			
R-Squared	.99746	R-Bar-Squared	.99601
S.E. of Regression	.043973	F-stat. F(8, 14)	688.1719[.000]

Interpretation of Coefficients ai, and bi:

It means that a change of unit of the independent variable (regressor) will entail a change equals to the coefficient bi for the dependent variable since bi is an elasticity.

For example the increase of one percent of the previous level of HIV (lagged variable: LHIV (-1)) will be associated with an increase of 1.194% of HIV in this current year with almost no error (.000) associated with this hyopthesis. The augmentation of the urban population (POPURB) of 1% will be associated with a drop of .57346% of the current rate of HIV.

If the secondary school enrolment of a previous year (SSENR (-1)) augments by one percent it would bring about an increase of .4485% of the HIV rate in consecutive year with possible

error of 1.2%. This means that the previous levels of secondary school enrolment were positively associated with HIV. The two variables have had the same direction until recently. By now, it no longer holds in at least 9%. This would entail a start of behaviour change by the population group having a secondary school or higher level of education.

The antiretroviral therapy (ARVCOV) in the past has helped to bring down the rate of HIV but it is now associated with the increase of HIV for a bit more than one out of 3 people (34.5%of the cases). This needs more exploration to understand how and why people differently react to the existence of AIDS partial medication. Since the death can be avoided or postponed, the HIV/AIDS risk is limited or minimized to the extent that the protection against HIV and access to ARVs would be systematic.

As DW statistic is only valid when lagged values are not included in the regressors, it is corrected and replaced by h-statistic in the case of a single one-period lag of the dependent variable LHIV (-1) . If h-statistic is > 1.96, the hypothesis that disturbances vt in HIVt are serially correlated is rejected.

F (8, 14) 688.1719[.000]: F is too big and accepts every coefficient. It is not a good measure it can't reject any value simply because its interval is too large. F is, thus inconclusive as a test for the equation of LHIV.

Errors correction model associated with long-run estimates

While there are estimated long –run relationships between variables, the model below has calculated short-term errors. Based on these errors it is showed how long it will take to come back to equilibrium by this operation: 100 %(1/-.63408) years= 19months. .

The error correction coefficient is estimated at -.63408 (.19447). It is statistically highly significant and has the correct sign, and suggests a quick speed of convergence to equilibrium (less than 2years).The larger the error correction coefficient (in the absolute value) the faster the GDP returns to previous equilibrium, once it has been shocked by HIV.

In the short run errors correction estimates would permit to manage (to correct towards the equilibrium) the short term period by using the results below which are concerned with the short run, along the long-run relationships. The regressors are in derivates format to describe the change in the short term period.

It was feasible to ignore initial data (from 1982 to 1986) because their effects are too small. HIV shock is maximal between 5-6 years and has lasting effects up to 14 years.

Conclusion,

Akaike Info. Criterion (AIC) and Schwarz Bayesian Criterion (SBC) suggest that the correct order r is between DF and ADF (1). It is therefore not possible to reject the null hypothesis of a unit root in the log GDPR at 5% of significance level. Hence there is a unit root in the economic growth (LGDPR). HIV and GDP are serially correlated. Each curve is diverging but negatively which means that the GDP is collapsing and the HIV will reverse and will come to a complete end in the very long term. This demonstrates the existence of other factors more important than HIV in determining the GDP trend.

HIV and GDP change in the same direction (diminishing). There is multicollinearity. Studenmund (2001) minimises the consequences of the limitation if it only the increase of the variances of the coeffients.

CHAPTER 5- CONCLUSIONS AND OBSERVATIONS

5.1 Epidemiological factors:

Behind figures, there are human beings. High rate of HIV prevalence goes with an unprecedented high mortality of a young active population in the unexpected period of life.

Skilled labour while more productive was at more risk of HIV than the unskilled labour. However, there is a slight change, whereby, the education starts reversing the HIOV spread.

Females are getting more infected than men; this can accumulate over long periods in a compounding way.

The net reproduction net is very slightly negatively influenced by HIV.
The crude birth rate tends to rise in the reaction to HIV but the HIV mortality offsets the impact and reduces the net reproduction rate in the context of HIV.
The previous level of HIV is strongly conducive to HIV spread. It seems that it plays as limiting factor exactly like the process of diminishing number of freedom and this is proved statistically with a high level of confidence. The dependence has unexpectedly shown a declining trend. This is possible mainly because of the fertility trend and the treatment by the antiretroviral which maintain people in life for about ten years or so. ARV keeps adult people for a longer period within the workforce group.

Surprisingly, the sexual violence has had limited consequences on HIV spread by the fact of the fast elimination of newly infected, and also the rural areas oppressors were likely less infected.

5.2 Social health factors

The general conditions and health services access are an important factor for HIV transmission if lacking or prevention factor when they are well attended. Limited health services access factor is an amplifier HIV factor. For instance by expanding the STIs treatment, among others, *Trichomonas,* it could substantially decrease in HIV transmission. Females are more susceptible to the HIV infection than men and have a higher probability of getting unmarried which is an additional risk for STIs.

Furthermore, the life expectancy at birth (LEAB) in Rwanda today stands at 54,5 years (average for men and women) instead of 60 years if there was no HIV. The loss is estimated to about 6years by 2015. However this measure is too imprecise and should be supported by the likelihood of reaching adult age. Nonetheless, it is a good proxy for health status. Bloom *et al* (2001) found that one year of increase life expectancy leads to an increase of 4% in the output. This means that in 2015 if every other variable held constant, the loss in output would be 6X4%=24 % of the overall output. This can be exaggerated or close to reality, it hard to predict based on one factor, and it should be not taken for granted. The high infant mortality and the HIV/AIDS pull down the life expectancy at birth (LEAB).

The infant mortality was 97.8/‰ in the context of HIV scenario1 and 90.51% in 2005 (NOHIV scenario).. In 2015, the same rate would be 81.19‰ instead of being 68.7‰ in absence of HIV. The loss will be 12.48‰ which corresponds to HIV victims only via the infant mortality.

The additional TBC cases due to HIV/AIDS would reach as high as 17.680 by 2015. The poverty and malnutrition favour TBC. These factors are highly interrelated .They weaken the body making it more susceptible to TBC and other diseases.

The impact of ARV treatment could be in both directions but with different weights:
A positive role of supporting the body and extend the quasi normal lifetime for around 10 years or more for PLWHA to the extent that ARV easy access gives hope and transforms HIV/AIDS from a death into a chronic amenable and manageable disease. The pervading trauma is almost automatically avoided with subsequent AIDS denial and stigmatization. When the medication is available the combination of ARV coverage and IEC become easier,

thereby the behaviour change can take on among infected and the society simply because the disclosure is only possible if there is still life after infection

However, Stein (2005) points out the fact that ARV can in some circumstances play a negative role against ABC policy. It may mitigate the education efforts undertaken for precautionary sex and abstinence. Also Greener (2002 hypothesised a possible widespread treatment may undermine the current attempts to encourage behavioral change aimed at preventing further spread of the virus, since it may cause people to feel safer, and more able to engage in risky behavior. If this happened, it would also weaken the beneficial effects of treatment.

Behaviour change, sex and culture conflicts: *"it (culture) has lost real meaning and should be done away with. Moreover, it does not stop promiscuity rather the opposite, look around, and see what is happening?"*[40]

When the culture is no longer working HIV is easily spread. It really becomes difficult to fight against it in the environment predominated by the heterosexual contamination.
If social factors which influence the culture and prevailing beliefs and values, are fragmented depersonalizing, they will undoubtedly contribute to HIV expansion.

5.3 Socio-economic, and Institutional factors and HIV :

While the OLS could not confirm with a significant level of confidence the strong positive relationship between the previous level GDP and HIV, the ARDL proves to be an improved methodology and confirm it with a level of confidence of more of than 95%.The endogenous theory is embedded in the traditional quality-quantity methods and underpins institutional and processes methods. It refutes the residual approach to poverty and HIV policies exemplified in World Bank safety nets approach of 1980s and 1990's currently predominating in some sub-programmes Rwanda (fortunately not HIV/AIDS!).

[40] UNDP- (2001) Fight against HIV/AIDS Republic of Liberia page 32

In spite of the confirmed relationship between GDP and HIV, the long term trend of GDP was more determined by institutional factors rather than the economic variables such as investments … Therefore the model could highly gain more explanatory capacity by integrating the african dummies which would deal with institutions variables. But at the same time these institutional factors are strongly correlated with economic factors.
This underpins the use of the ADRL approach by letting all variables interact. The existing level education (lagged variable) was found to facilitate the HIV spread in the past (ARDL results) but showing, at the same time, a slight change with a very low level of confidence (negative coefficient for current level of education).

Until recently some studies did not integrate HIV/AIDS as an endogenous factor to human development in many studies. It was an added-on like poverty and macroeconomics in the Word Bank and International Monetary Fund (IMF) policy models (Dubey, 2004). This has had as a consequence the underestimation of its impact, more particularly in countries with a high HIV prevalence rate. UNDP Human Development Reports (1997, 2002, 2005) to cite the least, instead, insisted on it with such perspicacity that convinces that institutions are critical to poverty alleviation, and it goes without saying that a poorest nation does not easily delivery on HIV targets; it can be stuck in HIV fighting.

It comes to mind to compare North Korea and South Korea or North and South Italy cases to understand how important the institutions in the development process are.

The residual approach as opposed to the endogenous approach suggests more labour, more of condoms, more anti-retroviral …; without structural considerations (institutional factors are of a limited influence) might be ineffective in generalized HIV stage as Duby (2004) emphatically concludes about World Bank interventions in India for fighting social exclusion.
As expected the Aid has a long term negative impact on GDP but has a relative small positive impact on the GDP while the debt has surprisingly a very limited impact on the GDP in the VAR model (exactly-identified model).

Therefore HIV/AIDS policies and programme have to be mainstreamed in other policies and programmes from the definition to the evaluation post execution. The processes are also as

important as institutions set for fighting HIV/AIDS in preventing and mitigating their effect sides. This process is a learnt lesson from the poverty reduction strategies.

HIV/AIDS impoverishes quickly and deeply. Poverty increases the risk of being trapped in situations which leads to HIV/AIDS spreading.

Overally, the social exclusion as the main cause of the political violence has led to breakdowns and cycles in the GDP curve by which the proportion of the population under the poverty line has culminated to 82 % in 1994. In the context of a lack of basic amenities, HIV/AIDS mutually interlinks with poverty. They become dynamically integrative. HIV/AIDS is neither specific to marginal deviant social status nor confined to poorest strata in the national economy as pretend Nattras. It cuts across the whole society with more presence, ramifications and consequences in the urban areas.

The dynamic poverty-HIV/AIDS topography is absorptive. HIV/AIDS exacerbates poverty by extending inequality. The figures presented are far from demonstrating the full reality of HIV/AIDS implications. Some traps are too deep and charged with strong energy (trauma, social exclusion and stigmatisation) and difficult to qualify and/or quantify or simply to fully understand them.

There are many and important qualitative factors that current knowledge does not permit to weigh in the conjunction with HIV/AIDS. This is possible even though with limited HIV mortality and morbidity. For example, the loss of a portion of some entrepreneurs can adversely impact to the local economy in a disproportionate manner. This category is concentrated in towns and their life is so networked that can result in an increase in a HIV contamination.

Although the urban population is too limited but more productive, it has been spreading HIV/AIDS and increasing the mortality, thereby, disproportionately and adversely impacting on the GDP more than the rural population. This seems to change in the near future when the HIV trend is expected to reverse around 2008.

In overall, the impact of HIV on GDP in Rwanda is limited unless the rate changes dramatically beyond the scenarios hypothesised. HIV and GDP do not have a short term relationship. One should bear in mind that such results are subject to the capacity of delivering the ARV quickly and to efficiently universalise it in the short run.

However, it can be argued that the state-of-art techniques used so far do not capture the real impact of HIV. This caveat opens the debate of the question of conclusiveness of the results even though pertinent. This has reflection does not take into account the very adaptive capacity and innovation of institutions and individuals to overcome challenges and obstacles.

Way Forward

This model has proved successful and explanatory. However there are other factors which are kept aside but crucial for the full reality. It would gain explanatory power by an extended modelling including institutional factors which are very influential. Some writers have tried to understand the poor African and Latin American economic growth achievements by various econometric modelling. They have shed light to different pending issues: political violence, open conflicts, corruption, rent seeking, natural resources plundering. On top that Rwanda is constrained by limited natural resources (landlessness, landlockness, in the context of high density and persistent high fertility.

As a remedial perspective, the model would integrate African dummies to explain some causations since the neo-liberal model (residual approach) have failed to provide convincing explanations. UNDP (2005) puts it as follows:

"The human development costs of failure to provide a vision backed by a practical strategy are immense, but insufficiently appreciated. Collapsing food systems, disintegration of health and education services and lost income are all aspects of conflict that have negative implications for human development. So do psychological stress and trauma. Statistics alone cannot reflect the full costs—and data are often at their weakest in countries undergoing violent conflict. But what is clear is that the immediate human costs, though enormous, represent a small fraction of the price countries pay for conflict (2005 HDR: 154)."

HIV and poverty alike create traps that become like black holes (poverty pockets combined with high HIV socially excluded) which are strongly attractive. By mapping HIV traps and social exclusion, this would contribute to prescriptive and/or reactive policies in regard to strong and equitable economic gorwth. Overall, the study would support and integrate the National long term Perspective Policies (NLTPP).
In fact HIV/AIDS has had so far less consequences than the social exclusion which culminated in political violence and war cycles.

The cultural change and new perspectives in interdisciplinary studies should compel for more research into new ways of fighting HIV/AIDS. Integrative thinking in information, education, and communication have opened new avenues for the behaviour change not only for HIV fighting but in all life learning attitudes and processes which are very crucial to get the best of everyone in HIV fighting .

Also, the research on pathways linking environments, behaviors and HIV/AIDS would provide some breakthroughs in the assessment of HIV impact.

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J. APPENDICES

APPENDICES I.1

YEAR	GDPR	POP	INVEST	HIV	**LABSKIL**	**LABUNSKIL**	LAND	AID	**LEAB**
1980	209	5.2	16	24	65	2699	2.73	151.0	47.1
1981	230	5.4	17	30	74	2781	2.61	153.0	47.3
1982	223	5.6	16	34	84	2867	2.49	165.0	47.4
1983	243	5.8	17	36	94	2970	2.35	168.0	48.1
1984	242	6.0	16	42	105	3072	2.20	173.0	48.8
1985	294	6.2	15	48	113	3174	2.06	175.0	48.7
1986	320	6.4	13	54	122	3232	1.93	165.0	48.5
1987	341	6.6	15	61	142	3340	1.81	180.0	48.1
1988	326	6.8	14	69	153	3407	1.72	189.0	49.0

1989	347	7.0	13	77	165	3507	1.65	193.0	51.0
1990	244	6.9	14	85	172	3443	1.58	198.7	52.6
1991	233	7.1	13	94	187	3174	1.51	363.6	51.0
1992	229	7.3	16	103	200	3195	1.45	345.7	49.0
1993	227	7.5	17	112	211	3285	1.38	379.0	47.0
1994	116	5.2	4	**158**	**104**	**2300**	0.72	125.0	11.3
1995	100	5.7	14	151	196	2696	0.73	145.0	43.0
1996	210	6.2	26	142	231	2933	0.79	150.0	46.0
1997	217	7.6	22	141	293	3595	1.00	346.6	49.0
1998	232	7.7	20	171	308	3390	1.04	241.0	49.0
1999	248	7.8	23	193	323	3434	1.03	385.0	49.0
2000	212	7.9	18	211	340	4230	1.03	360.0	50.0
2001	197	8.2	18	229	373	4344	0.99	344.0	50.0
2002	204	8.3	18	274	406	4446	0.95	352.6	50.5
2003	188	8.3	19	299	429	4446	0.92	285.6	51.0

YEAR	CDEBT	NEXCH	POPURB	SECSENR	POPNURS	LAGGDP	ARVCOV
1980	**0.0**	92.8	5	5	10,960	0.00	0
1981	12.6	92.8	5	5	10,520	209	0
1982	23.9	92.8	6	4.8	10,130	230	0
1983	25.6	94.8	6.4	5	9,740	223	0
1984	21.1	104.4	6.7	5.1	9,350	243	0
1985	18.2	93.5	7	5.3	8,960	242	0
1986	14.6	84.2	7.3	5.2	8,570	294	0
1987	24.5	73.0	7.6	5.4	8,180	320	0
1988	13.6	76.7	8	5.6	7,790	341	0
1989	6.2	77.6	8.4	5.8	7,600	326	0
1990	49.8	121.1	9	5.9	7,450	347	0
1991	8.8	119.8	9.3	5.6	7,760	244	0
1992	13.0	146.3	9.5	5.8	7,500	233	0
1993	10.4	145.8	9.8	5.6	7,360	229	0
1994	14.0	280.0	7	5	18,000	227	0
1995	86.8	297.7	12	7	9,800	116	0
1996	4.6	304.2	13	8	10,000	100	0
1997	9.1	304.7	14	10	9,700	210	0
1998	16.9	330.7	15	11.3	9,500	217	0
1999	-6.8	335.3	15.5	12	9,850	232	1
2000	15.2	390.0	16	13.9	6,365	248	1
2001	12.1	443.1	16.4	14.8	5,009	212	1
2002	17.5	475.4	17	16	4,800	197	1
2003	22.0	537.9	18.02	17	4,730	204	1

Appendice I.2

Error Correction Representation for the Selected ARDL Model ARDL (1,0,1,1,0,0) selected based on Schwarz Bayesian Criterion

****

Dependent variable is dLGDPR

23 observations used for estimation from 1981 to 2003

****

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dLHIV	**-1.8071**	**.54456**	**-3.3184[.004]**
dLINVEST	.30608	.31293	.97810[.343]
dLSKIL	.0055449	.56885	.0097476[.992]
dLUNSKIL	.70774	.51367	1.3778[.187]
dLLAND	**-.94971**	**.39913**	**-2.3795[.030]**
dINPT	-1.2804	3.1165	-.41085[.687]
ecm(-1)	**-.59907**	**.24797**	**-2.4158[.028]**

****

List of additional temporary variables created:

dLGDPR = LGDPR-LGDPR(-1)

dLHIV = LHIV-LHIV(-1)

dLINVEST = LINVEST-LINVEST(-1)

dLSKIL = LSKIL-LSKIL(-1)

dLUNSKIL = LUNSKIL-LUNSKIL(-1)

dLLAND = LLAND-LLAND(-1)

dINPT = INPT-INPT(-1)

ecm = LGDPR + 3.0165*LHIV + .15189*LINVEST -2.4818*LSKIL -1.1814*LUNSKIL + 1.5853*LLAND + 2.1373*INPT

R-Squared .83799 R-Bar-Squared .74541

S.E. of Regression .12163 F-stat. F(6, 16) 12.0689[.000]

Mean of Dependent Variable -.0045927 S.D. of Dependent Variable .24106

Residual Sum of Squares .20712 Equation Log-likelihood 21.5289

Akaike Info. Criterion 12.5289 Schwarz Bayesian Criterion 7.4192

DW-statistic 2.1350

****

Appendices I.3

ECM for variable LGDPR estimated by OLS based on cointegrating VAR(2)

****

Dependent variable is dLGDPR

22 observations used for estimation from 1982 to 2003

****

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
Intercept	8.8516	15.2522	.58035[.576]
dLGDPR1	**.12429**	**.58592**	**.21213[.837]**
dLHIV1	**-.12095**	**2.2820**	**-.053001[.959]**
dLINVEST1	-.37159	.74890	-.49618[.632]
dLSKIL1	1.3547	2.2062	.61404[.554]
dLUNSKIL1	.081498	2.2595	.036069[.972]
dLLAND1	-1.2768	2.3515	-.54297[.600]
dLAID1	.24066	.47538	.50625[.625]
ecm1(-1)	-.034244	.21409	-.15995[.876]
ecm2(-1)	-.10680	.21409	-.49883[.630]
ecm3(-1)	-.028921	.21409	-.13508[.896]
ecm4(-1)	-.17209	.21409	-.80380[.442]
ecm5(-1)	.37539	.21409	1.7534[.113]

****

List of additional temporary variables created:

dLGDPR = LGDPR-LGDPR(-1)

dLGDPR1 = LGDPR(-1)-LGDPR(-2)

dLHIV1 = LHIV(-1)-LHIV(-2)

dLINVEST1 = LINVEST(-1)-LINVEST(-2)

dLSKIL1 = LSKIL(-1)-LSKIL(-2)

dLUNSKIL1 = LUNSKIL(-1)-LUNSKIL(-2)

dLLAND1 = LLAND(-1)-LLAND(-2)

dLAID1 = LAID(-1)-LAID(-2)

ecm1 = -1.9830*LGDPR -4.9696*LHIV -3.2331*LINVEST + 7.5950*LSKIL -2

.4969*LUNSKIL -.15909*LLAND -.24113*LAID;ecm2 = 1.4247*LGDPR + 8.8039

*LHIV + 1.5924*LINVEST -5.2402*LSKIL -6.2563*LUNSKIL + 7.3131*LLAND -.54800*LAID;ecm3 = .47350*LGDPR -4.8080*LHIV + 1.6329*LINVEST + 3.9132*LSKIL + .029846*LUNSKIL -3.8792*LLAND + .55840*LAID;ecm4 = 2.2826*LGDPR + 1.9917*LHIV + 2.6981*LINVEST -10.7342*LSKIL + 8.7729*LUNSKIL - 6.5993*LLAND + 3.4846*LAID; ecm5 = -.038758*LGDPR + 1.5448*LHIV + .63598*LINVEST -.62637*LSKIL -.69247*LUNSKIL + .93473*LLAND -.96887*LAID

****

R-Squared .67449 R-Bar-Squared .24047

S.E. of Regression .21409 F-stat. F(12, 9) 1.5541[.258]

Mean of Dependent Variable -.0092743 S.D. of Dependent Variable .24566

Residual Sum of Squares .41253 Equation Log-likelihood 12.5248

Akaike Info. Criterion -.47525 Schwarz Bayesian Criterions -7.5670

DW-statistic 2.3618 System Log-likelihood 369.2707

****

Appendice I.4

Estimated Cointegrated Vectors in Johansen Estimation (Normalized in Brackets)
Cointegration with unrestricted intercepts and no trends in the VAR

****

22 observations from 1982 to 2003. Order of VAR = 2, chosen r =6.
List of variables included in the cointegrating vector:
LHIV LSSENR LPOPURB LPOPNURS LGDPR
LLEAB ARVCOV

The first variable is a dependent variable; in this case LGHIV is specified as dependent.

	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5	Vector 6
LHIV	-2.7879	1.5063	1.4014	.36891	.52477	2.7012
	(-1.0000)	(-1.0000)	(-1.0000)	(-1.0000)	(-1.0000)	(-1.0000)
LSSENR	.42359	2.5065	-1.8147	.46507	-.24589	.0081329
	(.15194)	**(-1.6640)**	(1.2949)	(-1.2607)	(.46857)	(-0030108)
LPOPURB	**4.5591**	**-5.4159**	-1.1223	**-2.0385**	**-1.3051**	**-4.3972**
	(1.6353)	**(3.5955)**	(.80082)	**(5.5259)**	**(2.4869)**	**(1.6279)**
LPOPNURS	-2.7743	-.10302	1.2924	**-1.7436**	**-2.1895**	**3.6343**
	(-.99511)	(.068395)	(-.92221)	**(4.7263)**	**(4.1723)**	**(-1.3454)**
LGDPR	.31678	.094304	-.39406	**-1.2153**	.12220	1.7211
	(.11363)	(-.062606)	(.28119)	**(3.2942)**	(-.23286)	(-.63717)
LLEAB	**-3.7962**	.43310	**3.1207**	**1.5564**	**-1.4504**	**3.8913**
	(-1.3617)	(-.28753)	**(-2.2269)**	**(-4.2189)**	**(2.7639)**	**(-1.4406)**

ARVCOV	-.73069	-.21320	**1.9600**	**-1.5334**	**-1.6224**	2.5948
	(-.26209)	(.14154)	**(-1.3986)**	**(4.1566)**	**(3.0916)**	(-.96062)

Appendices I.5

Estimated Cointegrated Vectors in Johansen Estimation (Normalized in Brackets)

Cointegration with unrestricted intercepts and no trends in the VAR

****

22 observations from 1982 to 2003. Order of VAR = 2, chosen r =5.

List of variables included in the cointegrating vector:

LGDPR LHIV LINVEST LSKIL LUNSKIL

LLAND LAID

The first variable is a dependent variable; in this case LGDPR is specified as dependent.

	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
LGDPR	-1.9830	1.4247	.47350	2.2826	-.038758
	(-1.0000)	(-1.0000)	(-1.0000)	(-1.0000)	(-1.0000)
LHIV	-4.9696	8.8039	-4.8080	1.9917	1.5448
	(-2.5060)	**(-6.1796)**	**(10.1543)**	(-.87253)	**(39.8580)**
LINVEST	-3.2331	1.5924	1.6329	2.6981	.63598
	(-1.6304)	(-1.1177)	(-3.4487)	(-1.1820)	**(16.4090)**
LSKIL	7.5950	-5.2402	3.9132	-10.7342	-.62637
	(3.8299)	**(3.6782)**	**(-8.2644)**	**(4.7026)**	**(-16.1613)**
LUNSKIL	-2.4969	-6.2563	.029846	8.7729	-.69247
	(-1.2591)	**(4.3914)**	(-.063032)	**(-3.8433)**	**(-17.8665)**
LLAND	-.15909	7.3131	-3.8792	-6.5993	.93473
	(-.080223)	(-5.1332)	(8.1927)	(2.8911)	**(24.1173)**
LAID	-.24113	-.54800	.55840	3.4846	-.96887
	(-.12159)	(.38465)	(-1.1793)	(-1.5266)	**(-24.9980)**

Appendice I.6

Unit root tests for variable LGDPR

The Dickey-Fuller regressions include an intercept but not a trend

****

18 observations used in the estimation of all ADF regressions.

Sample period from 1986 to 2003

****

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.8371	.46886	-1.5311	-2.4215	-1.6539
ADF(1)	**-2.0596**	**.99251**	**-2.0075**	**-3.3430**	**-2.1916**
ADF(2)	-1.4822	1.2410	-2.7590	-4.5398	-3.0046
ADF(3)	-1.6788	1.7245	-3.2755	-5.5014	-3.5824
ADF(4)	-1.6108	1.8054	-4.1946	-6.8657	-4.5629
ADF(5)	-1.4713	1.8314	-5.1686	-8.2849	-5.5983

****

95% critical value for the augmented Dickey-Fuller statistic = -3.0401

LL = Maximized log-likelihood AIC = Akaike Information Criterion

SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LGDPR

The Dickey-Fuller regressions include an intercept and a linear trend

****

18 observations used in the estimation of all ADF regressions.

Sample period from 1986 to 2003

****

	Test Statistic	LL	AIC	SBC	HQC
DF	**-2.0501**	**.**97832	-2.0217	-3.3572	-2.2058
ADF (1)	**-2.4197**	1.9048	-2.0952	-3.8759	-2.3407
ADF (2)	**-1.8131**	1.9611	-3.0389	-5.2648	-3.3458
ADF (3)	**-2.1488**	2.8928	-3.1072	-5.7783	-3.4755
ADF (4)	**-2.2852**	3.5449	-3.4551	-6.5714	-3.8848
ADF (5)	**-2.3309**	4.1220	-3.8780	-7.4394	-4.3690

****

95% critical value for the augmented Dickey-Fuller statistic = **-3.6921**

LL = Maximized log-likelihood AIC = Akaike Information Criterion

SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LHIV

The Dickey-Fuller regressions include an intercept and a linear trend

****

18 observations used in the estimation of all ADF regressions.

Sample period from 1986 to 2003

****

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.6200	21.6304	18.6304	17.2949	18.4463
ADF (1)	-2.9161	22.5386	18.5386	16.7579	18.2931
ADF (2)	-2.3997	22.5395	17.5395	15.3135	17.2325
ADF (3)	-1.7859	22.9320	16.9320	14.2608	16.5637
ADF (4)	-1.9242	23.4852	16.4852	13.3689	16.0555
ADF (5)	-1.6439	23.6532	15.6532	12.0917	15.1621

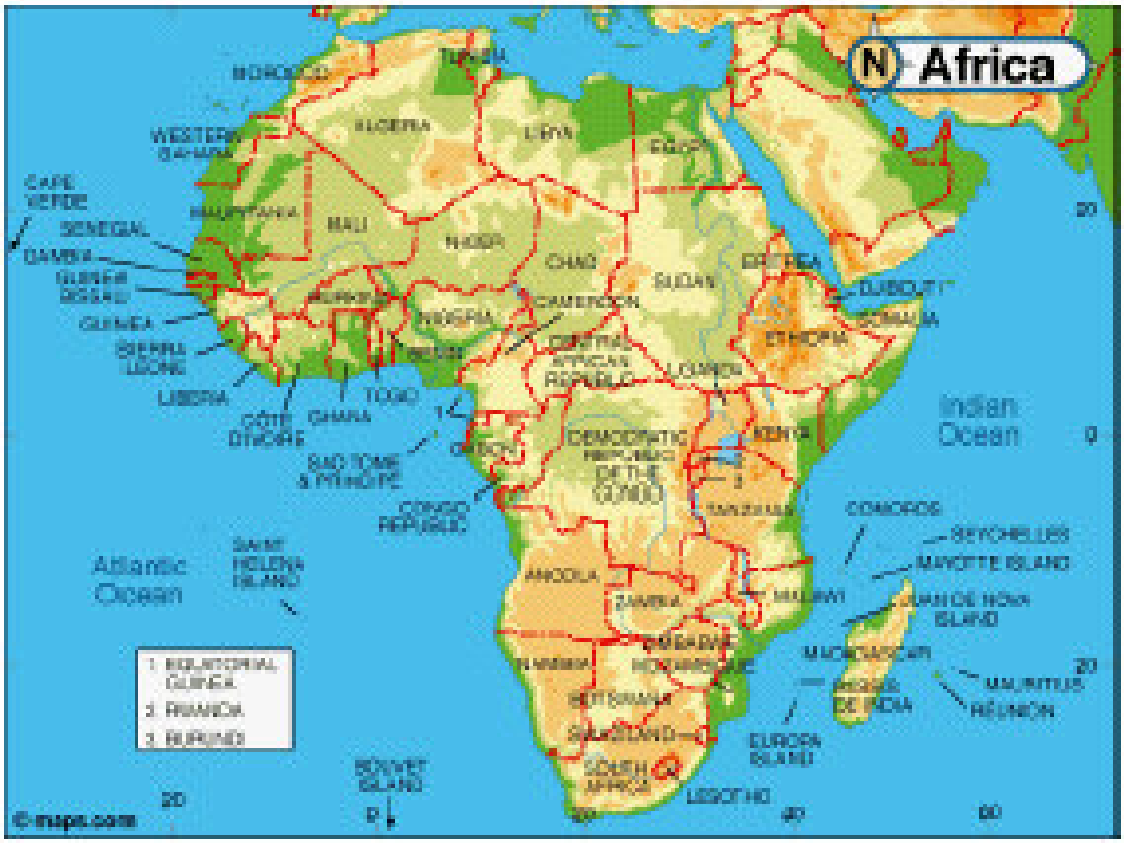
****

95% critical value for the augmented Dickey-Fuller statistic = -3.6921

LL = Maximized log-likelihood AIC = Akaike Information Criterion

SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Map of Africa



From : Herman Musahara, (2004) Ph.D Dissertation, Western Cape.

APPENDICES II: GRAPHS