

**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,
KUMASI**

**THE ECONOMIC IMPACT OF HIV/AIDS ON LABOUR AND CAPITAL ON THE
GHANAIAAN ECONOMY**

by

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CERTIFICATION

I herein certify that, this work was carried out solely by Twumasi, Ebenezer Birch (PG 2014308) in the department of Mathematics, Institute of Distance Learning, in partial fulfillment of the requirement for the award of Master of Science Degree in Industrial Mathematics.

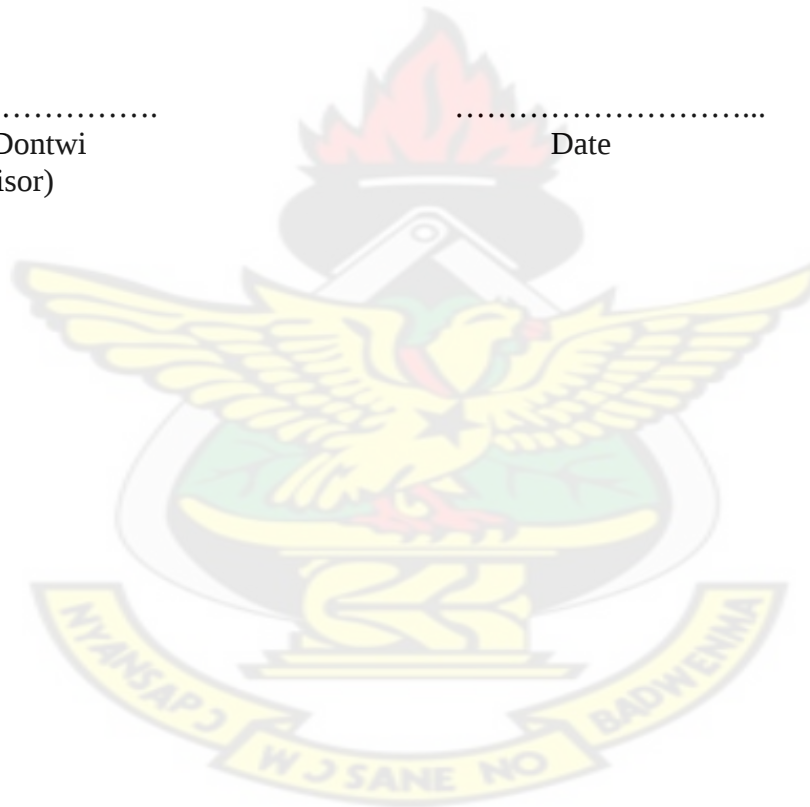
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DECLARATION

I hereby declare that this submission is my own work towards the Msc, and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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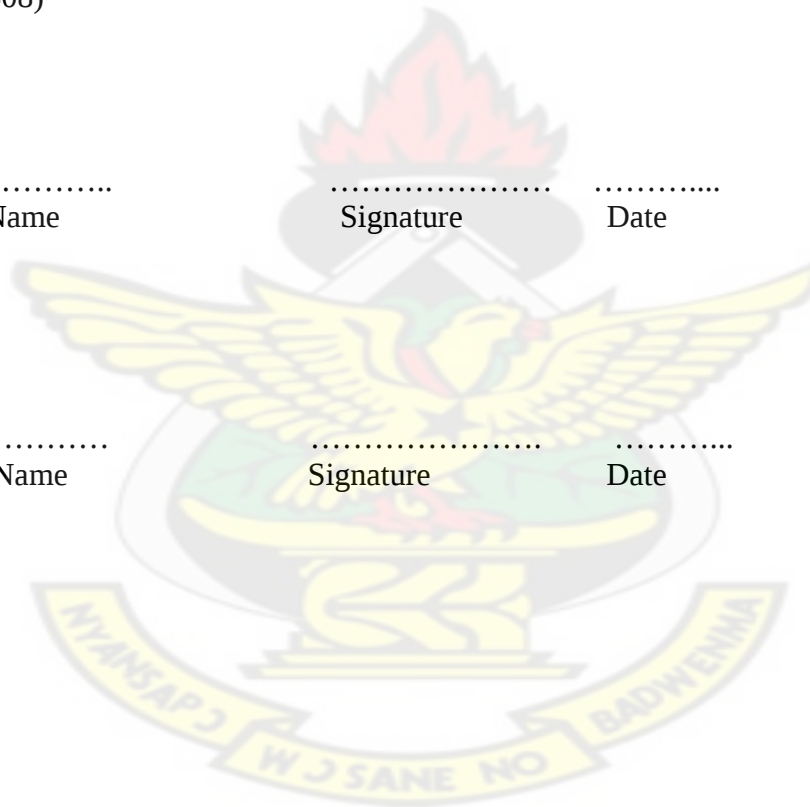
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DEDICATION

I dedicate this thesis work to my loving parents who laid the solid foundation for my informal and formal education, and all other family members, particularly; Ellen, Karen, Jane, Mabel, Elvis and Henry, for their prayers, and encouragements during my course of studies.

Lastly, to Mr., Kofi Anokye – Manu, Headmaster of Okomfo Anokye Senior High School – Wiemoase, Ashanti Region, and Mr., S.B. Osei (a retired officer of B.R.R.I. – KNUST), Bomso – Kumasi.



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ABSTRACT

There is no doubt that the greatest public health problem threatening the human race in these times is HIV/AIDS pandemic. The greatest burden of this scourge is in sub – Saharan Africa. This thesis reveals the impact of HIV/AIDS on labour and capital on Ghanaian economy. The model constructed used data spanning from 2006 to 2008. The findings revealed that, the epidemic impacts directly on labour supply and indirectly on the provision of capital. Descriptive research design was used, a mathematical model was constructed, which appropriately relied on the principles of predator – prey model, for studying the dynamics of the impact of the epidemic on an economy. The economic impact of HIV/AIDS is identified by tracing through the effects on households, firms and the government and thus on measures of overall economic activity. Numerous studies that were reviewed during the study had shown that, high prevalence of malaria is correlated with low rates of economic growth, with particular reference to HIV/AIDS, it is fair to say that, it has a trenchant, or impoverishing effect on economies. The costs of HIV/AIDS come in the form of reduced growth, declines in savings and investment rates, and huge health care costs. Those studies that were sampled had been extremely valuable in improving or sharpening our understanding of the threat posed by the epidemic. The young people in their most productive years are more at risk of HIV infection than other demographic group. This has had the effect of sharply reducing life expectancies across the continent. Ghana is considered as one of the countries with low HIV/AIDS prevalence rates, yet the annual AIDS deaths was 17,058 and prevalence is high among the 40 – 44, and 45 – 49 year groups.

The first – order system of differential equations which models the impact of HIV and AIDS on labour supply and capital is as shown here; $u(x, y) = \left[kx \left(1 - \frac{y}{Y} \right), -hy \left(1 - \frac{x}{X} \right) \right]$. The

equation, $u(x, y) = 0$ was solved, Two equilibrium points $(0, 0)$ and (X, Y) were obtained from the solution. The stability of the first equilibrium point is unstable saddle point. The stability of the second equilibrium point is stable centre, because its eigenvalues were purely imaginary. The results, discussions, and recommendations of the thesis were based on the behaviour or stability in the neighborhood of the equilibrium point (X, Y) .

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CHAPTER ONE

INTRODUCTION

1.0. OVERVIEW

The chapter focuses on the background of the study, statement of the research problem, objectives of the study, methodology, significance, research question / hypothesis, research limitations, delimitations, organization / structure of the study, and definition of terms.

1.1 BACKGROUND OF THE STUDY

Acquired Immune Deficiency Syndrome (AIDS) was first recognized internationally in 1981 and in Ghana in 1986. AIDS is caused by the human immunodeficiency virus (HIV) which compromises the immune system and makes the body prone to opportunistic infections (GSS 2008).

The HIV / AIDS pandemic is the greatest public health disaster of our age. It is a global pandemic, but it is concentrated in Africa, which contains about 70 percent of the people living with HIV and AIDS across the world (De Waal, A. 2003). Infection is concentrated in the working age or prime-aged adults' population (ages 15-49) with women infected at earlier ages than men. A study had shown that an estimated number of 20 million Africans have died since the start of the HIV / AIDS (UNAIDS, 2003) A further 29.4 million people are presently living

with the virus (De Waal, 2003). This has received considered attention by epidemiologists and demographers, as well as health economists concerned with the impact of the disease.

More recently, an IMF publication comprehensively classifies the impact of HIV/AIDS into three broad categories; demographic impact of the disease, macroeconomic impact, and impact on government finance and public services (Haacker, 2004). By disproportionately affecting the young adults and those in the productive age group, the primary demographic impact of the pandemic is estimated to lead to an increase in dependency ratio. This effect is also reflected in the significant rise in orphan rates, and the greater number of women – headed families (UNAIDS, UNICEF, and USAIDS 2004).

For the macroeconomic impact, there is bound to be rise in health expenditure and lower income generating potential and savings among households, private firms, and business may also suffer from lower productivity on account of higher personnel costs due to health – related expenses on absenteeism, sickness, death, and recruitment, as well as organizational disruptions. These constitute an additional burden and a deterrent both to expanding domestic investment and fostering foreign direct investment (World Economic Forum 2004). Similar effect can be seen in the public sector, where significant pressure on budget is created by the decline in the revenue side, given the reduction in working age labour force, and increase in the expenditure side resulting from higher health and welfare costs.

Other writers also consider HIV / AIDS as a crisis and at the same time a chronic condition. It is a crisis, because the speed with which the virus had spread has proved to be quite overwhelming.

It also appears to interact with other stresses and shocks in unprecedented ways (Asea, and De Waal, 2003). The epidemic is a chronic condition, because it impacts most heavily on the most productive sectors of African economies, namely, prime-aged adults. Thus the virus is depriving these economies of scarce skills, children of their parents and a continent of a generation in the prime of their working lives. This is where HIV/AIDS is distinct from most of the other diseases that afflict Africa (Asea, 2003).

Knowledge of AIDS is universal in Ghana; 98 percent of women and 99 percent of men have heard of AIDS. Nevertheless, a survey had shown that only 25 percent of women and 33 percent of men have a comprehensive knowledge of HIV/AIDS prevention and transmission i.e. knowing that a healthy – looking person can have HIV (the virus that causes AIDS), (GDHS, 2008). The attitude of many Ghanaians toward people living with AIDS is encouraging, because, 75 percent of women and 79 percent of men age 15 – 49 are willing to care for a family member with HIV in their own household. However, only one in three women and two in five men say that they would buy fresh vegetables from a vendor with AIDS, (GSS, 2008).

The main focus of this thesis is not on this human tragedy, written ten million fold across our continent, but on the wider social and economic impacts that this brings in its wake. While this work provides, at best, imperfect measures of the impact of HIV/AIDS on national wellbeing, it can still be of use to policy makers, and agencies involved in development cooperation to develop a policy response to HIV/AIDS. Focus on the economic impacts on households and industries as well as economic aggregates can help to sharpen understanding of the direct and indirect effects of the epidemic.

The epidemic is deepening poverty, reversing human development achievements, worsening gender inequalities, eroding the ability of governments to maintain economic growth (Collins and Rau, 2001). The epidemic is changing the contours and dynamics of poverty through its demographic and socio-economic impacts, which may create inter-generational poverty by improvising surviving orphans (often forcing them out of school, thus limiting their livelihood options), by fragmenting or dissolving households, and by decimating the fragile asset base of the poor.

Agriculture is the largest and the most dependable sector in most African economies, making up the majority of employment, but it is coming under increasing pressure from the HIV/AIDS epidemic. If just a few workers are lost at crucial times of the year then this can even have a disproportionate effect on harvest and income.

In Ghana, Agriculture contributes 34 percent of the gross domestic product (GDP) (GSS, 2008) and it employs about 50 percent of the population (GSS, 2002). Between 2003 and 2008, however, there was a slight decline in the growth rate of the agriculture sector, from 6 to 5 percent which can be attributed to loss of labour productivity (GSS, 2008).

According to Todaro and Smith (2004), Health is a prerequisite for increase in productivity. Health is one of the most important assets a human being has. It permits us to fully develop our capacities. Life cycle models have explained how one's health status can determine future income, wealth and consumption (Lilliard and Weiss 1997; Smith, 1999). Barron (1996),

comments, health is a capital productive asset and an engine of economic growth. Using this argument, we can consider health as a determinant of human capital. Likewise, Mushkin (1962), indicates human capital formation, with the help of health services, and education are based on the argument that people develop themselves when they invest in these assets and will earn a future return with them. (Haacker,2004).

In developing countries in particular, manual work makes up a large proportion of output, and physical endurance and strength rely crucially on sound health, this increases the level of productivity in the economy. Healthier populations- due to lower health related expenditures and higher likelihood of future survival are more likely to save and invest for the future, and their savings are invested in the infrastructure and factories that are essential for economic prosperity or expansion (Haacker, 2004).

Capital is vital for economic development, this includes- physical capital and human capital formation (McDonad and Roberts, 2004). The study by Knowles and Owen (1995) explicitly models both education and health as components of human capital as follows; $Q_t = (K_t)^\alpha (E_t)^\beta (H_t)^\gamma (A_t L_t)^{(1-\alpha-\beta-\gamma)}$. They assume that aggregate output in a country at time t, Q_t is a function of physical inputs K_t , educational attainment E_t , health H_t , labour L_t , and labour augmenting productivity A_t . The exponents α , β , and γ are elasticities. Recently, analysts have argued that HIV/AIDS will not only lead to loss of human capital but also to weakening of mechanism whereby knowledge and skills are transmitted and acquired (De Waal, 2003). This contributes to the present understanding of the economic impact of this debilitating disease. The disease has the potential to reduce the rate of increase of production per input (labour) of a household, a firm, or

a country, because the input which is labour, is being decreased substantially through effects of AIDS. For this reason, African economies or parts thereof will struggle to retain current skill levels and production levels. This requires mitigation of the impact of the epidemic on social and economic developments (Romer and Weil, 1992).

Over the past decade the government of Ghana has embarked on various economic and poverty – reduction programmes with the aim of improving the living conditions of its citizenry. In 2007 the Livelihood Empowerment Against Poverty Programme (LEAP) was introduced, and in 2008 individuals identified as poor started receiving monthly allowances (GSS, 2008). Keeping pace with this programme, The Ghana AIDS commission, which is the coordinating body for all HIV/AIDS related activities in the country, is reviewing the National Strategic Framework, covering 2006 – 2010, with stakeholders, and multilateral partners, for reducing new HIV infections, address service delivery issues and individual and societal vulnerability, and promote multidisciplinary approach to HIV/AIDS programmes. Ghana's goal is to prevent new HIV infections as well as to mitigate the socioeconomic and psychological effects of the epidemic on individuals, communities, and the nation (GHDS, and GSS, 2003).

Sickness also contributes to the scarcity of labour because of both the incapacity of workers and the time others have to devote to looking after them. The effect of these losses is that such households rarely recover even their initial level of living, since their capacity is eroded (De Waal and Asea, 2003). There are, therefore, several reasons to include health as an input or a determinant of the macroeconomic production process. Consideration of Paul A Samuelson's (1987) production function, which is of the form; $f(y) = -0.16y^2 + 1.6y$ can help. In this model,

the amount of output (domestic products), $f(y)$, with labour force of size y , can be reduced if skill labour supply shrinks due to any health hazard. So health improvements therefore, spur the increase in output, and savings which, by enabling greater investment in physical capital, spurs economic growth. Since firms may also be significantly affected, there is a fear that the costs of AIDS to companies will discourage investment in Africa (De Waal and Asea, 2003).

A common methodology used by health economists to assess the total indirect costs of premature death is the human capital approach. The human capital approach typically estimates the value of productivity cost by computing the present value of the stricken individual's future earnings under certain assumptions about his or her life style, wage profile, and future participation in labour force. The earnings stream is discounted to the time of death or initial illness. Another approach proposed by Cuddington (1993) is the growth model. Here, the classic Solow (1956) growth model, is extended to incorporate the key macroeconomic approach which focuses on estimating the cost of individual cases of the disease in terms of present value. The mortality effect of HIV/AIDS has two impacts, first is to lower population growth rates. The second impact is to change the demographic composition of the population, because a combination of death and illness associated with HIV and AIDS outstrips all other causes of staff turnover (Mankiw and Romer 1992). In the context of population growth, it can be stated that; $\frac{dp}{dt} = kp$,

where, k (the relative growth rate) = $\frac{1}{p} \frac{dp}{dt}$. The significance of the k , is that, it measures the percentage growth rate. So AIDS prevalence or mortality impacts negatively on the relative growth rate k , of the population. Perhaps the most important point to note is that the causality between HIV/AIDS prevalence and macroeconomic devastation works both ways. Just as the

epidemic places severe strain on the functioning of the economy, the economic impact fosters an environment in which the epidemic proliferates (Haacker, 2004).

Sub-Saharan Africa potentially faces a vicious cycle of economic slowdown, poverty and the spread of HIV/AIDS. Wealth and health are intricately and unquestionably related (Hamoudi and Sachs, 1999). It is against this background that, this study examines the impacts of HIV/AIDS on macroeconomic growth, supply of quality labour force, poverty reduction strategies, government finance and public services.

1.2 THE STATEMENT OF THE PROBLEM

It is hard to believe that a disease, that was all but unknown barely two decades ago, has – to date – caused the death of about 18.8 million people globally (UNAIDS, 1999). Even, despite recent improved access to anti – retroviral drugs, and care in many regions of the world, HIV/AIDS epidemic claimed approximately 3.1 million lives worldwide, in 2005 alone (UNAIDS, 2005). The African continent has the highest incidence of HIV/AIDS in the world today. The very worst affected countries on the continent – indeed in the world – are Southern Africa. The pandemic is the greatest public health disaster of this age, it causes rapid turnover of workers, and much associated absenteeism.

In order to fully appreciate the disease burdens, and enormity of the crisis unleashed by the HIV and AIDS epidemic in Africa, as elsewhere, it is necessary not only to understand the epidemiology of the disease, but to also understand its impact on the growth of economies. It is against this background, that the present study seeks to find, and shed light, on the economic

impact of HIV and AIDS on labour and capital on Ghanaian economy – effective supply of labour force, and gross poverty reduction efforts.

1.3. OBJECTIVES

The objectives for this research study are;

1. to model the economic impact of HIV and AIDS, using a system of ordinary differential equations.
2. to obtain solutions of the differential equations, and to interpret them in the context of the study.
3. to discuss the stability of each equilibrium point.
4. to make recommendations, based on the solution, and interpretations, to policy makers, stakeholders, the general public, and for further studies.

1.4 METHODOLOGY

The research design employed in carrying out this study is a simple descriptive research, because, a secondary data will be collected to describe the association between health (i.e. the epidemiological environment) and economic growth.

The population for the study will include the individuals, households, communities, regions, and firms in Ghana that are affected by the HIV/AIDS pandemic. The sample includes all those who were tested HIV and AIDS positive, during 2006 – 2008 HIV sentinel survey period. The data will be analysed by using Matlab software.

1.5 SIGNIFICANCE OF THE STUDY

The findings of this study would help individuals and households to appreciate the long term devastating and debilitating effects of the HIV/AIDS epidemic on human, community, and national, development, so as to take the necessary steps towards limiting the effects of this pandemic.

Besides, the solution of this problem can help policy makers to develop comprehensive policies tailored to the needs of the economies of individual households, firms and the nation as a whole. Moreover, the solution of this problem would help policy makers and the government to come out with economic measures or programmes which give best value for money.

Above all, the outcome of this research will help the government to assess the overall impact of HIV/AIDS on the efficiency of public services, the fiscal consequences, domestic tax base and thus government revenue.

1.6. RESEARCH LIMITATIONS

It is the wish of the researcher to consider the overall interdependent effects of the HIV/AIDS on the economies of individual households, firms and countries in the Sub- Saharan African countries and South African countries for the results to be more concise.

But, due to financial constraints, limited time and with data still scarce, the accessible source of data will be the individuals, households, communities in Ghana that are affected by the epidemic.

1.7. RESEARCH QUESTIONS/HYPOTHESES

To achieve the purpose of the study, or to obtain a solution to the problem, the following research questions/ hypotheses have been proposed;

1. The HIV/AIDS has no economic effect/ impact on the determinants of economic growth in the long term.
2. HIV/AIDS has no economic effect /impact on the quality and supply of labour force to both formal and informal sectors in Ghana.
3. HIV/AIDS has no effect/ impact on the gross poverty reduction efforts in Ghana.

1.8 ORGANIZATION OF THE STUDY

This study consists of five chapters. Chapter one of the study is the introduction, which describes the background of the study, statement of the research problem, objectives of the study, methodology, significance of the study, research limitations, research questions/hypotheses, organisation of the study, and definition of terms.

Chapter two comprises the review of related literature. This focuses on the conceptual base of the study thus, the usefulness and application of mathematics. It discusses the economic impact of HIV/AIDS, on the long term growth and development of an economy. The effect of the epidemic

on the quality, and supply of labour force from households (because households own the labour force) to all sectors of the economy. It also looks at the effect of HIV/AIDS on the gross poverty reduction efforts in Ghana. Chapter three is concerned with the methodology employed in carrying out the study which includes; research design, population, sample, data collection, writing of the mathematical model for studying the dynamics of the problem, and data analysis.

Chapter four, deals with the presentation of results, obtaining solution for the model, interpretation of results, and other findings. Finally, chapter five presents the summary of the research findings, implications of the study, conclusions based on the study, and recommendations.

1.9 DEFINITION OF TERMS

The following definitions will apply to the selected terms in this study;

AIDS; Acquired Immune Deficiency Syndrome

ART; Anti retroviral Therapy

GDHS; Ghana demographic and health survey

GSS; Ghana statistical service

HIV; Human immunodeficiency Virus

HSS; HIV sentinel survey

LEAP; Livelihood Empowerment Against Poverty

NACP; National AIDS control Programme

PHRL; Public Health and Reference Laboratory

UNAIDS; United Nations Agency for International Development Strategy.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Mathematics is a science of patterns that is useful in many areas. Indeed, the most rapid areas of growth in applications of mathematics have been in the social, biological, and behavioural sciences. Financial analysts, legal scholars, political pollsters, and sales managers all rely on sophisticated mathematical models to analyze data and make projections. Even artists and musicians use mathematically based computer programs to aid in their work. No longer just a tool for the physical sciences, mathematics is a language for all disciplines. No matter what major a student chooses, mathematics can play a key role in solving interesting problems in that discipline (Zitarelli and Coughlin 1991).

It is often desirable to describe the behaviour of some real-life system or phenomenon in mathematical terms. The mathematical description, often by means of a function or an equation, of a real-world phenomenon, is called a mathematical model, and is constructed with certain goals in mind (Stewart, 1999). For example, we may wish to know the life expectancy of a person at birth, understand the mechanism of a certain ecosystem by studying the growth of animal populations in that system, carry out demographic analysis, spread of information, spread of communicable diseases, radioactive decay and using absorbing stochastic matrices to exhibit a long term trend (like mental illness or in business), or together with game theory, to formulate

and solve variety of problems with practical applications related to vaccines, and public health in general (Goldstein and Schneider, 1995).

A model is a simplified picture, its purpose is to help or facilitate understanding of reality and perhaps to make predictions about future behaviour, because it avoids confusing details of reality. Once constructed, it can be appropriately applied to several different situations. The compound interest formula, given by $A(t) = P(1 + r)^t$ for example, can be used to measure the effectiveness of investment by doubling time or applied to many areas outside banking. It can also serve as a model for population growth under certain assumptions (Zitarelli and Coughlin 1991).

The construction of a mathematical model of a certain system or phenomenon starts with identification and description of the variables that are responsible for changing the system or phenomenon. Secondly, a set of reasonable assumptions or hypotheses about the system or phenomenon is made. The mathematical depiction of all these assumptions may be a differential equation, a system of differential equations, exponential function, or a difference equation (Stewart 1999).

There are several different situations where mathematics can be applied or used as a tool for solving problems, which includes; advertising strategy, book production cost, carpentry, cost of living, demand curves, economic forecasting, farming, financial management, population growth, school bussing, vehicle inspection and mortality rates, and many more.

Many studies have attempted to measure the impact of HIV/AIDS. Most have focused on the probable impact of the pandemic on different demographic and microeconomic indicators in the long term. This study focuses particularly on constructing or developing a model for studying the dynamics or impact of HIV/AIDS on labour and capital on Ghanaian economy. Other types of models that have been developed for studying interactions between health and macroeconomic growth include; the computable general equilibrium models, computer simulation models, econometric models using cross-sectional data or time series data, etc.

More recent research has begun to establish that the apparent correlation between health and wealth operates through a number of channels including the effects of improved health on demography, education, the labour market production and investment.

2.2 ESTIMATING THE ECONOMIC IMPACT

Recent studies by Gallup and Sachs (2000) have, by using cross-country measures of malaria prevalence to explain cross-country growth, shown that high malaria prevalence is correlated with low rates of economic growth. With particular reference to HIV/AIDS, it is fair to say that, the initial orientation of academic and policy research was to see the epidemic as a public health problem, not a development one as such. However, there is now general agreement that the pandemic has a trenchant effect on the economy.

A number of studies, notably, Cuddington (1991) on Tanzania, Kambou, Devarajan and Over (1991) on Cameroon and a third by Myers et al (1991) on Thailand have shown that the economic costs of HIV/AIDS are colossal. They come in the form of reduced growth, declines in savings and investment rates, and huge health care costs. These and other studies that have come

in their wake, have been extremely valuable in improving or sharpening our understanding of the threat posed by the epidemic. Even so, it is important to acknowledge the limitations in the techniques and methods employed in these studies and the caveats with which their conclusions must be taken.

As Cohen (1991) points out, the estimation of the long-term effects of HIV depends on our ability to predict the likely course of the disease. Indeed, the widely used measure of disease burdens, i.e. the disability adjusted life years (DALYs) and its various refinements, do not capture the full economic costs of disease especially as they fail to take account of the effects of a disease burden on the future generations and even the full measure of indirect costs of today's generation. So the caveats are sounded here as a reminder that we don't know everything about the epidemiology of the disease, so the economic impact which they quantify are potential consequences and effects that can be averted by conscious and expanded policy action (Sachs, 2000).

Major shifts in attitudes are required if any implemented policies for prevention are to be effective. This means grappling with sensitive issues of sexuality and gender relationships, where major fundamental changes are required. Such changes will be extremely difficult to bring about, but there are no alternatives.

2.3 THE ECONOMIC IMPACT OF HIV/AIDS ON DETERMINANTS OF ECONOMIC GROWTH IN THE LONG TERM

Economists draw a distinction between short – term economic stabilization and long term economic growth. Economic growth refers only to the quantity of goods and services produced.

It is often measured as the rate of change in GDP. So economic growth is primarily concerned with the long – run. If HIV/AIDS hits a household or a community, economic activities begin to shrink.

Therefore, estimating the combined impact of these various interdependent effects on the performance of an economy is a complex task. So, to simplify the measurement of “economic performance” economists have tended to focus on the average income, or gross domestic product (GDP), per capita.

The World Bank in 1992 estimated that across 30 sub-Saharan economies, AIDS reduces GDP growth by between 0.8 and 1.4 percentage points a year. Studies in the year 2000 found that South Africa is expected to lose 1.6 percentage points of growth a year, while Botswana may lose up to 4.4 percentage points annually. The level of national savings depends on domestic income less domestic expenditure on current output plus net savings from overseas. If as a consequence of HIV, current consumption expenditures rise relative to income then there will be lower domestic savings rate, and fewer domestic resources will be available to finance investment (Bloom, 1993).

An important factor in generating direct investment by foreign companies in several Asian economies over the past two decades has been the availability of low cost and plentiful labour (Malaysia and Thailand offer good examples). HIV and AIDS has the potential for changing the costs of such labour as well as its availability. This investment has been a critical element in the transformation and development of economies, and any reduction will have severe implications

for economic performance (Bloom and Lyon, 1993). So the epidemic hampers long-term growth prospects. Investment allows for the accumulation of capital, which in turn allows firms to expand production and raise national income. However, HIV/AIDS leads savings to fall dramatically. A savings deficiency therefore hampers the opportunity for investment, preventing the economy from expanding.

The joint United Nations Program on HIV/AIDS (UNAIDS) estimated that in Ghana, the HIV/AIDS prevalence in adults is 3.1 % at the end of 2003, with an estimated 350, 000 people living with the disease. Ghana's 2003 demographic and Health Survey reported prevalence at 2.2 % among the 9000 people who agreed to be tested. "Health profile; Ghana" USAID (March 2005). This, therefore, suggests that a certain percentage of Ghana's GDP would be lost as a result of AIDS.

Current estimates suggest that HIV/AIDS has reduced the rate of growth of Africa's per capita income by 0.7 percentage points per year, (Bonnell 2000) clearly then, the epidemic is reversing the modest gains made in recent times (Over 1992), the effects on growth at the macro-economic level- are gradual and drawn out over time, partly due to the long incubation period of the virus (Bonnell 2000 : Annex 5:3). Broadly speaking, it is known that, poverty, income inequality, labour migration, gender inequality, low levels of education, and a range of socio-cultural variables and initial health conditions facilitate the spread of HIV/AIDS and are associated with higher prevalence rates (Bonnell, 2000)

This implies that workers' productivity will be affected, which is likely to decline sharply as a result of HIV/AIDS. The effects on macro-economy are expected to increase significantly over time.

2.4 THE IMPACT OF HIV/AIDS ON THE QUALITY AND SUPPLY OF LABOUR FORCE

HIV/AIDS has the potential for a devastating impact on economic growth because of its impact on the labour market – growth in the labour input, labour hours worked in a given week reduces. So illness and mortality from the epidemic reduce services provided by labour in the course of production. The composition or quality of the labour force also changes, and there is a new mix of skilled and unskilled, with falling numbers of experienced workers in all sectors of the economic activity. The young people, in their most productive years are more at risk of HIV infection than other demographic group (Cladwell, 2006). In these societies that experience rising adult mortality, the passing on of acquired skills and knowledge, which has been such a major factor in the growth of labour productivity diminishes. Demographic change, therefore, seems to have played a significant role in enhancing development and subsequently influenced economic growth and poverty reduction (Dixon, 2002).

The concern is not only with reduction in the size of the labour force, but also its quality. Many of those infected with HIV/AIDS are experienced and skilled workers in their productive prime representing considerable human capital losses. It can, therefore, be said that the loss of skilled workers and the changing structure of labour force means reduction of capacity for the transfer

of technical skills from worker to worker, and between generations. These are processes that have been taken for granted in the past, but that are now threatened by HIV/AIDS (Cohen, 1991). This is likely to lower both the average age of many workforces and their level of skills and experience. The human capital formation and quality will also be seriously eroded, by the impact of the epidemic.

Labour- intensive firms, on the one hand, are primarily faced with the problem of higher turnover in the labour force, capital- intensive companies, on the other hand, typically rely more on the experience and knowledge of a few personnel (Isaken et al., 2002). The long period of illness, absenteeism (from work by infected and affected workers) and death of colleagues associated with AIDS reduces labour productivity and hence revenue falls.

One review reported that the annual costs associated with sickness and reduced productivity as a result of HIV/AIDS ranged from \$17 per employee in a Kenyan car manufacturing firm to \$300 in Ugandan Railway Corporation. (Elias, 2002). Lower domestic productivity reduces exports, while imports of expensive healthcare goods may increase. The output of the economy will certainly be reduced by HIV, and there will be a loss of potential production (Cohen, 1991)

Beyond the disruptions to public services associated with increased attrition rates, HIV/AIDS also affects the composition of government employees in various dimensions and the level of human capital available to the government. The effects are said to be catastrophic- not just on workers and their families, but on businesses and the overall national economy. This may also decrease the economy's attractiveness to foreign investors, and diminish tax revenue.

Loss of staff members has consequently led to under- staffing of certain facilities and slowed down provision of services. (De Waal, 2003).

2.5 THE ECONOMIC IMPACT OF HIV/AIDS ON GROSS

POVERTY REDUCTION EFFORTS

Many governments have been pursuing human development objectives with a focus on the elimination of poverty, disease and ignorance. The approaches to meet the millennium development goals (MDGs) on eliminating hunger, jobs creation and increase incomes, have been, however, hampered by limitations in capacity, financing and governance problems. Ghana is not an exception, so in the year 2000, the government of Ghana, with the objective of ensuring effective management and a unified response to the HIV and AIDS epidemic, adopted a multi-sectorial approach to address the developmental challenges of the epidemic (GSS, 2008).

The persistence of extreme poverty is often solely attributed to inadequate political and economic institutions, which fail to provide the critical foundations for functioning market economies (Barro, 1997). But there are important correlates of global poverty that fall within the realm of the biological sciences and epidemiology, such as high prevalence of infectious diseases, (such as HIV/AIDS) low life expectancies, and high rates of reproduction (WHO, and UN Millennium Project, 2007). The most conventional explanation for these correlates is that poverty is an underlying cause of disease and mortality, and high mortality rates drive high rates of reproduction.

The increase in mortality and morbidity as a result of AIDS, reduce living standards directly and have repercussions that affect all areas of the economy. The loss of; people of working age, household's production and income, drastically increases the dependency ratio. This in turn means that surviving children are less likely to be educated or well- nourished. It has been argued that, without mitigation, this will make it impossible for governments to reduce poverty (Haacker, 2004).

The epidemic also strikes the poor who can least afford treatment and care, thereby increasing existing problems of poverty (Haacker, 2004). The situation in Ghana is no different, according to the 2008 annual report of the national AIDS/STI control programme (NACP), in order to make significant change in the lives of people living with HIV, (PLHIV), NACP continued with the provision of anti-retroviral drugs, and financial grants were given to them (PLHIV), to support their psycho-social meetings and also to undertake income generating activities.

A study has shown that, Ghana is one of the few countries in Sub- Saharan Africa that can be regarded as low prevalence country. Yet, these impact assessments are important, in order to inform the implementation or intensification of both effective prevention activities and targeted care, surveillance and support strategies.

CHAPTER THREE

METHODOLOGY

3.0. RESEARCH DESIGN

The method chosen for this study is a simple descriptive research, because, the writer only wants to, by means of data, establish the association between health hazards and economic growth of individuals, communities, firms, and a nation as a whole.

3.1. STUDY AREAS

The areas under study are the individuals, households, communities, regions, and firms in Ghana. Subjects for this study were all adult HIV infected patients aged 15-49 years. That is pregnant women attending antenatal clinics during the 2006-2008 HIV sentinel survey (HSS) period. Male, and female patients seeking treatment for sexually transmitted infections (STIs) at sexually transmitted infections clinics during the same survey period. The sample size for this study is the 240,802 total HIV population in the country (HSS, 2009).

The choice of this population was made in order to know the prevalence rate, assess, understand the economic cost associated with the sickness and reduced productivity, estimate, or predict the overwhelming and impoverishing effects of the HIV/AIDS' deaths on households income, and even the gross domestic products (G.D.P.), per capita income, and the growth of the economy in Ghana.

It is believed that the epidemic has the potential for a devastating impact on economic growth because of its impact on the labour market (Haacker 2008).

3.2 SOURCE OF DATA

The data for this analysis were secondary data obtained from the demographic survey conducted by the Ghana statistical service, and the HIV sentinel survey annual report obtained from the epidemiological unit of the Komfo Anokye Teaching Hospital (KATH) Kumasi, Ghana.

Analysis was done on the data to build an appropriate model for determining or predicting the devastating impact of the HIV/AIDS epidemic on the development of the economy, based on the following parameters:

- I. The economic impact of HIV/AIDS on the quality and supply of labour force to both formal and informal sectors in Ghana.
- II. The economic impact of the epidemic on the gross poverty reduction efforts in Ghana.
- III. The economic impact of the epidemic on the determinants of economic growth in the long term.

3.3 THE ECONOMIC IMPACT ON THE QUALITY AND SUPPLY OF LABOR FORCE

Infectious diseases continue to be most significant in poor or developing countries where birth rates and transmission rates are systematically high, (Mclean and Anderson, 1988).

Patterns of morbidity, fertility, and mortality in particular age groups that supply labour to formal and informal sectors are determined by interactions between infectious diseases and systematic

human socioeconomic processes. It is becoming increasingly clear that many infectious diseases such as HIV/AIDS are themselves causes of poverty, owing to their effects on labour productivity. (Bonds and Rohani, 2009).

The human immunodeficiency virus (HIV) reveals its developmental effects or its impact on economic and social systems by reducing both the quantity and quality of labour available to produce output. A model is presented here, to show how the epidemic affects factors like; the level of net savings, investment rates, economic growth rate, the level of Gross National Product (GNP), per capita income, and on the size of the effective labour supply by skill or education, which has critical implications, for what can be produced, and under what conditions of production (Cohen, 2008).

After all, economic activity requires human resources- specifically, human capital, and therefore relies on biological processes in the form of physical labour and cognition which are often compromised by infectious diseases; Nokes et al (1992); (Holding and Snow, 2001).

Indeed, fertility, poverty, and disease are not only signatures to each other, but they also interact with each other in an important and predictable ways that can be built into traditional disease ecology model, which can be useful for the analysis of demographic transitions (Sachs, 2005).

In Ghana, for instance, the government is now set to transform the rural economy in order to ensure sustained and even economic growth. Substantial investments in agriculture would be the driving force behind the transformation of the rural economy. It is therefore, incumbent on the

youth to access credit to undertake productive ventures. The government has re-introduced the youth-in- Agriculture program to encourage the youth to venture into farming. So hard work is much needed to transform the economy. (Duffour, K. 2010), (The finance minister), Economy Set For Take-off, The Daily Graphic,___ number 18115, pp 1, 3 and 7. Undoubtedly, the prevalence of any infectious disease, in such a time frame, that impacts heavily on physical strength and endurance will be detrimental to the growth of the economy at present, and for decades to come.

Economists say that, a worker who is well-fed and free from disease will be more productive than one who is weak and ill. So in order to deepen our understanding of how the supply of labour affects the growth of an economy, a model is presented in this section, which appropriately relies on the principles of predator- prey model (Lotka, 1925), (Volterra,1926), (Anderson and May, 1992).

Assume the following facts about the model;

- I. there is no HIV/AIDS outbreak or prevalence
- II. the rate of increase of labour supply by skill and education to produce output is proportional to the size of labour available

This can be expressed mathematically as

$$\dot{y} = hy \quad y \geq 0 \quad \text{where, } h \text{ is a positive constant}$$

Since h , is a positive constant, it implies that the rate of increase of labour supply is an increasing function of time. The analytical solution of the model gives; $y = De^{ht}$, which is an exponential function, and it models the supply of labour not affected by the prevalence of an epidemic. It is clearly seen that the supply of labour will grow or increase exponentially.

The solution $y = De^{ht}$ is a one parameter family of solutions of the equation $y' = hy$ on the interval $(-\infty, \infty)$. The solution varies as the parameter changes, depending on initial conditions.

However, to give a more realistic description or impression of the supply of labour, which has been adversely affected by the prevalence of HIV/AIDS, the rate of supply of effective labour force will decline sharply, through illnesses and absenteeism, this leads directly to the model shown here,

$$y' = -hy \quad \text{where } y \geq 0$$

The analytical solution of this equation will yield a solution curve of the form $y = D_1e^{-ht}$, which means the much needed skilled labour, the variable input to ensure sustained output and economic growth is now declining slowly or exhibiting 'negative growth'.

All things being equal, if the number of labour available is so low in proportion to capital as a result of health hazards such as AIDS then production will decrease.

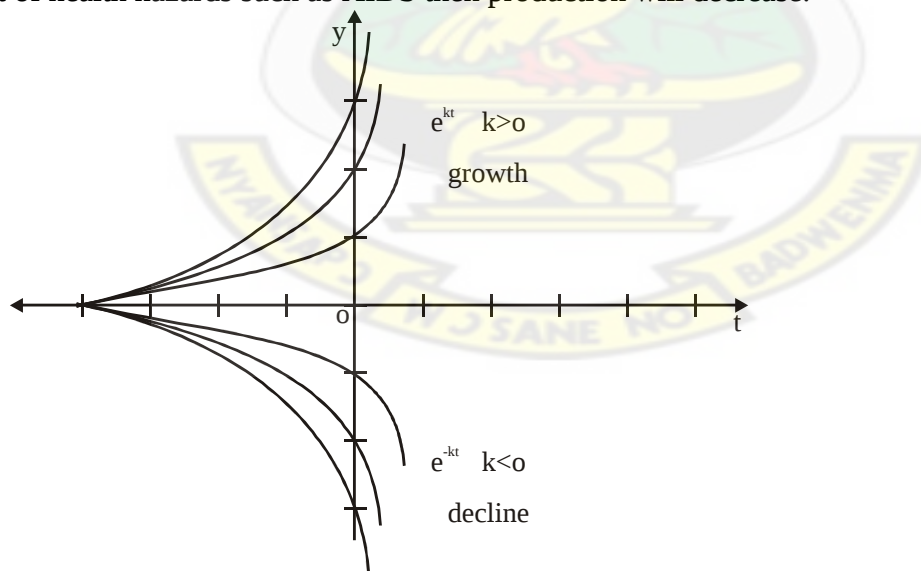


Fig. 3.1

This simple graph (supply of labour against time) allows one to study the dynamics of labour supply as time increases. The rate of growth or decline of the supply of labour is a consequence of health condition. Good health ensures growth, as shown by the curves above the horizontal axis, whilst health hazard such as AIDS causes a decline of labour supply as depicted by the curves below the horizontal axis. With the help of this graph, the harmful or devastating effects of the HIV/AIDS epidemic on the size of labour supply, and for that matter the growth of an economy of the nation can easily be appreciated. This should, therefore, call for an effective, expanded, and integrated policy response or prescriptions to mitigate the spread of the epidemic. This is imperative, because, the disease in effect, is a major threat to production and development of a country. Thus, most policy interventions will have to focus on households and communities as the effective intervention points in the social and economic structure.

3.4 THE ECONOMIC IMPACT OF THE EPIDEMIC ON GROSS POVERTY REDUCTION EFFORTS

While most of the world had enjoyed exponential economic growth, undeveloped Sub-Saharan African countries are still beset by poverty, because of the feedback between economics and the ecology of infectious diseases, (Keenan, 2009).

In fact, the burden of infectious diseases is likely to be a cause of poverty and has been implicated as an underlying barrier to economic development, (Strauss and Thomas, 1998).

The profits theory holds that the amount of investment spending depends on the amount of profits that firms are making. This theory therefore suggests that, output depends on the supply of inputs, for all variable inputs, particularly labour available, will find employment.

Essentially, economies can grow only if they can produce enough so that there is a little bit left over-for-saving, after the needs of the people have been met. The ability to save is crucial to growth, because it increases the potential to produce in the future, (Haughton, J., 1992). It is therefore clear that, the amount of production, and hence revenue or income will fall with a decline in labour supply, due to AIDS and its associated illness and absenteeism. Once income reduces, savings is likely to reduce, which has the potential to cripple economic expansion of a household, a firm, or a nation.

It is, however, the case that the most direct impact of HIV/AIDS mortality and morbidity is at the household level-the very base of the economy. The impact on households with HIV normally broadly the same pattern: loss of income, if a breadwinner stops work due to sickness or death, or if a breadwinner has to stop work to look after a sick family member. So much, is the impact, on a household's labour supply, and for that reason reduces the household's daily, monthly, and annual income. Decline in the households' savings is further stretched by the cost of health care and funerals. (De Waal, 2003).

Households typically use up much of their savings to meet health care costs and funeral costs. They may also sell assets to meet urgent expenditure needs. AIDS death brings with it loss of productive resources through the sale of livestock to pay for sickness, mourning and funeral expenses, as well as sharp decline in productivity (De Waal, 2003).

Assuming a household is affected by the HIV/AIDS, then its income, savings and investments, altogether, considered as capital, x and the size of labour supply represented as y , will reduce,

this is the true picture, of the devastating impact of the epidemic, because AIDS has no cure at present. The burden, enormity, and severity of the disease can be portrayed by the dynamics of the models shown here;

$$\dot{x} = -kx, \quad \text{and} \quad \dot{y} = -hy, \quad x \geq 0 \quad y \geq 0$$

The negative sign in the first equation means, the rate of growth of capital $\dot{x}$, will be decreasing with time, because of the loss of income through the death of a breadwinner, due to AIDS. In the second equation, the negative sign means that, the rate of growth y of labour supply is decreasing, or being lost to HIV/AIDS pandemic. The loss of a household's production and income as a result of AIDS' morbidity and mortality, especially amongst the young people, means that surviving children and young adults are less likely to be well-nourished. If schooling and health, investments in children, shrinks at present, the economy could be affected for decades (Beegle, 2008).

Among other things, healthy agricultural development, for instance, can reduce poverty, release labour to other productive sectors, and earn foreign exchange, as well as supply of food (Haughton, J., 1992).

Economic growth declines as; the population grows more slowly, national savings reduces, and rising health care cost deter investment (Haacker, 2004). This subjects the generation through vicious cycle of economic slowdown, poverty and the spread of HIV/AIDS. This therefore hampers all efforts to reduce poverty.

The short and long term effects of this situation can be described by the model shown here. The following facts can be assumed;

- I. a one year improvement in a population's life expectancy
- II. a stable population

The rate of growth of output or income represented by $u(x, y)$ per unit of capital is directly proportional to the difference between the rate of increase in the size of labour supply and the rate of increase in capital. This can be expressed mathematically as;

$$U(x, y) = \mu(\dot{y} - \dot{x}) \quad \text{where;}$$

$\dot{y}$ = rate of increase in the size of labour supply

$\dot{x}$ = rate of growth of capital

μ = constant of proportionality, or rate of growth of production or income.

This model depicts that, for any value of $\mu \leq 1$ and for any values in which the rate of supply of skilled labour begins to decline, as a result of health hazards, to the extent that $\dot{x} > \dot{y}$, then, the rate of growth of productivity $u(x, y)$ will be negative or experience a negative growth, and the rate of return on capital will also be declining. Considered as investment, better health care can increase labour productivity and also lengthen the productive live span of a nation's workers. The graph below shows how production, or output varies with the supply of labour. It also measures the output of a firm at a given level of input. This can be appropriately used to measure the output or income of a household. The production function is $f(y) = -ay^2 + by$, where a , and b , are constants.

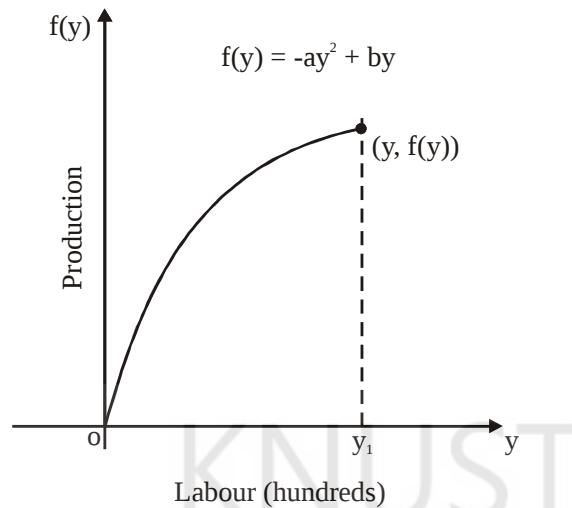


Fig. 3.2

The graph above indicates that any severe reduction in the supply of labour can adversely affect productivity. An important economic concept derived from here is marginal product, which is the derivative of the production function, which measures the rate of change of output as input changes. The largest number of labour units available to the firm is y_1 . This is valid only for values of y in the interval $[0, y_1]$

3.5 THE ECONOMIC IMPACT OF THE HIV/AIDS ON DETERMINANTS OF ECONOMIC GROWTH IN THE LONG TERM

The extraordinary impact of the HIV/AIDS on development is attributable to its ability to undermine three main determinants of economic growth, namely; physical, human, and social capital (Bonnell, 2000). The epidemic exerts much impoverishing effects on individuals' productivity, household assets and income, investments in children, and economic growth.

Perhaps the empirically most well-established and uncontroversial effect has been found at the individual level and for people living with AIDS. Studies have found significant negative effects on the patient's capacity to engage in income-earning activities. (Russell, 2004).

In line with the neoclassical economic growth theory, the rate at which the output or income of the economy grows depends basically on; savings, and the act of changing what is saved into capital good, the rate at which its capital stock, labour force, and technological know-how grow over time, a production function can be used to assess the economic impact or effect of the HIV/AIDS on output and economic growth.

Assuming the following facts;

- I. a one year improvement in a population's life expectancy
- II. a stable population
- III. a production function with constant returns to scale,

A relationship for any period of time may be simply expressed in the form:

$$Y = F(K, L, A) \quad \text{where}$$

K = capital stock

L = the size of labour force

A = an index of technological know-how

Let the production function stated above be replaced by a point $(x, y) = (x(t), y(t))$ in a plane, representing two determinants of production or economic growth, i.e. physical capital $x = x(t)$ and human capital or labour $y = y(t)$ at any time t . As t increases the point $(x, y) = (x(t), y(t))$ will trace a path that represents the variation of capital and labour with time. At a particular time t , it is supposed that these factors of production are $x(t)$, and $y(t)$. The purpose is to determine

how these evolve with time. The evolution of the two determinants can be represented as a path as shown here;

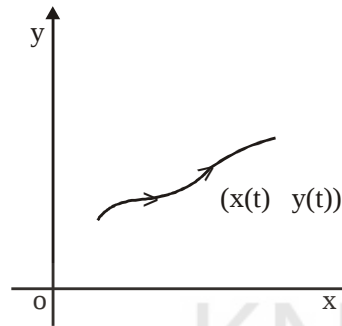


Fig. 3.3

The directions on the path indicate the directions in which the point $(x(t), y(t))$, moves.

Using vector notation, the pair of determinants may be represented by the vector $\mathbf{x} = [x, y]^T$

which means $\dot{\mathbf{x}} = [\dot{x}, \dot{y}]^T$

Assuming the following facts about a household or the population in the country;

- i. There is no HIV/AIDS epidemic, therefore, both capital and labour supply are evolving independently
- ii. The rate of growth of capital is proportional to the current capital stock
- iii. The number and quality of labour supply increases in a rate proportional to the present size of labour

This may be modelled by the pair of equations

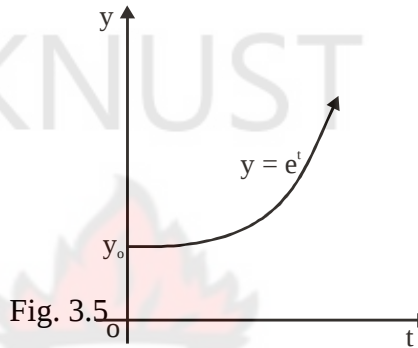
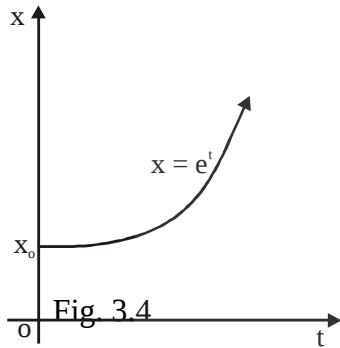
$$\dot{x} = kx, \quad \dot{y} = hy, \quad x \geq 0, \quad y \geq 0$$

Since k , and h , the proportionate growth rates, are positive constants, it means in an ideal situation, when there is no serious health hazards, or outbreak of any infectious diseases such as the HIV/AIDS the economy will be growing exponentially.

Choosing a suitable value for the amount of capital $x(t)$ and labour supply $y(t)$ at time $t = 0$, for example, give the explicit solutions;

$$x = x_0 e^{kt}, \quad x \geq 0, \quad y = y_0 e^{ht}, \quad y \geq 0$$

These exponential functions can also be solved geometrically as shown in figures 3.4, and 3.5 for any time $t \geq 0$



These two situations may be described as exponential growth in physical capital and human capital. This can be achieved through better health care, and well-being of the majority of a country's people.

Careful study or analysis of the dynamics of this model reveals that, HIV/AIDS can affect output or total income through its economic impact on capital accumulation, due to low productivity that leads to low per capita income. It can also impact heavily on the supply of labour force – labour productivity. Because, there is an apparent correlation between health, wealth, labour productivity, and levels of real GDP per capita.

McDonald and Roberts (2004) assume that, HIV/AIDS prevalence has an effect on accumulation of health capital. Health outcomes in a country are assumed to be a function of several inputs.

These inputs Z_t include factors such as health expenditure, education, infrastructure, and so forth.

Health outcomes are also assumed to be functions of a country's epidemiological environment d_t , such as disease prevalence rates. The health outcome function can be summarized as;

$$H_t = f (Z_t, d_t).$$

By taking the HIV/AIDS prevalence rates to proxy for d_t , one can estimate its impact on macroeconomic growth through its effect on health capital accumulation.

In a real Ghanaian society, and elsewhere, it is unlikely that capital invested and the size of quality labour supply will increase harmoniously to ensure smooth growth of the economy, therefore, in the wake of HIV/AIDS prevalence the following assumptions can be made;

- i. The growth rate of capital will be decreased by a factor proportional to xy ,
- ii. The declining growth rate of labour supply need to be increased by a factor proportional to xy
- iii. HIV/AIDS can affect top level personal – those who own the capital

This requires that the first model $\dot{x} = kx$, and $\dot{y} = hy$, ($x \geq 0, y \geq 0$) should be revised, to include changes based on these assumptions. So the system of differential equations that models the impact of HIV/AIDS on an economy is now given by;

$$\dot{x} = kx - \beta xy \quad \text{and} \quad \dot{y} = -hy + \alpha xy, \quad \text{for some positive constants } \beta, \text{ and } \alpha$$

Together, this system of differential equations models the pair of factors of production or vital determinants of economic growth. The system is said to be coupled because the rates of change of capital and labour supply depend on both x and y .

Let $\beta = \frac{k}{Y}$, for some positive constant Y , and $\alpha = \frac{h}{X}$, for some constant X , so that the

system of equations becomes

$$\dot{x} = kx \left(1 - \frac{y}{Y}\right), \quad \dot{y} = -hy \left(1 - \frac{x}{X}\right).$$

Where k , h , X , and Y are positive constants. This can be written as $\dot{x} = u(x, y)$, and the vector field $u(x, y)$ is given by

$$U(x, y) = \left[kx \left(1 - \frac{y}{Y}\right), -hy \left(1 - \frac{x}{X}\right) \right]$$

Solving this system of non-linear differential equations will help one to appreciate the dynamics of how provision of capital and the size of labour supply depend on each other, or evolve in response to each other, to ensure economic growth or decline, which partly depends on the prevailing health condition. Besides the impoverishing effects of the HIV/AIDS on the long term growth of economies can also be appreciated. The model seems to predict that both determinants $x(t)$ and $y(t)$ are periodic in time.

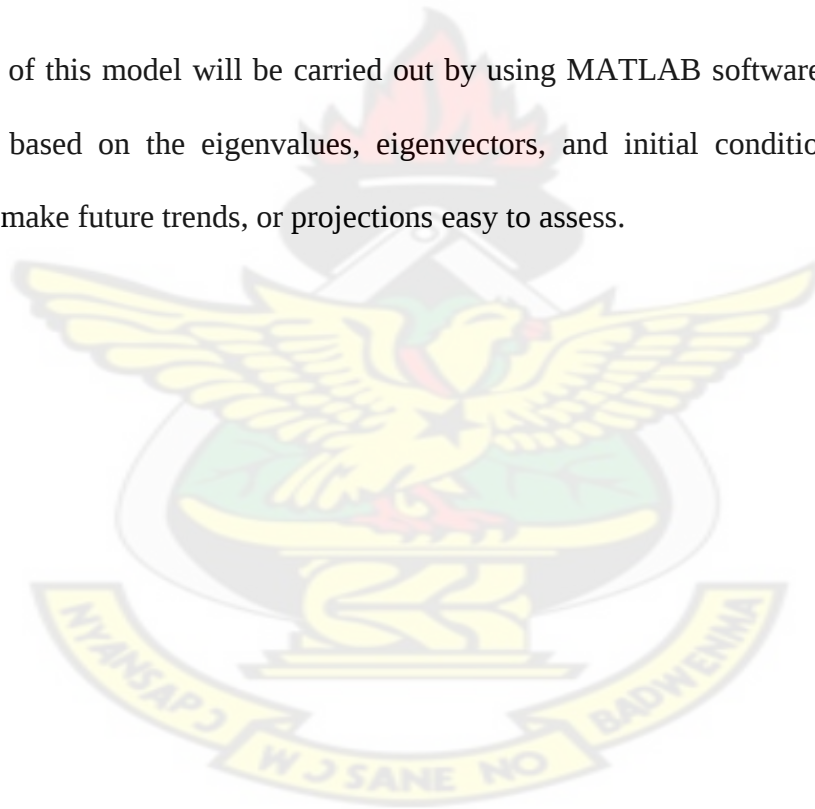
There is evidence that, as awareness of the risks associated with HIV infection increases, there is a change in social behaviour, and also that, therapy with behavioural change alters the course of

HIV epidemic, Becker, N. G., Egerton, L. K. (1994). This is one reason why this present study is being carried out.

Every effort to minimize and there after eradicate a disease should begin with the effort to understand the dynamics of the models presented here.

3.6 DATA ANALYSIS

Further analysis of this model will be carried out by using MATLAB software. The plotting of phase portraits, based on the eigenvalues, eigenvectors, and initial conditions will depict a pattern that will make future trends, or projections easy to assess.



CHAPTER FOUR

RESULTS

4.1 INTRODUCTION

This thesis has estimated the impact of HIV and AIDS on the growth and development of economies, with particular reference to Ghana's economy, using sample from 2006 to 2008. The model will help to capture the impact of the epidemic on growth since its effect can be felt through capital and labour supply, which were the variables used. Despite data limitation, the study permits a number of conclusions. On the global scene, the epidemic had caused much devastation to many economies, demographic compositions, and the structure of many workforce. Adult HIV prevalence in the country, from the data, is 1.7 percent. This infection rate, although lower than that of neighboring countries, should be considered seriously.

It was found out that globally, it is a tragic irony that almost three decades after the Alma-Ata declaration elevated health to the status, a basic and fundamental human right and explicitly recognized its relationship with economic development, countries are witnessing, at the threshold of a new millennium, what may amount to the biggest health and development challenge the world has ever confronted – a disease which is unique in its devastating impact on the social, economic and demographic foundations of development (UNAIDS, 1999 a).

The disease has taken on different forms in different parts of the world. In some populations, the epidemic is equally prevalent among men and women, in others, certain

vulnerable groups have been disproportionately affected (Anaafi, et al, 1997; Orubuoye, et al, 1993); in many cases the situation is dynamic and the disease has moved between different sub – populations evolving with time (Essex 1998: 427). Explanations for these distinct patterns are to be found in diverse factors including biology, behaviour, gender, culture, poverty, mobility and the interplay between (Moses et al. 1994; Oppong, 1998). The table below gives a brief summary of some HIV and AIDS infective all over the world.

Table 4.1 Global Summary of HIV/AIDS Epidemic (as at December, 1999)

	People newly infected with HIV	Number of people living with HIV/AIDS	AIDS deaths
Men	2.4 million	17.3 million	1.1 million
Women	2.3 million	15.7 million	1.2 million
Children < 15yrs	0.7 million	1.3 million	0.5 million
TOTAL	5.4 million	34.3 million	2.8 million

This data was obtained from (UNAIDS, 2000).

4.2 ECONOMIC ANALYSIS

Economic analysis helps in evaluating; the impact of HIV and AIDS, the costs and benefits of mitigation programs or activities, the impact on the capacity of the economic system to deliver improved standards of living in the future. Through such analysis, there has come, a paucity of information or evidence to indicate the importance of health to economic and social development. Bloom, Canning, and Sevilla (2001) find that a one year improvement in a populations' life expectancy (a standard measure of health status) contributes to a 4 percent increase in output.

In another study, the same authors estimated that, a one year percentage point increase in adult survival rates boosts labour productivity by about 2.8 percent.

Formal analysis suggest that a country can, on average, expect to see per capita incomes grow by an extra 0.3 to 0.5 percentage points a year, for every five years it adds to its life expectancy (Bloom, and Malaney, 2000).

Moreover, studies that consider ‘full income’ – which assigns economic value to changes in life expectancy, suggest that, falling mortality rates have a more substantial positive impact on economic development. For example, in an assessment of the growth of real income per capita in the United States over the 20th century, Nordus, William (2003) concluded that over half of the growth in full income up to 1950 was attributable to mortality decline.

Bloom, Canning, and Jamison (2004) suggest in a new review of the literature on ‘Value of a Statistical Life (VSL) indicators’ that, the adverse economic impact of AIDS in Sub – Saharan Africa has already been more significant than GDP per capita data indicate. VSL analysis for Malawi shows a positive growth rate in full income in the 1980s. However, in the 1990s, as adults of working age began to die from AIDS, the full income rate turned sharply negative, compared with a more gentle decline in GDP per capita.

It is important to recognize that while measures of the impact on economic aggregates – such as GDP or per capita GDP provide useful indications of the overall economic impact, they typically fail to capture a significant proportion of the economy’s delivery of economic wellbeing to its people. This is, because, lots of economic activities are often unmeasured. More importantly,

measures such as production and consumption are only a partial indication of welfare, so that small changes in measured economic impact may not necessarily mean that welfare impacts are small (Allen, 1997).

4.3 THE ECONOMIC IMPACT ON THE QUALITY AND SUPPLY OF LABOUR FORCE

The economic impact of HIV/AIDS are identified by tracing through the effects on households, firms and the government and thus on measures of overall economic activity (Ainsworth, and Teokul, 2000).

In Ghana, the HIV sentinel survey (HSS), is a cross – sectional survey, and for the past seventeen years, the HSS has been the primary source of data for the National HIV and AIDS estimates in Ghana. The estimates are vital for planning as well as mitigating the impact of the epidemic. The collection of samples (Adults aged 15 – 49 yrs) by the HSS was for a period not exceeding 12 weeks, in each year (2006 – 2008, for this data). All samples were submitted to the National Public Health and Reference Laboratory (PHRL) for confirmation using immunoblot (INNOLIA), (HSS, and NACP, 2008).

According to the survey, rural sites accounted for 38 percent of the total number of HIV and AIDS samples analyzed in the year 2008. Three regions, greater Accra, Ashanti, and Eastern had HIV prevalence rate of 3 percent and above (HSS, 2008). HIV prevalence, however, had declined in all age groups except the 40 – 44, and 45 – 49 year groups (HSS, 2008). This can change the age structure of the population and labour force in Ghana.

Since 2003, a cumulative total of 23,614 people have enrolled on the Anti Retroviral Therapy (ART). These were made up of 22,585 adults and 1,029 children, out of this number, 1,055 have died, representing 4.5 percent, and 909 have been lost to follow ups. Currently, 21,584 people are on the ART, which represents 91.3 percent of those who have ever been put on anti retroviral therapy (NACP, HSS, 2008). The table below shows the number of people who were put on anti retroviral therapy, (ART) since 2006, i.e. only ART clients.

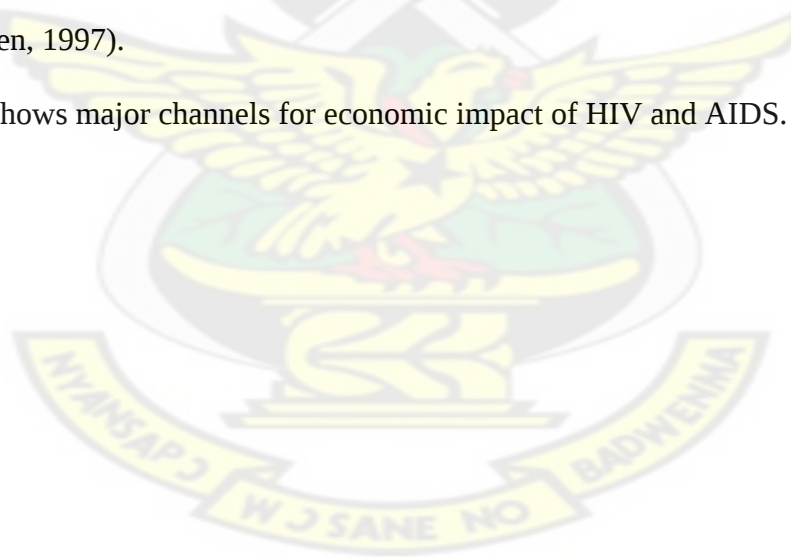
Table 4.2 ART Adult service data

	2006			2007			2008		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Number on HIV clinical care	2,138	3,783	5,921	4,109	9,121	13,230	4,970	12,082	17,052
Number of adults on ART	1,144	2,012	3,156	2,010	3,773	5,783	2,852	6,883	9,735
Number on co-trimoxazole prophylaxis (OIs)	4,530	2,576	4,106	3,390	6,927	10,317	3,955	9,180	13,135
Number lost to follow ups	8	23	31	332	491	823	148	230	378
Number lost due to death	24	27	51	115	159	274	200	300	500

Discussion; From this table, it can be seen that, not all the people living with HIV and AIDS, in Ghana, from 2006 to 2008 were put on the anti retroviral therapy. Yet out of the few who had that care, a cumulative total of 825 adults, from the table, (men and women aged 15 – 49) died due to AIDS.

It can be said that, such number of deaths, is an erosion of accumulated human capital, or labour supply. This can (or has the potential to) reduce household income, creates pressures for a reallocation of expenditures and of internal resources to address the care needs. Adult sickness and death and household response to cope with the resulting loss of income can lead to withdrawal of children from school to substitute for adult labour. This impacts on labour supply, and consumption patterns will be transmitted through to the enterprise and government sectors of the economy (Allen, 1997).

The chart below shows major channels for economic impact of HIV and AIDS.



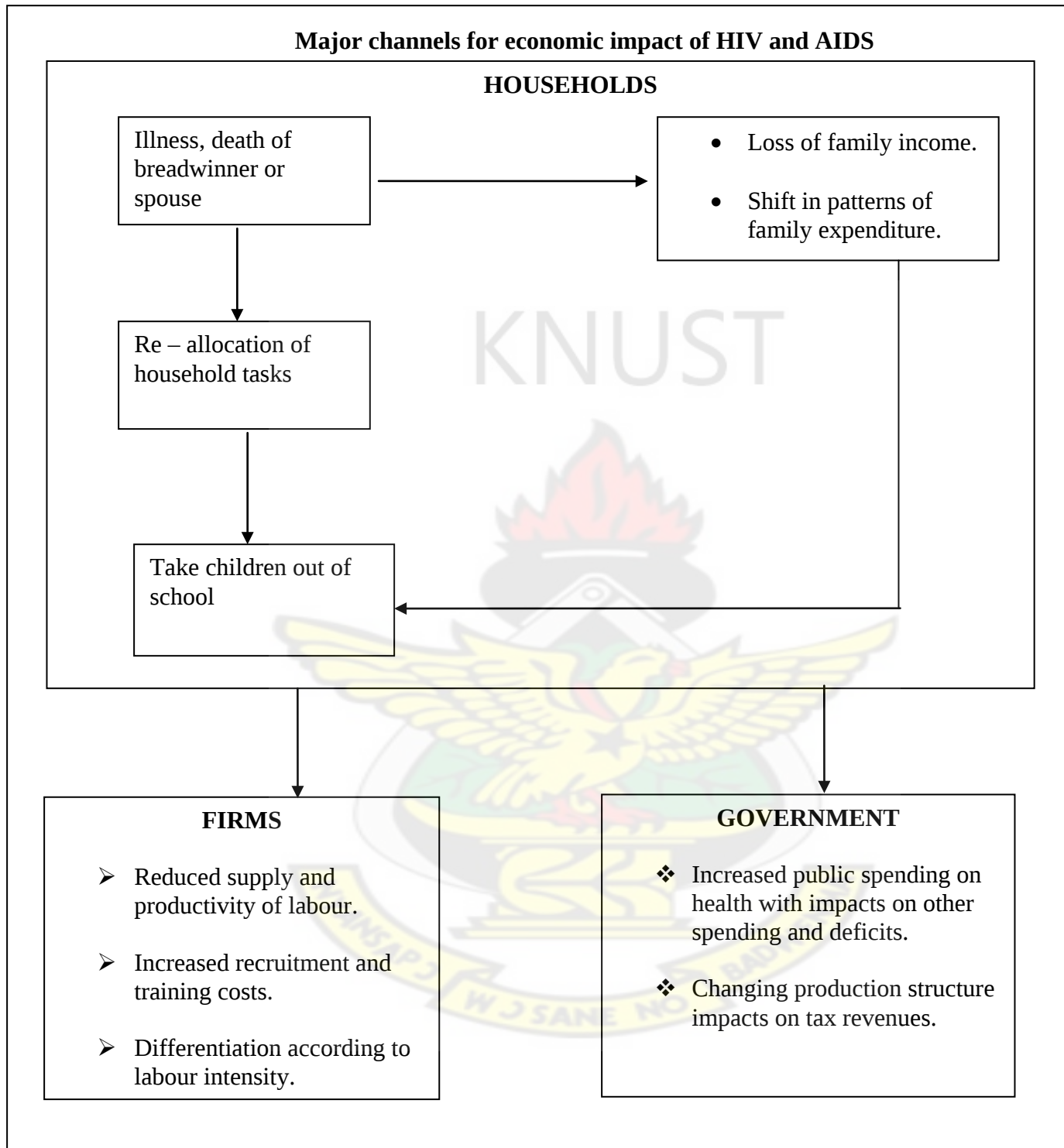


Chart 4.1 Major channels for economic impact of HIV/AIDS

More rapid turnover of workers may mean that the workforce is less experienced, which will, along with increased absenteeism, impact on productivity. According to the data, the HIV prevalence among the 40 – 49 year group is still high. So to get a very clear picture of the impact, it can be assumed that, the 825 people (from table 4.2) who died between 2006 and 2008, because of AIDS, about 76 percent of them (625) were in this age bracket (high incidence age group). Assume once again that, about 60 percent of the six hundred and twenty - five i.e. 375 were urban class, middle – level workers, who could earn an annual salary of about GHc 3,600, contributes 5-percent of the salary to the social security fund, married with two dependent children, then using the Internal Revenue Service (IRS 2008), tax information shown below with calculated tax relief, it can be estimated that;

Table 4.3 IRS tax information for 2008

Chargeable/taxable income	Rate of tax
First GH¢ 120 p. a.	Nil or 0 %
Next GH¢ 120 p. a.	5 %
Next GH¢ 300 p. a.	10 %
Next GH¢ 1860 p. a.	15 %
Next GH¢ 2400 p. a.	20 %
Exceeding GH¢ 4800 p.a.	30 %

If those people were alive then, each person would have had personal tax liability of GH¢ 500 per annum. Which, when multiplied by 375, would have amounted to GH¢ 187,500 as annual personal tax revenue for the government. Assume once again that, out of the remaining 450 people, i.e. $(825 - 375 = 450)$ about 300 were adults who belong to the self- employed

(characterized by very limited skill labour) sector, operating informal structures in Ghana. Even if each person could have paid GH¢ 100 per annum, as tax, from their businesses, that money would have amounted to GH¢ 30,000 per annum. The two categories of workers (skilled and unskilled) could have paid a total amount of GH¢ 217,500 into the government's tax revenue. Yet, all this estimated amount had gone down the drain due to AIDS. Indeed, this had impacted or impinged heavily on the government's tax revenue. Similarly, any family whose member had died through AIDS as table 4.2 shows, had also lost huge sum of money, whether the deceased was the breadwinner or not.

4.3 THE ECONOMIC IMPACT OF THE EPIDEMIC ON GROSS POVERTY REDUCTION EFFORTS

Poor economic growth has been largely responsible for the worsening of poverty situation in all Sub – Saharan African countries (Ainsworth, and Over, 1994). High levels of poverty – and its corollary, low levels of assets, which means that, a large number of people are vulnerable to the adverse economic effects of the HIV and AIDS epidemic. Low growth has contributed, through its effect on government revenues, to an increasingly limited capacity in the public sector to respond to the challenge that a serious epidemic may pose (Ainsworth, and Over, 1994).

In a presentation made at the 2008 consultative group/annual partnership meeting, then minister of state for economic planning, enumerated the nature and scope of development problems in Ghana, and mentioned among other things; social and human development compromised with poor educational and health outcomes, with implications for productivity and future development; MDGs achievement difficult, poverty incidence high despite improvements in last

two decades, inequality worsening between regions and within regions. (Osei Akoto, 2008). The poor health outcomes mentioned during the presentation can partly be attributed to the prevalence of HIV and AIDS.

During 2008, in Ghana, data on reported AIDS cases was collected by the HIV sentinel survey team at the various sentinel sites. AIDS case reporting has been used for over a decade by the Ministry of Health to assess the magnitude of the HIV and AIDS epidemic, and the distribution of AIDS cases in the country is shown in the table below.

Table 4.4 Reported AIDS cases by Region

	2007		2008	
Region	New reported AIDS cases	AIDS deaths	New reported AIDS cases	AIDS deaths
Ashanti	1,718	67	1,545	36
Brong Ahafo	2,681	189	3,552	246
Central	1,081	90	1,338	67
Eastern	12,259	235	5,275	275
G . Accra	2,498	190	3,078	307
Northern	269	7	127	2
Upper East	451	61	383	26
Upper West	340	20	348	24
Volta	1,781	120	988	39
Western	1,014	24	753	31
Total	24,014	1,003	17,387	1,053

Source; National AIDS control programme (NACP) and (HSS, 2008).

Discussion; From the table, it can be seen that, the total new AIDS reported cases for 2007 and 2008 was 41,401 out of which 2,056 died. Assume 70 percent of the deceased aged between 30 and 49, had spouses, who were the breadwinners, then it means about 1,439 families had lost

their breadwinners; thus lost of income to such families, and shift in patterns of family expenditure.

In areas where HIV and AIDS had impinged so hard, the proportion of dependants to income earners is anticipated to rise. Increasing dependency is usually related to increasing poverty. Available capital for investment is likely to reduce. The response is usually a cut back in education of children and nutrition levels reduces. The latter can have immediate impacts on productivity of labour, while the impact of lower education is lagged or becomes a long term (Bollinger, and Stover, 1999).

The treatment of family assets following the death of a spouse (particularly males) will have a major impact on the number of households already in poverty. The ability to remarry and social safety nets offered by extended family are also important determinants of whether families affected by the loss of breadwinner move into poverty, since female headed households are several times more likely to be below the absolute poverty line (Bollinger, and Stover, 1999).

According to the UNDP's Human Development Report, the richest ten percent account for 40.5 percent of national consumption, while the poorest ten percent account for only 1.7 percent (UNDP, 2001). Since income and asset distribution are usually highly correlated, this could mean that the poorer groups in the community have little in the way of assets.

In many Ghanaian societies, women and men fulfill different roles in interaction with subsistence and market activities. So the response to declining household production and income may fall

disproportionately on women. Because of such diversities in Ghanaian societies, it is difficult to generalize about the interaction between gender structure and the economic impact of HIV and AIDS.

4.4 THE ECONOMIC IMPACT OF THE HIV/AIDS ON DETERMINANTS OF ECONOMIC GROWTH IN THE LONG TERM

If HIV and AIDS has a negative impact on the growth of GDP then, it will certainly affect the trajectory of government revenue, as the base for most revenues will probably grow more slowly. Personal income tax revenues may be negatively affected, depending on how the effects on skilled and formal sector employment unfold (Bollinger, and Stover, 1999).

While there is myriad of microeconomic level impacts of an HIV/AIDS epidemic the main macroeconomic effects will arise through the change in the supply of labour and the flow – on effects of changes in income onto demand for goods and services, which in turn will impact on production decisions. To capture these flow – on effects, a model which appropriately relies on the predator – prey model is used as a basis for studying how the provision of capital and size of quality labour supply affect an economic growth, and also how the effects of AIDS on these determinants can affect the economy of Ghana.

The main factors, or determinants of interest are the availability or provision of capital and labour supply. The model is a comprehensive, economy – wide model, incorporating the household sector, the government sector, and the production sector. The model contains a detailed treatment of the labour market. The workforce is disaggregated into high skilled, semi

skilled, unskilled workers, with the supply of labour of each skilled category responding to real wage levels. The labour market also dichotomized between rural and urban areas.

Each sector combines labour of various skill categories with capital and material inputs according to its technology to produce its output. Growth in capital and labour employed in each sector drive productivity and growth in output, and hence GDP.

In 2008, the estimated adult National HIV prevalence in Ghana was 1.7 percent, while urban HIV prevalence was estimated as 2.1 percent and rural as 1.5 percent. The table below gives the details.

Table 4.5 National HIV prevalence as at December 2008

Total HIV population	240,802
Prevalence (%)	1.7
Incidence (%)	0.13
Total new infections	23,234
Annual AIDS deaths	17,058
Children < 15 yrs	21,202
Children new infection	3,755
AIDS orphans	135,905

Discussion; From this table, it can be seen that 17,058 people die each year as a result of AIDS, this will certainly affect the demographic composition of Ghana's population, the quality of labour supply to both formal and informal sectors.

It is reported that, the economy of Ghana is dominated by the activities of enterprises in the informal sector. It is estimated that, in terms of economic activity, about 86.3 percent is carried out by the self-employed sector mostly operating informal structures. (Ghana living standard survey, 2000), even though quite a significant number could easily be classified as earning below

the taxable threshold of income liable to tax. According to records at the Registrar General's Department, Ghana, there are 266,760 self – employed registered in the informal sector (Amamoo Lydia, 2008, Assistant Commissioner, IRS).

It is reasonable to say that, the 17,058 people who die each year through AIDS are workers in the private – sector, and also from the public sector, which will adversely affect output; an impact that will be compounded by reductions in productive efficiency, associated with increased incidences of ill health and shortages of critical skills. It is also likely that, this incident can reduce savings rates as well as to increase poverty.

As the data reveals the tragedies being caused by AIDS to this nation, it can naturally be fitted into the pair of equations which has been constructed in this study as the model for the present analysis.

Considered together, this pair of equations is called a first – order system (only first derivatives, but more than one dependent variable) of differential equations that models the impact of HIV/AIDS on labour and capital on Ghanaian economy. It is assumed that HIV/AIDS can also affect those who own the capital – top level management. $u(x, y) = [kx \left(1 - \frac{y}{Y} \right), -hy \left(1 - \frac{x}{X} \right)]$. Let $x(t) = x_0$ and $y(t) = y_0$ be constant solutions of the system of differential equations, which model provision of capital and supply of labour. It therefore, follows that $\dot{x}(t) = 0$, $\dot{y}(t) = 0$, this can be used to find the equilibrium points of the system.

The equation, $u(x, y) = 0$ need to be solved, which becomes

$$\begin{pmatrix} kx \left(1 - \frac{y}{Y}\right) \\ -hy \left(1 - \frac{x}{X}\right) \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

This gives the simultaneous equations $kx \left(1 - \frac{y}{Y}\right) = 0$, and $-hy \left(1 - \frac{x}{X}\right) = 0$

Equilibrium points are; (0,0) and (X,Y). The first equilibrium point has both capital and the supply of labour being zero, there is no capital no labour, i.e. nothing happens. The other equilibrium point occurs when there are X amount of capital and Y number of labour supply i.e. when the two factors or determinants of production remain constant.

In order to find the linear approximation of this non-linear system, each component of the vector $u(x, y)$ should be written as a function of two variables, x, and y

$$U(x, y) = [u(x, y), v(x, y)]^T$$

This can be represented in a matrix form as;

$$\begin{pmatrix} u(x, y) \\ v(x, y) \end{pmatrix} = \begin{bmatrix} \frac{\partial u}{\partial x}(x, y) & \frac{\partial u}{\partial y}(x, y) \\ \frac{\partial v}{\partial x}(x, y) & \frac{\partial v}{\partial y}(x, y) \end{bmatrix} \begin{pmatrix} p \\ q \end{pmatrix}$$

Where $x(t) = x_e + p(t)$

$y(t) = y_e + q(t)$

It is also true that $\dot{x} = \dot{p}$ and $\dot{y} = \dot{q}$

The linear approximations to the non-linear system for the perturbations (changes in the factors of production caused by severe health hazard, HIV and AIDS, in this situation), p and q from the equilibrium point (X, Y) is $\dot{p} = -\frac{kX}{Y}q$ and $\dot{q} = \frac{hY}{X}p$

The matrix coefficient that arise from the linear approximation is

$$\begin{pmatrix} 0 & -\frac{kX}{Y}q \\ \frac{hY}{X}p & 0 \end{pmatrix}$$

The matrix equation that results from this is as shown below;

$$\begin{pmatrix} p \\ q \end{pmatrix} = \begin{pmatrix} 0 & -\frac{kX}{Y} \\ \frac{hY}{X} & 0 \end{pmatrix} \begin{pmatrix} p \\ q \end{pmatrix}$$

Using the eigenvalue, eigenvector, method for solving the equation gives;

$$\begin{pmatrix} p \\ q \end{pmatrix} = \begin{pmatrix} -\lambda & -\frac{kX}{Y} \\ \frac{hY}{X} & -\lambda \end{pmatrix} \begin{pmatrix} p \\ q \end{pmatrix}$$

The $\det. (A - \lambda I) = 0$, from which the characteristic polynomial becomes;

$$\lambda^2 + hk = 0, \text{ where, } h = 0.017, \text{ and } k = 0.05$$

$$\lambda^2 + 8.5 \times 10^{-4} = 0, \quad \lambda = \pm 0.0292i, \quad \lambda = \pm 0.03i$$

when $\lambda = 0.03i$, the corresponding eigenvector is $\begin{pmatrix} 1 \\ -0.03i \end{pmatrix}$, but when $\lambda = -0.03i$ the

corresponding eigenvector is $\begin{pmatrix} 1 \\ 0.03i \end{pmatrix}$. The general solution becomes ;

$$\begin{pmatrix} p(t) \\ q(t) \end{pmatrix} = A \begin{pmatrix} 1 \\ -0.03i \end{pmatrix} e^{0.03it} + B \begin{pmatrix} 1 \\ 0.03i \end{pmatrix} e^{-0.03it}$$

further still the general solution becomes;

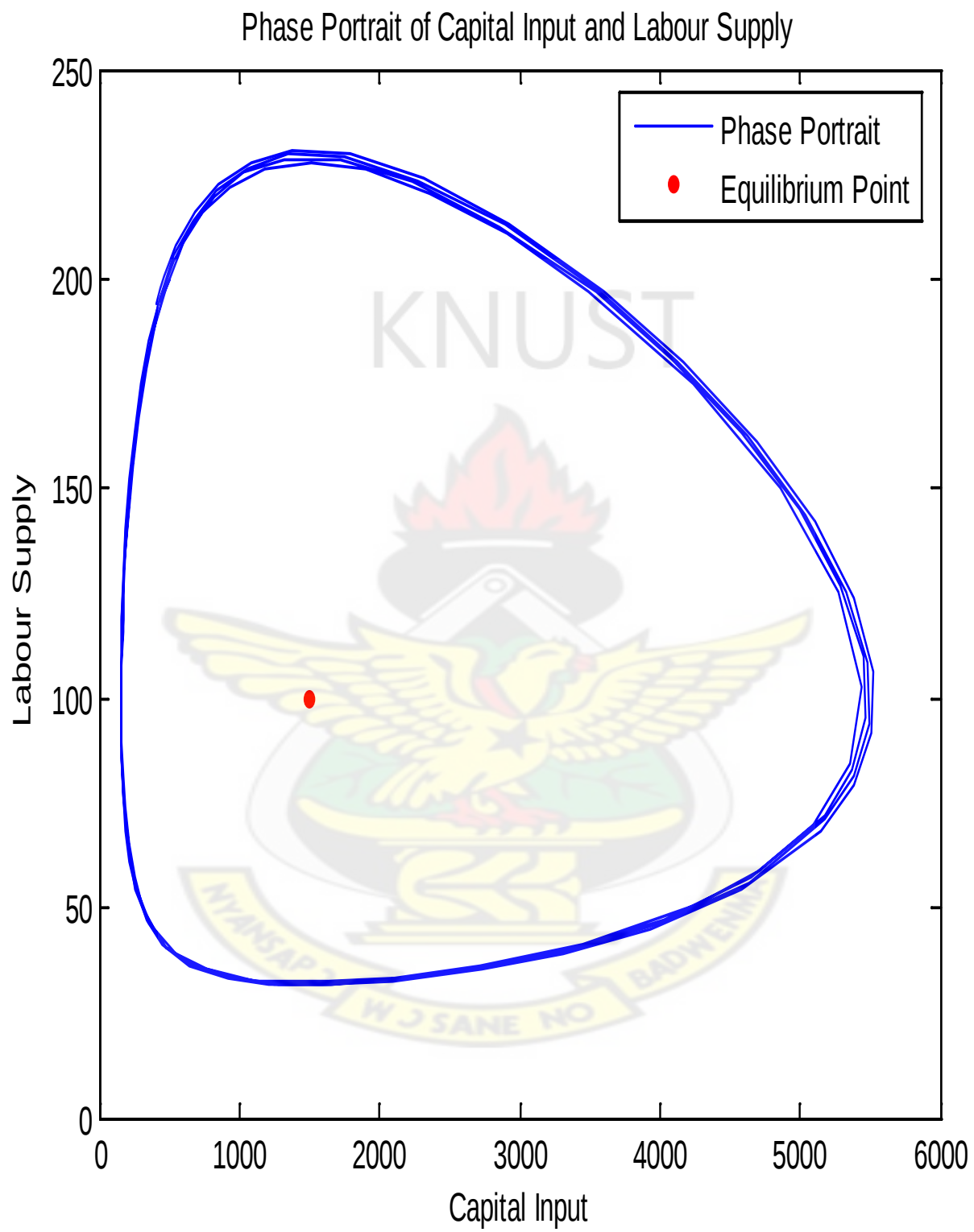
$$\begin{pmatrix} p(t) \\ q(t) \end{pmatrix} = C \begin{pmatrix} \cos 0.03t \\ 0.03 \sin 0.03t \end{pmatrix} + D \begin{pmatrix} \sin 0.03t \\ -0.03 \cos 0.03t \end{pmatrix}. \text{ Since the eigenvalues of the matrix of}$$

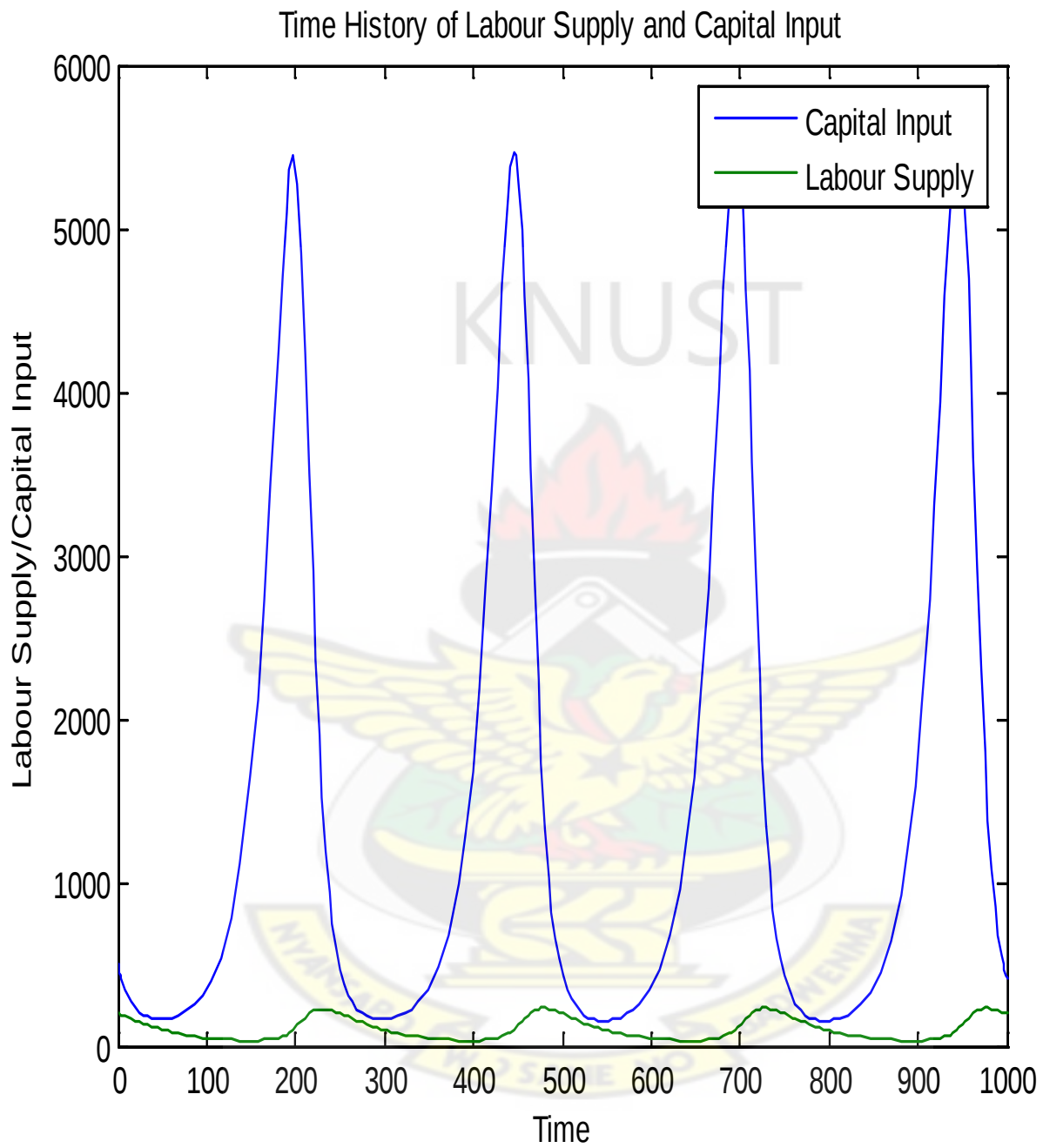
coefficients are purely imaginary, the equation of the trajectories is,

$K = C^2 + D^2$, so the paths are approximately circular, or elliptical. An equilibrium point which has this behaviour in its neighborhood is called a stable centre. So the equilibrium point (X, Y) of the original non – linear system of the model is a stable centre.

It is assumed that HIV/AIDS directly affect labour supply, and indirectly affect capital invested.

The phase portrait of this behavior together with the time history are shown here.





Let h , the constant of proportionality for the growth rate of labour supply be represented by the national HIV prevalence rate, i.e. $h = 0.017$, and k , the constant of proportionality for the provision of capital be 0.05.

The matrix equation that results from this is as shown below;

$$\begin{pmatrix} \dot{p} \\ \dot{q} \end{pmatrix} = \begin{pmatrix} k & 0 \\ 0 & -h \end{pmatrix} \begin{pmatrix} p \\ q \end{pmatrix}$$

This equation can be solved analytically to obtain the general solution using eigenvalue, eigenvector method. This suggests that $x(t) = A e^{\lambda t}$, where v is a constant vector is a solution.

$$Av = \lambda v \quad Av - \lambda v = 0 \quad (A - \lambda I)v = 0$$

$$\begin{pmatrix} \dot{p} \\ \dot{q} \end{pmatrix} = \begin{pmatrix} 0.05 & 0 \\ 0 & -0.017 \end{pmatrix} \begin{pmatrix} p \\ q \end{pmatrix} \quad \det(A - \lambda I) = 0$$

$$\begin{pmatrix} 0.05 - \lambda & 0 \\ 0 & -0.017 - \lambda \end{pmatrix}, \text{ the determinant is; } (0.05 - \lambda)(-0.017 - \lambda) = 0$$

The roots of this equation are ; $\lambda = 0.05$, $\lambda = -0.017$

The corresponding eigenvectors are ; $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$,

the general solution can be written as;

$$\begin{pmatrix} P(t) \\ q(t) \end{pmatrix} = A \begin{pmatrix} 1 \\ 0 \end{pmatrix} e^{-0.017t} + B \begin{pmatrix} 0 \\ 1 \end{pmatrix} e^{0.05t}$$

The interest is in the behaviour of phase paths near equilibrium point at $p = 0$ and $q = 0$. When $B = 0$ and $A \neq 0$, on these paths are the solutions $p(t) = Ae^{-0.017t}$, $q(t) = 0$, so the point $(p(t), q(t))$ moves towards the origin along the p – axis as t increases. On the other hand, the paths with $A = 0$ and $B \neq 0$, the solution gives $p(t) = 0$, $q(t) = e^{0.05t}$, so the point $(p(t), q(t))$ moves away from the origin along q -axis as t increases. Clearly, when these behaviours are plotted on a phase plane, non stable phase paths or portraits will be seen, which therefore mean that, the original non linear system also have an unstable saddle equilibrium point at $(0,0)$. This behavior will continue indefinitely.

But, this does not happen in real life economic situation, and is of no interest to the research.

Results indicate a negative (though insignificant) effect of HIV/AIDS on economic growth through capital. The negative impact of capital from the model could be as a result of capital spent in treatment and prevention of the epidemic, which now does not allow capital to have enough grip on the aggregate output.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATION

5.1. OVERVIEW

This chapter focuses on the summary of the study, conclusion, and recommendations for stakeholders, policy makers, and for further studies.

5.2. SUMMARY

The study was designed to find out the economic impact of HIV and AIDS on labour and capital on the Ghanaian economy – effective labour force, and the gross poverty reduction efforts, and related it to Ghana's economy. National adult HIV and AIDS prevalence is 1.7 percent. This infection rate is lower than that of neighboring African countries.

The research design was a simple descriptive research. It was found among other facts that; the HIV/AIDS infection is concentrated in the working age, or prime – aged adults' population (ages 15 – 49), with women infected at earlier ages than men, thus, it impacts most heavily on the most productive sectors of African economies as well as Ghana. This has had the effect of sharply reducing life expectancies, and the quality of life across the continent. The demographics of the African continent are being systematically changed by the epidemic, most obviously in respect of adult mortality. Results indicate a negative effect of the epidemic, because, it is deepening poverty, reversing human development achievements, worsening gender inequalities, eroding the

ability of governments to maintain economic growth. The HIV and AIDS, has the potential to create inter – generational poverty in African countries, and in Ghana.

One of the peculiarly vicious tragedies of HIV and AIDS is that, just as it is demanding that we do more in treatment and prevention of the epidemic, it is undermining our capacity even to maintain what we are doing.

There is now general agreement that the pandemic has a trenchant effect on growth of economies including Ghana's economy. There is an increase in mortality and morbidity as a result of AIDS, living standards are being reduced directly. It is also changing the age structure of the population and labour forces, which can adversely affect economic output. The most obvious patterns of mortality and morbidity around the globe are found among the poor, who lack the basic resources for disease prevention and treatment. This agrees with the founding of Ogum and Ikechukwu (2004), that poverty is a fertile ground for the spread of epidemics. Many epidemiological models predict that high rates of reproduction are among the most important direct determinants of disease burdens. An understanding of global development over the short and long term, therefore, requires a broader scientific understanding of the complex interactions between infectious diseases and human reproductive and economic behaviour. Clearly, reductions in the disease burdens can be achieved through lower fertility.

It is reported that knowledge of AIDS is universal in Ghana, yet only about 25 percent of women and 33 percent of men have a comprehensive knowledge of its transmission and prevention.

The data for this study were secondary data obtained from the demographic survey conducted by the Ghana statistical service, and the HIV sentinel survey annual report obtained from the epidemiological unit of the Komfo Anokye Teaching Hospital (KATH), Kumasi Ghana. The sample size for the study was 240,802 total HIV population in the country, and annual AIDS deaths in the country is 17,058. In 2008, the estimated adult National HIV prevalence in Ghana was 1.7 percent, while urban HIV prevalence was estimated as 2.1 percent and rural as 1.5 percent. In this country, HIV prevalence had declined in all age groups, except the 40 – 44, and 45 – 49, year groups. Ghana is considered as one of the few countries in Sub – Sahara Africa with low prevalence.

A model which appropriately relies on the principles of predator – prey model was developed to study the dynamics of interactions between the growth of capital, effective labour supply, and health hazard such as HIV and AIDS prevalence, and its repercussions or ramifications on the general economic growth of the country.

A pair of first order systems of differential equations was constructed. The pair of equations was solved analytically to obtain the general solution, using eigenvalue, eigenvector method. Two equilibrium points $(0, 0)$ and (X, Y) were obtained from the linearized differential equations which approximated the original non – linear system. The stability of the equilibrium point $(0, 0)$ was found to be unstable saddle point. But, the stability of (X, Y) was found to be stable centre, since the eigenvalues were purely imaginary. The interest of the research was in the behaviour of the phase paths near the equilibrium point (X, Y) .

5.3. CONCLUSION

From the findings, the following conclusions could be made on the problem set forth for investigation, i.e. economic impact of HIV and AIDS on labour and capital on the Ghanaian economy. It appears the high incidence of poverty in Sub – Saharan Africa and Ghana can be partly attributed to the high prevalence of HIV and AIDS epidemic in the sub region. The epidemic has direct adverse impact on households' labour supply, and indirectly on capital accumulation or invested.

It appears one vicious tragedy of the HIV and AIDS is the long – term macro – economic challenges it poses on the affected or infected individuals, and on a nation as a whole.

The epidemic is deepening poverty, reversing human development achievements.

5.4. RECOMMENDATIONS FOR POLICY MAKERS

It is herein recommended that for our economies to grow, and citizens getting the opportunity to develop themselves, then an integrated, well – structured multidisciplinary approach to prevention and treatment of HIV and AIDS, should be carried out continuously to mitigate the socioeconomic and psychological effects of the epidemic on individuals, communities, and the nation as a whole.

There should be an increased awareness of the risks associated with HIV, and AIDS, since this can bring about a change in social behaviour, and thus, therapy with behavioural change alters the course of the epidemic.

5.5. RECOMMENDATIONS FOR FURTHER STUDIES

The result of this research require further exploration with a more consistent database, especially on labour force. More information is also needed on the social and economic costs of the HIV/AIDS epidemic. Much further work is required to improve the availability and quality of data on HIV/AIDS prevalence and aspect of the labour force in regard to the informal and formal economies, persons in part time and temporary employment, women and men, workers of different ages, occupation groups, labour productivity and sources of income. This would make it possible to shed light on the relationship between HIV/AIDS and economic growth.



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APPENDIX

The matlab code used for the phase portrait is given below ,

```
function ydot=sysma(t,y)

%y1 - capital input; y2 - labour supply

y1dot=0.05*y(1)*(1-y(2)/100);

y2dot=-0.017*y(2)*(1-y(1)/1500);

ydot = [y1dot; y2dot];

-----

function phase_plot(tspan,y0)

%y0 - initial capital input and labour supply; tspan is the time range

X=1500; Y=100; %the equilibrium point (X,Y)

[TOUT,YOUT] = ode45('sysma',tspan,y0);

%TOUT - a vector of time returned by the solver ODE45

%YOUT - Labour Supply and Capital Input values calculated at each time point in

%the vector TOUT

Capital_Input=YOUT(:,1);

Labour_Supply=YOUT(:,2);

n=length(TOUT); N=ones(n,1);

x=X*N; y=Y*N;
```

```
%Phase Portrait Plot

figure(1)

plot(Capital_Input, Labour_Supply,X,Y,'.r','MarkerSize',15)

title('Phase Portrait of Capital Input and Labour Supply');

xlabel('Capital Input');

ylabel('Labour Supply');

legend('Phase Portrait','Equilibrium Point')
```

```
%Labour Supply and Capital Input plot over time

figure(2)

plot(TOUT,Capital_Input,TOUT,Labour_Supply);

title('Time History of Labour Supply and Capital Input');

xlabel('Time');

ylabel('Labour Supply/Capital Input');

legend('Capital Input','Labour Supply')
```