ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

THE ROLE OF HEALTH CAPITAL TO ECONOMIC GROWTH IN SUB-SAHARAN AFRICA: A DYNAMIC PANEL DATA APPROACH

By

ABEBE AMBACHEW

A Master's Thesis Submitted to the School of Graduate Studies

Addis Ababa University

In Partial Fulfillment of the Requirements for the Degree of

Masters of Science in Economics (Economic Policy Analysis)

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"The Role of Health Capital to Economic Growth in Sub-Saharan Africa: A Dynamic Panel Data Approach."

By

Abebe Ambachew Ayana

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Abebe Ambachew

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LIST OF ACRONYMS

2SLS= Two sage least squared

AR= autoregressive

BACE=Bayesian Averaging of Classical Estimates

BL=Barro-Lee

DALY=Disability Adjusted Life Year

DCs=Developed Countries

DIFF-GMM=Difference Generalized Method of Momentum.

DPD= Dynamic Panel Data

EC=European Commission

GDP=Gross Domestic Product

GLS=Generalized Least Squared

GNI=Gross National Income

IMR=Infant Mortality Rate

IV= Instrumental Variable

LDCs=Least Squared Dummy Variable

LEB=Life Expectancy at Birth

LSDV=Least Squared Dummy Variable

MRW=Mankiw, Romer and Weil

NLIV=Non-Linear Instrumental Variable

NLS=Non-linear Least Squared

OLS=Ordinary Least Square

PP= page

PPP=Purchasing Power Parity

PWT=Penn-World Table

QALY=Quality Adjusted Life Year

SSA=Sub-Saharan Africa

SYS-GMM=System Generalized Method of Momentum

U5MR=Under –Five Mortality Rate

UN= United Nation

UNESCO=United Nation Education, Science and Cultural Organization

UNICEF=United Nation Children's Fund

USD=United States Dollar

WB=World Bank

WDI=World Development Indicators

WG=Within Group

WHO=World Health Organizations

Abstract

There are considerable differences in income per capita and output per worker across countries of the world. The original Neo- classical growth model was not able to explain such income differences. Most of the works aimed at augmenting this model by including human capital focus on education only. Little has been done in modeling stock of health capital as a determinant of economic growth and so far empirical evidences of this area are not able to come up with conclusive results regarding the health-wealth nexus. Some evidences support the view that 'health is wealth' while others contradict this and argue in support of the negative relationship; and we see some countries with better growth/development but with unfavorable health indicators and vice versa that makes the relationship less clear and calls for further research. Methodological shortcomings are mostly viewed as an important reason for inconsistent and inconclusive results in addressing the problem. Solving the endogeneity of health is the notable problem in this respect.

In this study, therefore, we tried to explicitly model the role of health human capital in economic growth of sub-Saharan African countries in which we included both health and education variables to augment the Neo-classical growth model. We used two data sources, the World Development Indicators 2008-09(WDI) and the Penn World Table (PWT) Version 6.3, to construct alternative panel datasets. Our dynamic panel data model was estimated by using the System and Difference Generalized Methods of Momentum (system GMM and difference GMM) that account the endogeneity of health and other regressors. The result reveals that health human capital (proxied by life expectancy at birth and infant mortality rate) positively and significantly affects economic growth of sub-Saharan Africa while the effect of education was found to be positive but insignificant. This finding has a policy implication that investing in health and improving health conditions helps countries accelerate their economic growth and reduce the existing poverty.

CHAPTER ONE

1. INTRODUCTION

1.1 Background

There are very large differences in income per capita and output per worker across countries today. Countries at the top of the world income distribution are more than thirty times as rich as those at the bottom. For example, in 2000, GDP (or income) per capita in the United States was over $34000. In contrast, income per capita is much lower in many other countries: about $8000 in Mexico, about $4000 in China, just over $2500 in India, only about $1000 in Nigeria. Currently, income per capita in sub-Saharan Africa is, on average, $1/25^{th}$ of U.S. income per capita and the income per capita in Mali, Democratic Republic of Congo (Zaire), and Ethiopia is as low as $1/35^{th}$ of U.S. income per capita. The income and growth difference is also apparent not only across countries at a given point in time but also for the same country across periods. For instance, the real GDP of the United States today is more than four times its 1960 level, and real GDP per person is near to three time of its 1960 level (WDI, 2008)

Economists in different periods have made consecutive efforts to explain the sources or reasons of such huge variations in income levels and growth rates. Governments across the globe make many ups and downs either to bring or maintain economic growth and development in their countries so that the welfare of the society can be enhanced. For centuries, economists debated, by taking different positions, how this macroeconomic objective can easily be achieved.

The evolution of economic growth theory has become inextricably linked to the evolution of economics itself, at least insofar as that discipline provides an explanation for the wealth of nations. Many of the elements that form the basis of modern economic growth theory have their origins in the work of classical economists such as Adam Smith, David Ricardo, and Thomas Malthus. (Casasnovas *et al*, 2005). Even if different people said a lot during their periods regarding economic growth, the modern and notably influential works in this area were started after the neoclassical theory of growth has been developed by Solow (1956), Swan (1956), Cass (1965) and Koopmans (1965).

The Solow-Swan (1956) neoclassical growth model assumes that output is determined by labor and physical capital that are narrowly defined and predicts that the sustained growth in living standards is due to technical progress and the rate of technological progress is exogenous. But the neoclassical growth theory is not able to explain the cross-country growth differences and the prediction of exogenous long- run growth rate remained unsatisfactory. After this important development, many authors keep improving the neoclassical growth model and came up with models, commonly known as endogenous growth models, which better fit the real world growth process.

The concept of capital in the neoclassical model can be usefully broadened from physical goods to include human capital in the form of education, experience, training, health and social capital. The notable works in this extension include Romer (1986), Lucas (1988), Rebelo(1991), Mankiw, Romer, and Weil (1992), Barro and Sala-i-Martin(1995, 2004), among others.

Mankiw, Romer, and Weil (1992), for instance, assumed a broad measure of capital to include human as well as physical capital. The extended Solow-Swan model is found to be much better equipped to explain large cross-country income differences for relatively small differences between savings rates and population growth rates and many of the convergence property of the augmented Solow-Swan model is also much better and works pretty well empirically. Therefore, there is a wide consensus that investment in human capital is as important factor that can partly explain growth differences.

One can understand Human capital as all the attributes of workers that potentially increase their productivity in all or some productive tasks (Acemoglu, 2009). The term is coined because much of these attributes are accumulated by workers through investments. Human capital theory, developed primarily by Becker (1965) and Mincer (1974), is about the role of human capital in the production process and about the incentives to invest in skills, including pre-labor market investments (in the form of schooling) and on-the-job investments (in the form of training). In addition to these theoretical works, many empirical works that extend the neoclassical growth theory emphasized only on education in counting the role of human capital in growth process.

Regardless of these new developments and extensions, little has been done in modeling stock of health capital as a determinant of growth rate and in proving whether it is a possible source of growth differences across countries. While human capital is a clear determinant of economic growth, only recently has health's role in this process become a focus of serious academic inquiry by marrying the separate fields of health economics and growth theory (Casasnovas et al, 2005). Many issues in linkages between health status and economic growth are remained unsolved and relationships are less clear and inconclusive as it can be seen from the findings of previous empirical investigations and the experience of some countries. In this study, therefore, attempt was made to explore the role of health capital in economic growth of sub-Sahara African countries by reconsidering some methodological issues that are mostly viewed as an important reason for inconsistent and inconclusive results in addressing the problem.

1.2 Problem Statement

The main, conventional, determinants of a country's rate of economic growth are growth in its labor force (enable a community to produce bigger combination of goods and services), capital stock (through net investment) and technical progress (improved techniques of production, machinery etc). Human capital is believed to be the most fundamental source of economic growth. It is a source of both increased productivity and technological advancement.

Most schools of thought believe health and economic growth are intertwined: health can strongly affect economic growth and economic growth can strongly affect health. Higher incomes promote better health through improved nutrition, better access to safe water and sanitation, and increased ability to purchase more and better-quality health care. However, health may be not only a consequence but also a cause of high income (Bloom and Canning, 2008). This can work through a number of mechanisms. It is argued that investments in health have direct effects on productivity per unit time and thus on economic growth. Healthy workers lose less time from work due to ill health and are more productive when working. Childhood health can have a direct effect on cognitive development and the ability to learn as well as school attendance which signifies the role of health on education. It is also argued that better health can promote saving, for instance, a longer prospective lifespan can increase the incentive to save for retirement, generating higher levels of saving and wealth, and a healthy workforce can increase the incentives for business investment (WHO, 2003; Bloom and Canning, 2008)

A number of empirical findings support this positive linkage between health status and economic growth. For instance in Britain, the combined impact of improved diets, reductions in infectious disease, better living standards, and environmental health resulted in increased labor force participation by poor, and increased output (Fogel, 2002). Similarly, in the East Asian experience, health improvements are identified as a major pillar of 'economic miracle', accounting for 1/3 of economic growth (Bloom and Canning, 2000).

As opposed to the above argument, some people argue that an expanding economy can co-exist with problems of income inequality and poverty. They point out that economic growth does not always lead to improvements in health and, conversely, improvements in health are not necessarily dependent on growth. They maintain that some countries (eg Brazil) have managed to receive impressive gains in reducing infant mortality rate during a period of just 1% growth in GDP per capita per year. Ruhm (2006) has argued that the empirical evidences supporting the view of positive relationship between health status and economic growth are quite weak and come from studies containing methodological shortcomings that are difficult to remedy. Recent research, using methods that better control for many sources of omitted variables bias, suggests that mortality decreases and many aspects of physical (although not necessarily mental) health improve when the economy temporarily weakens. This partially reflects reductions in external sources of death, such as traffic fatalities and other accidents, as well as environmental factors like decreases in pollution. For example, Christopher Ruhm (2000) estimate that a1 percentage point increases in unemployment reduces U.S. traffic deaths by 3.0 percent. Similar conclusions were reached in studies undertaken in Germany, Spain, France, Asian-Pacific nations, and OECD countries (Neumayer, (2004); Tapia Granados (2005); Buchmueller et al.(2006); Lin

(2005)). Recently, Acemoglu and Johnson (2006, 2007) have documented the inverse relationship between health (measured by life expectancy) and per capita GDP. Their reason for this to happen is that increased life expectancy raises population, which initially reduces capital-to-labor and land-to- labor ratios, thus depressing income per capita.

All these previous works shows that the relationship between health and economic growth is not yet clear. Some countries have favorable economic growth but unfavorable indicators of health (e.g. Middle East countries). Others have low growth or development but good indicators of health (e.g. Sri Lanka).Some countries might have the same level of growth but have different levels of health indicators – for example in 1997, life expectancy in Vietnam was almost double that of Guinea-Bissau despite having the same level of economic growth. Historical figures also support this fact. For example, Fogel (2002) outlined that life expectancy at birth in India in 1999 was 60 compared to 40 in Britain in 1820, when income per capita was approximately the same level as in India during this period. He outlined that income per capita in Britain in 1820 was $1707, while it stood at $1746 in India in 1998 (all figures are in 1990 international dollars).

This situation calls for specific regional study to know which premises are working in sub-Sahara African countries. Most of the previous works in this area are criticized for the data they employed and the methodology they used. For instance, many authors used time series data to address the issue but it requires distinguishing growth effect from business cycle effect and most works are not able to do so. In addition, choices of lag lengths and covariates, inconsistent and poorly documented data, the inability to solve the endogeneity of health, the sensitivity of results to choice of covariates, time periods and proxies for health makes previous results less reliable and necessitates further studies with better methodology in the area. As suggested by Ruhm

(2006), one way of achieving better result may be panel data methods on samples containing multiple geographic locations observed at several point in time since many confounding factors can be controlled by using such a method. Hence in this study panel data taken from different sub-Sahara African countries will be applied to address the problem at hand in a better way.

1.3 Objective of the Study

The general objective of this study is to identify the relationship between health status and economic growth in sub-Saharan African countries.

The specific objectives are:

1. to explore and explain the existing health condition of countries of sub-Saharan Africa.
2. to know causal relationship between health status and economic growth.
3. to account the output share of health capital stock in the augmented Solow framework.

1.4Research Questions

The followings are the major research questions that are supposed to be answered in this study.

1. What the existing health condition of Sub-Saharan Africa seems like?
2. What is the relationship between economic growth and health status in sub-Saharan Africa?
3. What is the share of health capital stock in the total output of the region?

1.5. Significance of the Study

Empirical evidences regarding the health-wealth nexus are not consistent and results are different from region to region. Frequently, either time series or single cross-section data, which are criticized from many grounds, are used by researchers in studies of growth process. Hence, using panel data techniques are believed to give better results. Therefore, this paper will apply the panel data techniques by treating sub- Saharan region separately and this is believed to have its own contribution in generating more reliable and conclusive results for sub- Saharan Africa in assessing the role played by accumulation of health capital stock for economic growth process. Pointing out the various channels by which health and wealth are related is quit important for policy makers to aware the various socio economic sectors that needs due attention and complementary investments to achieve sustainable and fast economic growth and development.

Most growth works which assessed the role of human capital in economic growth concentrated on education and only little has been done on role of health especially at macro level. Hence, this paper will produce an updated literature which will be used as an important starting point for future researchers in the area. Moreover, the result of this study is informative whether the existing investment on human capital development is productive. If not, policy makers and development partners will be able to make these investments in a more productive way by using this information.

1.6. Scope and limitations of the Study

This study is aimed at identifying the health-growth nexus in sub-Saharan Africa. Countries out of sub-Saharan region are not considered in the study. Even if many socio-economic variables are related to growth and worthy to study them thoroughly, this paper will give due emphasis for identifying the role of health capital stock in the growth process of developing economies, particularly in sub-Saharan Africa.

Regardless of some important contributions it may provide, this study is not free from limitations. Two limitations can be mentioned. One, this study address only the direct effect of health on economic conditions. But, health can affect growth indirectly through a number of channels. Our model is not able to account for such indirect effects and this failure may underestimate the role played by health capital stock. Two, health, if its true value wants to be assessed, should be measured in all its dimensions: mortality, morbidity, disability and discomfort. Life expectancy and infant mortality, our proxies of health, take into account mortality, but it is not perfectly correlated with the rest of the health dimensions. Moreover, these proxies of health reveal only the lifetime of the stock of human capital, saying nothing about the time in the labor force of this capital. This is a problem because, even though there is a solid connection between health, productivity and economic growth, health capital depreciates over time and at one point the relationship stops being binding. Taking these shortcomings in mind, our result is robust in many aspects.

1.7. Organizing the Paper

Once we started with this brief introduction, the whole paper is organized as follows. In the second chapter we presented the theoretical and empirical literature regarding health and economic growth. The third chapter discusses the research methodology in which the specification of the theoretical model, estimation and data issues are included. The fourth chapter presents the empirical results or findings and their interpretation. Finally, in the last chapter, chapter five, we draw possible conclusions and policy implications based on our findings.

CHAPTER TWO

LITREATURE REVIEW

2.1. Theoretical Literature Review

There are a number of growth models developed by different economists of their time. Some of these models are neither theoretically reliable nor empirically applicable and thus may not be able to explain the real world growth process. Following such models, people keep striving to extend or replace less applicable models with the better ones that suit to explain either the growth process of an economy or the existing cross-country income differences. Failure to explain the income differences among countries can be associated with failures to identify and include variables that contribute to high productivity. Health is one of such variables which is important in explaining growth but usually, and mistakenly, ignored by growth accountants till recently. In this section, the researcher has attempted to review the roles of health in human capital formation as well as different channels through which health and economic growth are related.

2.1.1 The Role of Health as a Component of Human Capital

There is a general consensus among development or growth economists that the stock of human capital plays a vital role for socio-economic development of a nation. Most writers argue in favor of development strategies that give a due emphasis on investment in human capital. In their opinion, this does not mean that additions to the stocks of natural and physical capital should be ignored, but does mean a major change in priorities. The justification for this change is: 'first, that the returns on investing in people are in general as high as, if not higher than, the returns to other forms of investment, second, that investment in human capital in some cases economizes on the use of physical capital and the exploitation of natural resources and, third, the benefits of investing in people are in general more evenly spread than the benefits from other forms of investment. A greater emphasis on human capital formation should therefore result in as fast and perhaps a faster pace of development,. more sustainable development and a more equitable distribution of the benefits of development'(European Commission,2005)

Even though there is a sound theoretical and empirical basis to the argument that human capital matters for economic growth, but for the most part human capital has so far been rather narrowly defined as education. Recent macroeconomic growth models are able to endogenize technological progress which was assumed to be exogenous source of growth in neoclassical growth frame work. Technological progress thus came to be seen as an 'endogenous' process that could be driven in particular by investments in human capital, largely understood as skilled labor. Much of this research was rooted in the initial formalization by Becker (1964) of a theory of human capital formation. His ideas were motivated by the evidence that the growth in physical capital and labor, at least as conventionally measured, explains a relatively small part of the growth of income in most countries. He sought to shed light on the importance of education for economic development by providing evidence on the monetary rates of return to education. According to Becker's human capital theory, investments in human capital raise an individual's productivity (both in market and non-market activities). Thus, individuals have an incentive to invest in themselves through education, training and health in order to increase their future earnings. Subsequent work has confirmed the importance of human capital — narrowly defined as educational attainment — as a determinant of economic growth.

But such models are incomplete to explain the cross-country income differences as well as the real world growth process since they failed to incorporate health as an important component of human capital like that of education. Because the return of investment in education itself depends up on the ability of individuals in acquiring knowledge, this condition in turn, also depends on health condition of the individual. This is the impact of health on education at the very walk of its process. Even if individuals are able to accumulate the required knowledge without any influence of health, their stock of knowledge cannot be exploited in bringing the technological change unless they are healthy. Therefore, more stock education doesn't necessarily lead to more technical knowledge and thus more growth unless it is backed up with more health capital stock. To account this interdependence, one has to bring these two human capital components in to a roof when attempt is made to model growth.

The idea of health representing an important component of human capital was introduced most prominently by Grossman (1972), but has recently been acknowledged more widely[1]. Grossman (1972) developed a model based on intertemporal utility maximization framework in which individuals derive utility from good health and consuming other commodities. The model assumes people are born with initial endowments of health which depreciate with age and grow with investment in health. He distinguishes between health as consumption good and health as a capital good. As a consumption good, health enters directly into the utility function of the individual, as people enjoy being healthy and drive utility. As a capital good, health reduces the number of days spent ill, and therefore, increases the number of days available for both market and non-market activities. In other words, available health stock produces a stream of healthy

[1] Even if in his original theory Becker (1964), before Grossman, pointed to health as one component of the stock of human capital, his early empirical work was exclusively on education.

time payoffs that determine market (investment aspect) and non-market participation (good health as a consumptive good). For the investment in health to have a positive payoff, it must reduce sick time and so that investment in health will have a return in terms of added labor income and wealth--- health seen as a commodity that is not valued *per se* but only for its impact on labor productivity/wealth. Thus, the production of health affects an individual's utility not only because of the pleasure of feeling in good health, but also because it increases the number of healthy days available for work (and therefore income) and leisure. This is known as the pure investment variants of the Grossman model that shows the impact of health on an economy about which this study needs to explore more. Furthermore, forty years back Grossman has made a point that 'Health is not passively purchased from markets -- it is produced in combining time with purchased medical inputs'. This point has an important implication for empirical investigations, like this paper, of this area since it warns us that health is endogenous.

Following the seminal work of Grossman many authors tried to incorporate health capital in their model of growth. Mankiw et al (1992) extended the Solow model of growth by adding human capital, specifying this variable has a significant impact on economic growth. Later, other authors developed models that included human capital, specifically health capital. Barro (1996), following a Ramsey scheme, develops a growth model including physical capital inputs, level of education, health capital, and the quantity of hours worked. In his analysis, Barro finds an increase in health indicators raises the incentives to invest in education and a raise in health capital lowers the rate of depreciation of health, adding there are diminishing marginal returns to investment in health. Very recently Acemoglu and Johnson (2006, 2007) developed a model that incorporates health along with demographic and economic variables to see the net effect of improved life expectancy on per capita GDP and other growth indicators. All these and other theoretical works contributed to understand the various channels through which health and economic growth are related. Once again to have a clear picture of it, the relationship between health and different economic variables has been reviewed in the following section.

2.1.2. Channels of Influence between Health and the Economy

Since human capital matters for economic outcomes and since health is an important component of human capital, health also matters for economic outcomes. At the same time, economic outcomes matter for health. There is now strong empirical evidence from developing and developed countries which demonstrates a two-way relationship: that economic growth improves health but improved health also significantly enhances economic productivity and growth. Health is determined by genetic, economic, social, cultural and environmental factors. But the health of a population may also, in return, influence the economic context.

The existing literature of this area suggests different channels through which health could contribute to economic outcomes at both the individual and the country level. These include through: higher productivity, higher labor supply, higher skills as a result of greater education and training, and more savings available for investment in physical and intellectual capital. These channels are represented in the right-hand side of Figure 2.1.

As illustrated in the left-hand side of Figure 2.1, the health of an individual depends on many factors: genetic endowments, lifestyle, living and working conditions (access and use of healthcare, education, wealth, housing, occupation) and the more general socioeconomic, cultural and environmental conditions. Several of these determinants of health can be influenced by public policies.

In assessing the contribution that health can make to growth, it is important to keep in mind the positive feedback from income to health. There are two ways in which income can influence health: through a direct effect on the material conditions that have a positive impact on biological survival and health, and through an effect on social participation, the opportunity to control life circumstances, and the feeling of security. Above a certain threshold of material deprivation, income may be more important because of its link with these social and psychological factors, particularly in societies where social participation depends heavily on individual income (Marmot 2002, cited in EC, 2005).

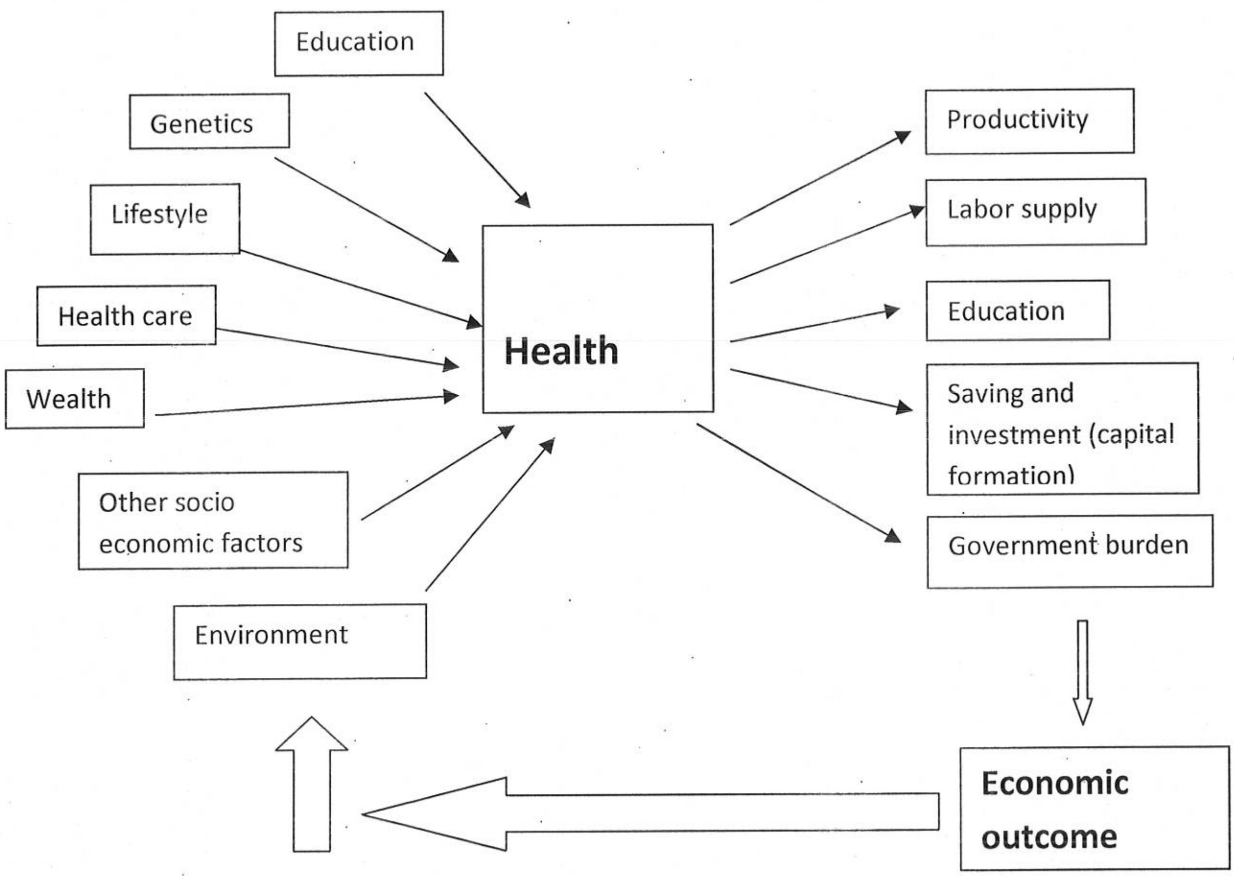
The main interest of the present study is to review the evidence on the positive effect of good health on the economy, not the reverse pathway. The principal mechanisms that could explain the effect of health on the economy are briefly described in the following sections.

Labor productivity

Healthier workers are physically more energetic and mentally more robust, so they suffer fewer lost workdays due to illness or the need to care for other family members who have fallen ill.

Healthier individuals could reasonably be expected to produce more per hour worked (WHO, 2002). They are more productive, and earn higher wages; they also help to attract foreign direct investment. Ill health may mean that people who are able to work have a reduced productivity, shortened working lives, and increased numbers of days lost to illness. On the other hand, more physically and mentally active individuals could also make a better and more efficient use of technology, machinery or equipment. A healthier labor force could also be expected to be more flexible and adaptable to changes.

Figure 2.1 the link between health and the economy



Labor supply

The impact of health on labor supply is theoretically ambiguous. As it is described by Grossman (1972) good health reduces the number of days an individual spends sick, which consequently results in an increase in the number of healthy days available for either work or leisure. But health also influences the decision to supply labor through its impact on wages, preferences and expected life horizon. The effect of health on labor supply through each of these intermediate factors is not always obvious. On the one hand, if wages are linked to productivity, and healthier workers are more productive, health improvements are expected to increase wages and thus the incentives to increase labor supply (substitution effect). On the other hand, being healthy might allow higher lifetime earnings and therefore an earlier withdrawal from the labor force (income effect). The way in which health affects individual preferences also affects whether and how health determines economic outcomes. One could imagine that, as health improves, working becomes less cumbersome, and therefore the individual might be ready to take up more work in exchange of leisure time. However, one could also imagine that a health improvement reduces the needs for consumption (e.g. of health treatments or medicines) and therefore reduces the relative preference for work, leading to a reduction of working time and an increase in leisure time.

Finally, if good health changes neither preferences nor wages, but raises life expectancy, the individual's needs for lifetime consumption would increase, leading to a higher labor supply. The decision to work could also be influenced by the health of relatives. In this case, the impact of health is also theoretically ambiguous. On the one hand, if other family members leave work due to health deterioration, this could cause a drop in household income, which the individual might try to compensate for by increasing his or her labor supply. This could also be the case if the onset of a health problem increases financial needs (for example due to increased need for healthcare). On the other hand, the need to care for a sick or disabled person could lead the individual to reduce his or her labor supply or to exit from the labor force. This negative effect is especially true in sub-Saharan African countries where the disease burden is immense and health care centers are too far from individuals home. Patients in such areas where modern transportation facilities are rarely available may need the help of healthy individuals to reach health centers. This may reduce labor supply and affects production.

Education

Health and success in education are also clearly linked. Healthy children are able to learn better, and they become better-educated and higher-earning adults. In a healthy family, children's education is less likely to be interrupted due to their ill health or the ill health of their family. Hence, since children with better health and nutrition tend to achieve higher educational attainment and suffer less from school absenteeism and early drop-out, improved health in early ages indirectly contributes to future productivity. Moreover, if good health is also linked to higher life expectancy, healthier individuals would have higher incentives to invest in education and training, as the depreciation rate of the skills acquired would be lower.

Good health promotes education through the effect of lower mortality and a longer prospective lifespan on increasing incentives to invest in human capital. This effect increases the benefits of education for the individual. In addition, lower infant mortality may encourage parents to invest more resources in fewer children, leading to low fertility but high levels of human capital investment in each child (Kalemli-Ozcan, 2002). Children's readiness for school may be hindered by cognitive and physical impairments. These problems may be due to inadequate nutrition and poor health of the mother and malnourished children are less likely to enroll in school; those who do enroll do so at a later age (UN, 2004).

Savings and investment

The state of health of an individual or a population is likely to impact not only upon the level of income but also the distribution of this income between savings and consumption and the willingness to undertake investment. Poor health affects both the ability to save and the impetus to save. Sickness can impose large out-of-pocket medical expenses that reduce current and accumulated household savings. This occurs in developed countries but is of particular concern in developing countries. In many developing countries the weakness of public and private insurance systems means that out of-pocket spending by households is the main source of financing of the health system. For example, out of pocket payment is the most basic form of health care financing in SSA –where a fee is charged to cover all or part of the cost of the service provided. Health shocks mean that families may be thrown into poverty if there is a lack of insurance and productive assets such as land or animals must be sold to pay for medical expenses (Xu *et al.*, 2003).

Because poor health tends to be associated with a short lifespan, increasing population health and expected longevity will have an effect on the planning horizon and will influence life-cycle behavior. With a fixed retirement age, a longer lifespan elicits greater savings for retirement. This means individuals in good health are likely to have a wider time horizon and their savings ratio may consequently be higher than the savings ratio of individuals in poor health. Other things being equal, a population whose life expectancy increases may therefore also be expected to have higher savings. This should also result in a higher propensity to invest in physical or intellectual capital.

Government burden

High disease burden and low health status of a country creates additional burden on the government through the need of high public expenditure for the health sector. This is particularly true in developing countries like Africa where most of the citizens are in absolute poverty to fulfill their medical care demand. In such conditions, governments have a responsibility to provide basic health services to their community that needs high public expenditure either for curative or preventive purpose. This consumes most part of the government limited resources which otherwise could have been available for other purposes like provision of basic infrastructures like road. When health shocks are occurred and governments face money and material shortage to withstand against such shocks, countries may be forced to ask either loan or aid. Given different conditions and economic implications of aid and indebtedness, this may construct another road that lead to the vicious circle of poverty.

Health and Demography

Another link between health and economic growth can be constructed indirectly through demographic channel since the change in fertility owning to health improvements and the resulting change in dependency ratio and other demographic variables have important implications on the economy. A successful demographic transition from high to low fertility depends in large part on improvement in health. The idea behind the demographic transition is that whenever mortality declines, it is followed, after a lag, by a decline of fertility. The first phase of the transition, when mortality declines, is typically brought by better sanitation and various public health measures. So long as fertility does not change, the decline in mortality brings an increase in population. In the second phase, fertility rates start declining as well, until—

eventually— population growth is restored to earlier levels, and then sometimes lower levels than before.

The simplest and most common explanation for the fall of fertility is that parents adjust to the fall of child mortality so as to restore their previous desired targets regarding their number of children. Following the fall in child mortality and the resulting fall in fertility, with fewer children, parents are likely to invest more in the education of each child. Rising life expectancies mean that there is a longer time in which to reap the benefits of investments in education. Thus rising life expectancies act to drive economic growth and human development. The lag between declines in mortality and fertility, when appropriately responded to, results in a "baby boom" generation that can kick-start a period of economic growth as it enters the workforce. This effect is called the demographic dividend, the realization of which, however, is heavily reliant on policies that allow extra workers to be absorbed into the workforce. Subsequent health improvements tend primarily to affect the elderly, reducing old-age mortality and lengthening the lifespan. In many theoretical models, a population explosion reduces income per capita by putting pressure on scarce resources and by diluting the capital–labor ratio. In these models population declines spur economic growth in per capita terms (Bloom and Canning, 2008).

In sum, there are a number of channels that may causally link health and economic outcomes on the individual and on the aggregate (macro) level. The most common denominator of all of these channels is that health can be seen as an integral part of human capital. Thus, the expecting result of this study regarding the health and growth relationship may be because of these different channels what is stylized in theory.

2.2. Empirical Literature Review

There is a growing interest among economists in assessing the impact of health, which may be proxied by either morbidity or mortality, on an economic status. This assessment can be done either at micro or macro levels. Most micro level studies of this issue utilize household survey data to account the burden of a specific disease or some major diseases on variables like wage, level of output, productivity or income that show economic status of an individual or household. On the other hand, macro level studies are always concerned with aggregate measure of health and level of income or growth of income.

There are two approaches to estimate the effect of health on economic growth (which is at macro level). The first is to take estimates of the effect of health from microeconomic studies and use these to calibrate the size of the effects at the aggregate level. The second is to estimate the aggregate relationship directly using macroeconomic data. Since this paper is aimed at assessing the impact of health on macroeconomic status, only papers done at macro level are reviewed and presented in this part. As it has been stated earlier, there is two- way causation between health and growth. Like that of this paper, some researchers are interested to analyze the impact of health status on economic growth, while others document the reverse causation. In this part, only papers that analyzed a causal relationship that goes to from health to wealth are reviewed and summarized as follows.

For many of the growth researchers who augment the original Solow model, papers of Mankiw *et al(*1992) and Islam(1995) are used as a good starting point. In both of these papers, the original Solow model was augmented by incorporating education only as a sole component of human capital. While Mankiw *et al(*1992), in the cross-sectional analyses, were able to get a positive and significant effect of education, proxied by school enrolment, Islam(1995) in his panel data analysis was not able to get a positive and significant effect of education, proxied by average years of schooling, on economic growth. The result obtained by Arcand *et al(2007)* first by applying the ordinary panel data estimators confirm the finding of Islam, but later when he make use of a more sophisticated estimating techniques –system GMM and Hausman –Taylor panel data estimators, he was able to get positive and significant effect of education on economic growth. Similarly, Acemoglu and Dell (2009) used only education to explain the within and between countries and municipalities income differences for a large number of countries in the Americas. Their result revealed that a significant fraction of the within-country differences cannot be explained by observed human capital and these authors conjecture that the sources of within- country and between-country differences are related. They also documented that about half of the between-country and between-municipality differences can be accounted for by differences in human capital, the remainder being due to residual factors. Note that human capital in these studies was narrowly measured by education only and health was not explicitly included.

There are also some authors who were able to model both health and education in the neoclassical framework. In such works the original Solow model is augmented by incorporating both education and health capitals. Barro (1996), Knowles and Owen(1995, 1997), McDonald and Roberts (2002, 2004) are the notable papers in this respect. For example, Knowles and Owen (1995) and McDonald and Roberts (2002) have augmented the Solow model by explicitly including health and education variables. By applying OLS estimator, both of these papers have agreed that health is positively and significantly correlated with income or growth while the role of education was found to be fragile. Based on their result or findings of different sub-samples, like DCs and LDCs, regarding these human capital variables, they concluded that health capital seemingly more important at low incomes and education capital more important at high incomes. But these studies used simple OLS estimator and were not able to solve the endogeneity of health.

However, in later periods, some of the above mentioned and other new writers of the area who considered both education and health in their growth regression acknowledged the endogeneity of health and tried to handle the problem by moving from OLS to instrumental variable (IV) estimator. For example, Knowles and Owen (1997) formulated a structural growth equation that incorporated education and health as a labor- augmented variables in aggregate production function and assessed the impact of education and health on economic growth in this effective –labor empirical growth framework. They used the cross-section data collected from 77 countries grouped in different sub-samples; they measured education and health by average years of schooling and life expectancy at birth, respectively. Then, they applied non- linear instrument variables (NLIV) estimating methods and their result suggests that a strong positive relationship exists between health and economic growth while the effect of education was found to be insignificant.

Similarly, Barro (1996) and McDonald and Roberts (2004) used instruments for health to solve the endogeneity problem. McDonald and Roberts (2004) implemented the same framework as above in assessing the indirect effect of HIV-AIDS on economic growth in which health was instrumented by its predicted value and gross secondary school enrolment was used as a proxy for education. His result was in line with the above discussed findings that health affects growth positively and significantly while education's role was found to be insignificant and sometimes negative, especially for LDCs sub-sample. Likewise, Barro (1996) developed a new model of health and economic growth and empirically investigate the impact of health, proxied by life expectancy at birth, on growth rate of per capita GDP for ten -yearly averaged data of 3 time points from the panel of 100 countries. He has taken 5 years earlier values of variables (lag values) as an instrument and applied the instrumental variable estimation technique (3SLS). His result also shows that the rise in life expectancy at birth from 50 to 70 years increases growth rate by 1.4% which indicates significant positive relationship between overall health status and subsequent economic growth appears to be substantial. In addition, the negative relationship between fertility rate and growth rate obtained in his result indirectly signifies the effect of health on economic growth because, as he argued, the fall in mortality leads to the decline in fertility that further expands growth. However, Acemoglu and Johnson (2007) refuted this idea by arguing that the decline in fertility is not large enough to compensate an increased in population owing to improved health, thus, growth may not be expanded. Moreover, Barro (1996) has got a positive and significant effect of average years of schooling but insignificant for secondary school enrolment measurements of education.

Even though the above reviewed papers, except in some cases of Barro(1996), that accounted for the role played by both health and education concluded the significance of health and the insignificancy of education, Sala-i-martin, Doppelhofer, and Miller(2003), as it is demonstrated in the book of Barro and Sala-i- Martin (2004), showed the significance of not only health but also education. In their study, these authors applied Bayesian Averaging of Classical Estimates (BACE) which constructs estimates by averaging OLS coefficients across models and they instrumented health by the proportion of country's area in the tropics, the index of malaria prevalence and initial life expectancy. The first two instruments of health were found to have a negative relation with growth reflect the poor economic performance of tropical countries is due to variables related to health. On the other hand, the initial life expectancy and literacy rate were found to be positively correlated with growth.

So far, we emphasized on papers that included either education only or both health and education as component(s) of human capital in cross-country growth regression. There have been also some empirics that include only health capital in accounting for the role of human capital in their regression. Weil (2007), Kirgia *et al* (2005) and Pritchett & Summers (1996) are the notable papers of this group that we reviewed as follows.

Weil (2007) used available microeconomic estimates of the effect of health on individual outcomes to construct macroeconomic estimates of the proximate effect of health on GDP per capita. Weil calibrates the effects of health using a range of micro estimates and found that these effects could be quite important in the aggregate. He employed a variety of methods to construct estimates of the return to health, which he combined with cross-country and historical data on height, adult survival rates, and age at menarche. In his panel study, Weil has concluded that eliminating health differences among countries would reduce the variance of log GDP per worker by 9.9 percent which again proves the positive and significant effect of health capital stock on growth.

In another cross –section study of African region, Kirgia *et al* (2005) analyzed the GDP loss attribute to maternal mortality by estimating the double log econometric model by OLS. They have demonstrated that maternal mortality has a significant negative effect on GDP; specifically the estimated result shows that the maternal mortality of a single person was found to reduce the GDP per capita by US$0.36 per year. But, the result of this paper seems less robust because the simultaneity problem that may occur due to the endogenous nature of health (or maternal mortality) was not addressed and the authors were silent about it. Likewise, Pritchett and Summers(1996) use cross-country panel data for 58 developing countries observed over the period 1960-85 that was reorganized as either five or two years panel. They used under-5 mortality as proxy for health and their fifth-differenced model yields a negative and significant elasticity of mortality with respect to growth, after controlling for time effects.

Whether health is modeled alone or along with education, all the papers reviewed and presented above showed that health conditions affect economic conditions positively and significantly and thus they concluded that 'Health is Wealth!' However, there have been some studies that contradict the above literature and argue for insignificant or negative correlation between health and economic conditions.

For example, Acemoglu and Johnson (2007) started by stating the inconclusiveness of the relationship between health and growth they investigated the effect of the general health conditions, proxied by the life expectancy at birth, on economic growth. Using estimates of mortality by disease before the 1940s, they constructed an instrument for changes in life expectancy, referred to as *predicted mortality*, which is based on the pre-intervention distribution of mortality from various diseases around the world. They estimated the equation in long distances i.e. panel including only two dates 1940 and 1980 or 1940 and 2000. Both the OLS the two stage least squared (2SLS) estimation results shows that the increase in life expectancy increases GDP (but insignificant), population and birth rate, but decreases, sometimes significantly, the GDP per capita and GDP per working population. Basing the neoclassical growth theory, they interpreted this inverse relationship as

> "*Increased life expectancy raises population, which initially reduces capital-to-labor and land-to-labor ratios, thus depressing income per capita. This initial decline is later compensated by higher output as more people enter the labor force and as more capital is accumulated. This compensation can be complete and may even exceed the initial level of income per capita if there are significant productivity benefits from longer life expectancy. Yet, the compensation may also be incomplete if the benefits from higher life expectancy are limited and if some factors of production, for example land, are supplied inelastically.*"

But later, Bloom *et al* (2009) criticized the process and findings of Acemoglu and Johnson (2007) and came up with reverse result by using the same dataset, but different control variables and readjusted assumptions to construct the instrument, predicted mortality. Even if by using the same specification for the same number of observations Bloom and Canning (2009) confirmed with most of the previous literature regarding the health- wealth link, Acemoglu and Johnson didn't admit the critics and again responded that their result is still robust. The debate has not yet been concluded.

In another study, Ruhm (2000, 2006) has argued that the empirical evidences supporting the view of positive relationship between health status and economic growth are quite weak and come from studies containing methodological shortcomings. And in his empirical investigation, he documented the negative correlation between health and economic conditions. He also reported as similar conclusions were reached in studies undertaken by Neumayer (2004); Tapia Granados (2005); Buchmueller et al.(2006) and Lin (2005). Similarly, Young (2005) evaluates the effect of the recent HIV/AIDS epidemic in Africa. Using micro estimates and calibration of the neoclassical growth model, he shows that the decline in population resulting from HIV/AIDS may increase income per capita despite significant disruptions and human suffering caused by the disease.

Aguayo-Rico *et al* (2005) in the three years panel of 52 countries data and by using Generalized Least squared (GLS) estimation method they failed to get significant result in any specification when life expectancy is used as a health indicator and they deduced from this condition that life expectancy is not a good measure of health. However, this conclusion is questionable since they did not address the endogeneity problem of life expectancy in the first place.

All the papers investigated so far were based on cross-country data like ours. But, we were able to get and review one paper of the same area but with time series data is the study undertaken by Pérez-Brignoli(2001). In this paper, he used time series data that cover the period 1950-1998 to investigate the effects of human capital investments and demographic variables on economic welfare in Costa Rica. Life expectancy at birth, infant mortality rate, and school enrollment rate were included as measures of human capital. The result revealed that both of the health indicators, life expectancy and infant mortality, were not significantly related to growth. The author interpreted the finding as:

'The weak relation between fertility and mortality change and per capita income illustrate the fact that in spite of the economic crisis and stagnation during the 1980s and 1990s [in

Coast Rica], life expectancy at birth was continuously increasing and the infant mortality rate was continuously declining. In other words, it seems that the investments in health had an "inertia effect" that came into effect once a certain level of improvement was achieved'.

Once we presented these important papers related to our area of interest, it is worthwhile to synthesize the literature.

2.3. Synthesizing the Literature

In the literature, it is possible to see that previously most emphasis was given to education only in considering human capital as determinant of growth. Some papers also totally ignore education and considered health only in their growth modeling. It is only few authors who were able to explicitly modeled both education and health as growth determinants under the framework of augmented Solow model.

When we look at papers who acknowledged the importance of health capital stock to explain cross-country income differences, their results was found to be inconclusive regarding the health-wealth nexus. In some studies, a level or growth of output was significantly explained by health capital stock while it was not the case in others. Methodological shortcomings were the common problem in most of the previous studies. For instance, there is no doubt that health by its nature is an endogenous variable and in the field of health economics, the endogenous causality between health and income has been the topic of several studies whose purpose is to establish the direction of the causality. Luft (1978) gives an informal explanation of this causality: "a lot of people who otherwise would not be poor are, simply because they are sick;

however, few people who otherwise would be healthy are sick because they are poor." Regardless of this fact, most of the previous studies were not able to handle the endogeneity of health and other regressors in their analysis. These include papers that were able to consider both health and education. So their results shouldn't be taken seriously.

Even if there are some studies who tried to handle the endogeneity problem by using instrumental variable estimator, the instruments they used are external instruments which are always criticized as week instrument since they hardly meet the criteria to be a good instrument. This gap calls for the new estimating technique that can generate internal and valid instruments for regressors. System GMM, what we applied, is the promising estimator that can handle all these econometric issues.

The differences in locations (regions where studies are undertaken), in addition to methodologies, may be one reason for such mixed and inconclusive results. Heterogeneities among countries are immense and so that counting the country effect and also time effect may yield better result. This would be possible if panel data methods are used. But, most studies of the area were based on single cross- section data and could not address the issue of heterogeneity. Sometimes, understanding the role of health by collapsing developed and developing countries in the same sample at a time may not be informative since growth processes and determinants in these extreme worlds may not necessarily be the same. Thus, there is a need to treat developing world separately. That is why this study needs to re-examine the health-wealth nexus by taking the panel of sub-Saharan African countries and by employing better econometric technique that can handle the main estimating issues. The details of the methodologies followed in this study are discussed in the next chapter.

CHAPTER THREE

RESEARCH METHODOLOGY AND DATA

In this chapter, we discuss the methodology applied for this study in a detailed manner. The chapter has two main parts. The first part discusses the theoretical model and derives the estimable equations. Once the empirical model is specified, our next concern in that part would be comparing all the possible candidate estimating techniques and pinpoint an estimator (or estimation method) to get unbiased and consistent parameter estimates. In the second part of the chapter, the nature and source of the data as well as the sampling procedure are presented. In that part, our data sources, the methods used to reorganize the data, the measurement of each variable considered in the study and the criteria used to select sample countries of the sub-Saharan Africa region are addressed.

3.1. Model Specification and Estimation Issues

3.1.1. Model Specification

There is no doubt that human capital plays a significant role for the growth and development of an economy as it has been reviewed in the literature. The question remains how to insert human capital, particularly education and health human capital for this study, in growth regression to account their role. This is by no means easy to answer as it depends both on the theoretical specifications used and on the empirical problems encountered. For instance, in the theory of Romer (1990) the growth of GDP is regressed on the level of human capital while in the theory of Lucas (1988) the growth of GDP is regressed on the growth of human capital. Equally, the effect of human capital on growth depends strongly on the empirical specification.

The growth economics literature provides two main macro approaches to include human capital in models of economic growth and other economic outcomes. The first approach extends the basic framework of the neo-classical (Solow-Swan) model to allow human capital as an *extra input* in modeling production function. This extension is in line with the Mankiw, Romer and Weil (1992) model in which they accommodate human capital in the traditional growth theory and provide a reasonable approximation for empirical analysis.

The second approach of extending the Solow- Swan model is that including human capital as a *labor augmenting factor* rather than including it as a separate factors of production. In this approach the variable labor in the production function is not a simple raw labor but the effective labor in which the health and education (and possibly other forms of human capital) are embodied. It can be argued that health and education human capital increases the quality of labor which, in turn, improves productivity. Such implicit way of modeling human capital in growth accounting was done by some authors like Knowles & Owen (1997), and Acemoglu & Johnson (2006, 2007). Basically, both of these approaches are almost the same in giving estimating equations. What is different here is the way of driving the theoretical growth model with human capital and the assumptions made in showing the theoretical relationship among the variables of interest.

In this paper, in order to derive an estimating growth equation that incorporate human capital variables, of which health human capital is our variable of interest, we augment the neoclassical (Solow-Swan) model by including health and education human capital. To this end, we follow the derivation process of Mankiw *et al* (1992), Islam (1995), Knowles and Owen (1995) and McDonald and Roberts (2002, 2004) since we are interested to compare our findings with these seminal works.

Thus, assuming the usual Cobb-Douglass production function with a constant return to scale and labor augmenting technical progress and considering three types of capital, the aggregate production function can be defined as

$$Y_{it} = (A_{it}L_{it})^{1-\alpha-\beta-\psi}K^{\alpha}{}_{it}E^{\beta}{}_{it}H^{\psi}{}_{it} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where Y is output , A is technology, L is labor, K, E and H are respectively physical, education and health capital, α, β, and ψ are the elasticities of output with respect to the three types of capital, and the subscripts denote country(i) and time (t). Dividing each term in the aggregate production function by effective labor $(A_{it}L_{it})$ gives the intensive form of equation (1) that can be written as

$$y_{it} = k^{\alpha}{}_{it}\, e^{\beta}{}_{it}\, h^{\psi}{}_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where y_{it} is output per effective labor unit in country i at time t and k_{it}, e_{it} and h_{it} are respectively physical, education and health capital per 'effective' labor unit. Labor force and technological advancement are assumed, as MRW did, to grow at constant rates given by n_i and g_t, respectively which can be modeled as

$$L_{it} = L_{i0}exp(n_i t) \dots\dots\dots\dots\dots\dots\dots\dots (3)$$

$$A_{it} = A_{i0}exp(g_t t) \dots\dots\dots\dots\dots\dots\dots\dots (4)$$

Where L_{i0} and A_{i0} are initial conditions of labor force and technical advancement, respectively. Assuming δ is the constant and also common rate by which physical, education and health capitals depreciate, then the accumulation of these three capitals is given by

$$K_{it} = I^{K}{}_{it-1} + (1-\delta)K_{it-1}$$

$$E_{it} = I^{E}{}_{it-1} + (1-\delta)E_{it-1} \qquad \text{---} (5)$$

$$H_{it} = I^{H}{}_{it-1} + (1-\delta)H_{it-1}$$

Dividing savings among physical, education and health human capital accumulations i.e education and health capital is treated as investment activity, such that

$$s_{it} = s^{K}{}_{it} + s^{E}{}_{it} + s^{H}{}_{it} = \frac{S_{it}}{Y_{it}} = \frac{I_{it}}{Y_{it}} = \frac{I^{K}{}_{it} + I^{E}{}_{it} + I^{H}{}_{it}}{Y_{it}}$$

then the rates of physical, education and health capital growth per unit of labor are defined as

$$\hat{k}_{it} = s^{K}{}_{it}\hat{y}_{it} - (n_i + g_t + \delta)\hat{k}_{it}$$

$$\hat{e}_{it} = s^{E}{}_{it}\hat{y}_{it} - (n_i + g_t + \delta)\hat{e}_{it} \qquad \text{.............................} (6)$$

$$\hat{h}_{it} = s^{H}{}_{it}\hat{y}_{it} - (n_i + g_t + \delta)\hat{h}_{it}$$

If, following MRW, we assume the existence of a steady state (with $\alpha+\beta+\psi < 1$) then, equations in (6) implies that the steady state values of physical, education and health capital are

$$k^{*}{}_{i} = \left[\frac{(s^{K}{}_{i})^{1-\beta-\psi}(s^{E}{}_{i})^{\beta}(s^{H}{}_{i})^{\psi}}{n_i+g_t+\delta}\right]^{1/(1-\alpha-\beta-\psi)} \qquad \text{...}(7)$$

$$e^{*}{}_{i} = \left[\frac{(s^{K}{}_{i})^{\alpha}(s^{E}{}_{i})^{1-\alpha-\psi}(s^{H}{}_{i})^{\psi}}{n_i+g_t+\delta}\right]^{1/(1-\alpha-\beta-\psi)} \qquad \text{..................................}(8$$

$$h^{*}{}_{i} = \left[\frac{(s^{K}{}_{i})^{\alpha}(s^{E}{}_{i})^{\beta}(s^{H}{}_{i})^{1-\alpha-\beta}}{n_i+g_t+\delta}\right]^{1/(1-\alpha-\beta-\psi)} \qquad \text{................................} (9)$$

Substituting (7) to (9) and (3) and (4) in (2) and taking natural logs gives

$$lny^*_{it} = lnA_{i0} + g_t - \frac{\alpha + \beta + \psi}{(1 - \alpha - \beta - \psi)} ln(n_i + g_i + \delta) + \frac{\alpha}{(1 - \alpha - \beta - \psi)} lns^K{}_i + \frac{\beta}{(1 - \alpha - \beta - \psi)} lns^E{}_i + \frac{\psi}{(1 - \alpha - \beta - \psi)} lns^H{}_i \ldots\ldots\ldots\ldots (10)$$

This equation (Eq. 10) is an extended version of Mankiw *et al* (1992) equation 11(pp, 417) and similar to Knowles and Owen's (1995) equation 11(pp, 101) and McDonald and Roberts's (2004) equation 3 (pp, 4) ; and this shows how income per capita depends on population growth and accumulation of physical capital and the two human capital components, health and education. Coefficients of regressors in equation 10 are functions of the factor shares. Under the disaggregated human capital specification, where health variable is not explicitly included, the physical capital's share of output, α, is expected to be about one-third while the share of human capital is difficult to gauge, but roughly expected to be between one-third and one half. Since disaggregated data on saving are lucking, empirical implementation of equation (10) is difficult; and the capital terms in this equation are rates of accumulation. However, it is also possible to derive alternative estimating equations by treating the augmenting capital terms as levels rather than rates. In other words, income per capita can alternatively be expressed as a function of the steady-state levels of educational and/or health capital. If we solve for $s^E{}_i$ and $s^H{}_i$ from Eq. (8) and (9) in terms of $e^*{}_i$ and $h^*{}_i$ and substituting in Eq. (10) yields

$$lny^*_{it} = lnA_{i0} + g_t t - \frac{\alpha}{(1 - \alpha)} ln(n_i + g_t + \delta) + \frac{\alpha}{(1 - \alpha)} lns^K{}_i + \frac{\beta}{(1 - \alpha)} lne^*{}_{it} + \frac{\psi}{(1 - \alpha)} lnh^*{}_{it} \ldots\ldots\ldots\ldots (11)$$

Similarly, combining the steady state level of health human capital with equation (10) gives another alternative estimating equation in which education capital is in rates of accumulation while health capital is taken as (steady state) level. This is given by

$$lny^*_{it} = lnA_{i0} + g_t t - \frac{\alpha+\beta}{(1-\alpha-\beta)} ln(n_i + g_t + \delta) + \frac{\alpha}{(1-\alpha-\beta)} lns^K{}_i + \frac{\beta}{(1-\alpha-\beta)} lns^E{}_i + \frac{\psi}{(1-\alpha-\beta)} lnh^*_{it} \dots\dots\dots\dots\dots (12)$$

Where the asterisk indicates the quantity of a particular capital per unit of effective labor unit is a steady state level. Here, one can understand that equation 12 leaves income as a function of the rate of investment in physical and education capital, the rate of population growth, and the level of health human capital. While (10) is implicitly derived from a steady state expression in terms of levels, the derivation of (11) and (12) do require the presumption of a steady state. MRW (1992, pp. 418) and McDonald and Roberts (2004, pp.5) made a point that, for estimation, the choice between (10), (11), and (12) depends on whether the available data on human capital correspond more closely to the rate of accumulation or to the level of human capital.

Estimating equations with a 'speed of convergence parameter, λ' can be obtained, following MRW (1992, pp. 422-423), by linearising the growth equation around the steady-state level of income per capita. Hence, growth equations corresponding to the levels equations in (11) and (12) can be obtained of the form:

$$lny^*_{it} - lny^*_{i0} = (1-e^{-\lambda\tau})lnA_{i0} + g_t t - \frac{(1-e^{-\lambda\tau})\alpha}{1-\alpha} ln(n_i + g_t + \delta) + \frac{(1-e^{-\lambda\tau})\alpha}{1-\alpha} lns^K{}_i + \frac{(1-e^{-\lambda\tau})\beta}{1-\alpha} lne^*_{it} + \frac{(1-e^{-\lambda\tau})\psi}{1-\alpha} lnh^*_{it} - (1-e^{-\lambda\tau})lny^*_{i0} \dots\dots\dots\dots (11')$$

$$lny^*_{it} - lny^*_{i0} = (1 - e^{-\lambda\tau})lnA_{i0} + g_t t - \frac{(1 - e^{-\lambda\tau})(\alpha + \beta)}{1 - \alpha - \beta} ln(n_i + g_t + \delta) + \frac{(1 - e^{-\lambda\tau})\alpha}{1 - \alpha - \beta} lns^K{}_i$$

$$+ \frac{(1 - e^{-\lambda\tau})\beta}{1 - \alpha - \beta} ln(s^E{}_i) + \frac{(1 - e^{-\lambda\tau})\psi}{1 - \alpha - \beta} lnh^*_{it} - (1 - e^{-\lambda\tau})lny^*_{i0} \quad \ldots\ldots\ldots\ldots\ldots (12')$$

By collecting the like terms together, Eq. (11') can be written in a dynamic panel data form as

$$lny^*_{it} = \gamma lny^*_{it-1} + \sum_{j=1}^{4} \theta_i x^j{}_{it} + \eta_t + \mu_i + v_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

From this DPD form of income per capita equation, we can specify the growth of income per capita equation as

$$\Delta lny^*_{it} = (\gamma - 1)lny^*_{it-1} + \sum_{j=1}^{4} \theta_i x^j{}_{it} + \eta_t + \mu_i + v_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13')$$

Similarly, the level and growth equations of income per capita of Eq. (12') can be written in compact and DPD form as

$$lny^*_{it} = \gamma lny^*_{it-1} + \sum_{j=1}^{4} \theta_i x^j{}_{it} + \eta_t + \mu_i + v_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

$$\Delta lny^*_{it} = (\gamma - 1)lny^*_{it-1} + \sum_{j=1}^{4} \theta_i x^j{}_{it} + \eta_t + \mu_i + v_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots (14')$$

Estimating Eq. (13) is the same as estimating Eq. (13'); it is a matter of changing the dependent variable and adjusting the coefficient of the initial condition accordingly when the speed of convergence is calculated. The same is true between Eq.(14) and (14'). In chapter four, the actual equations we estimated are Eq. (13') and (14').

Note that education capital and health capital variables in Eq. (13) and/or (13') are expressed in levels while in Eq. (14) and/or (14') education and health capital are entered as rate and level, respectively. As a result of this, the parameter components from which θ_i's are composed and the variables for which $x^j{}_{it}$ stands for in the two groups of equations may not necessarily be the same[2]. The following table entails what θ_i's and $x^j{}_{it}$ represent in the above specifications.

In the DPD models specified above the term μ_i denotes a full set of country specific fixed effects that are functions of different parameters and the initial technological levels A_{i0}; the η_t's incorporate time varying factors common across all countries; v_{it} denotes idiosyncratic errors or idiosyncratic disturbances. The summation of these errors terms (μ_i, η_t and v_{it}) constitutes the composite error term , U_{it}. In the growth equations specified above, θ_1 is expected to be negative while θ_2, θ_3 *and* θ_4 are deemed to be positive. Once θ_i's are estimated, we can calculate the structural parameters from which the output shares of each capital can be known. The coefficient for the lagged dependent variable $(\gamma - 1)$ is important to test the convergence hypotheses. But, to address these issues, getting unbiased and consistent estimates of the parameters of the model is vital.

[2] Here, Eq. (13) and (13') are considered as one group of equation while (14) and (14') are in another. Using the same notation for different things in these groups of equations is a matter of convenience.

Table 3.1. Meaning of notations in the estimating equations.

Parameter/or Variable	Stands for	
	In Eq.(13)and/or (13')	In Eq.(14)and/or (14')
γ	$e^{-\lambda\tau}$	$e^{-\lambda\tau}$
ϕ	$1-e^{-\lambda\tau}$	$1-e^{-\lambda\tau}$
θ_1	$\frac{-\phi\alpha}{1-\alpha}$	$\frac{-\phi(\alpha+\beta)}{1-\alpha}$
θ_2	$\frac{\phi\alpha}{1-\alpha}$	$\frac{\phi\alpha}{1-\alpha-\beta}$
θ_3	$\frac{\phi\beta}{1-\alpha}$	$\frac{\phi\beta}{1-\alpha-\beta}$
${x^1}_{it}$	$ln(n_i+g_t+\delta)$	$ln(n_i+g_t+\delta)$
${x^2}_{it}$	${lns^K}_i$	${lns^K}_i$
${x^3}_{it}$	$\ln({e^*}_{it})$	$\ln({s^E}_i)$
${x^4}_{it}$	$\ln({h^*}_{it})$	$\ln({h^*}_{it})$
η_t	$g_t t$	$g_t t$
μ_i	ϕlnA_{i0}	ϕlnA_{i0}

Therefore, in the next section, different econometric issues that are related to estimating method of DPD model like ours are reviewed and finally we rationalize the estimating method followed in this study.

3.1.2. Estimation Method: The Dynamic Panel Data Estimator

A large body of subsequent empirical research has been stimulated by MRW's seminal work which was based on single cross section regression data and OLS estimator. Islam (1995) criticized their approach on the grounds that single cross section regression is unable to deal with the unobservable country-specific aspect of the aggregate production function, thereby generating omitted variable bias; and the less convincing justification for OLS estimation which makes him follow a panel data approach. In other words, the growth regression approach encounters the omitted variable problem associated with the unobservable initial level of technology, A(0). In a single cross-section growth regression, this omitted term is left within the residual term. Since variations in technical efficiency across countries are likely to be correlated with other explanatory variables, estimates of regressors in a conditional convergence regression are biased and inconsistent.

Panel data methods make it possible to control for the unobserved country-specific effect by treating initial efficiency as a time-invariant fixed effect and eliminating its influence through a time dimensional transformation (Ding and Knight, 2008). Added to these, Caselli *et al.* (1996) and Hoeffler (2002) argued that at least a subset of the explanatory variables is expected to be endogenous, and that this problem may lead to unreliable estimated coefficients and convergence rates. They, therefore, recommended using a panel data, generalized method of moments (GMM) estimator to take into account both the omitted variable and endogeneity bias in the cross country growth regressions. Following these arguments, we adopt a dynamic panel data approach to address the issue in a more reliable way. The rest part of this section is devoted in exploring the problems in estimating DPD model in growth regression context and step by step the section ends up by proving and selecting system Generalized Method of Momentum(SYS-GMM) as a superior estimator to generate consistent and unbiased parameter estimates in our context.

Many economic relationships are dynamic in nature and thus many economic models suggest that current behavior depends up on past behavior (persistence, habit formation, partial adjustments etc), so in many cases we would like to estimate a dynamic model. Following this argument and other explicit advantages panel data has, in this study, we use panel data from sub-Saharan African countries and estimate the dynamic panel data model. Panel data is superior to single cross section and time series data since it allows the researcher to better understand the dynamics of adjustments. In addition, panel data set gives more informative data and more variability since large numbers of data points are available. This leads to less collinearity among variables and blows up degrees of freedom, which in turn, improves precision of estimation (more efficiency). Furthermore, panel data better controls the heterogeneity among economic agents (countries in our case) and allow us to construct and test more complicated behavioral models than purely cross section and time series data.

We have already derived and specified our dynamic panel data model from Eq. (13) to (14') in the previous section. However, estimation of such dynamic panel data models is not an easy task, especially, in the context of growth regression. We can raise some well known problems with estimating dynamic growth regression that have been widely discussed in growth literature. First of all, the regressions of equation (13) to (14') are dynamic in the sense that it includes the lagged dependent variable as a regressor. The presence of lagged dependent variable coupled with that of the fixed effects μ_i renders the OLS estimator inconsistent and biased upwards. Because in these equations, we can see that y_{it} is a function of μ_i, it immediately follows that y_{it-1} is also a function of μ_i. Therefore, y_{it-1} a right hand regressor in each equation is positively correlated with the error term. Added to this, the omitted variable bias, the measurement error and the endogeneity of other regressors and their possible correlation that might occur with the fixed effects tend to yield biased and inconsistent OLS estimators even if the v_{it} are not serially correlated (Baltagi, 2005, pp.135).

The within groups estimator eliminates this source of inconsistency by transforming the equations to eliminate μ_i. But it doesn't solve the dynamic panel bias (Bond, 2002, pp. 4; Nickell, 1981; Roodman, 2006 pp.18). Under the within group transformation, the lagged dependent variable becomes $y^*_{it-1}=y_{it-1}-\frac{1}{T-1}(y_{i2}+\cdots+y_{iT})$ while the error becomes $v^*_{it}=v_{it}-\frac{1}{T-1}(v_{i2}+\cdots+v_{iT})$. The problem here is that y_{it-1} term in y^*_{it-1} correlates negatively with the $-\frac{v_{it-1}}{T-1}$ in v^*_{it} while, symmetrically, the $-\frac{y_{it}}{T-1}$ and v_{it} terms move together. These leading correlations, which are both negative, dominate positive correlations between other components such as $-\frac{v_{it-1}}{T-1}$ and $-\frac{y_{it-1}}{T-1}$, so that the correlation between the transformed lagged dependent variable and the transformed error term can be shown to be negative. Therefore, for short panel like ours where T is small and thus $\frac{1}{T-1}(y_{i2}+\cdots+y_{iT})$ and $\frac{1}{T-1}(v_{i2}+\cdots+v_{iT})$ are significant, the within group estimator is also inconsistent. Standard results for omitted variables bias indicates that, at least in large samples, the within group estimator is biased downwards (Bond, 2002, pp. 5, Rooman, 2006, pp19).

The biasedness of the OLS and within estimators in opposite direction is somewhat informative about the true (or consistent) parameter estimates. From this situation, one might hope that a candidate consistent estimator will lie between the OLS and within groups estimates, or at least not be significantly higher than the former or significantly lower than the latter.

As it is cited in Baltagi(2005, pp. 135), most recently Kiviet(1995) proposed that the best way to handle dynamic panel bias is to perform Least Squared Dummy Variable(LSDV), then correct the results for the bias, which he finds can be predicted with surprising precision. However, the approach he proposed works only for balanced panels and doesn't address the potential endogeneity of other regressors. In our estimable equation, the variable of interest (health conditions) and other regressors are endogenous and as a result of this LSDV estimator is not the appropriate estimator for our model.

Following these theoretical and practical dissatisfactions in estimating DPD models by the methods stated above, recently, different authors have come to understand and prove that the General Method of Momentum (GMM) estimation technique is promising and better handles the econometrics problems discussed so far. There are two GMM estimators based on the assumption made and resulting moment restrictions, and thus, variables used as instrument in the estimation process. These are difference estimator and system estimator (DIF-GMM and SYS-GMM, here after). The difference and system GMM estimators are designed for panel analysis, and embody some assumptions about the data-generating process like the dynamic nature of the process and endogenous regressors; the idiosyncratic disturbances may have individual-specific patterns of heteroskedasticity and serial correlation but are uncorrelated across individuals and additionally the estimators assume that the number of time periods of available data, T, may be small, which seems in line with the nature of our data and model.

Holtz-Eakin *et al* (1988) and Arellano and Bond (1991) proposed a difference GMM estimator that uses wider unbalanced instrument sets. In this estimation method, the estimating equation transforms to the first difference as

$$\Delta y_{it} = \Delta \eta_t + \gamma(\Delta y_{it-1}) + \theta(\Delta x_{it}) + \Delta v_{it} \quad \text{.............................} \quad (15)$$

The first difference has caused the new error term $\Delta v_{it} = v_{it} - v_{it-1}$ to be correlated with lagged dependent variables, $\Delta y_{it-1} = y_{it-1} - y_{it-2}$ though the fixed effects are gone. Similarly, any predetermined variables in x that are not strictly exogenous becomes potentially endogenous because they too may be related to v_{it-1}. These couples of problems makes OLS estimator inconsistent in the differenced equation and leads us to consider the instrumental variables. The instrument is generated under the assumption that v_{it} is not serially correlated, but not necessarily independent over time, and with the resulting moment restrictions $E(y_{it-s}\boldsymbol{\Delta v_{it}}) = \mathbf{0}$ for t=3, ... , T and s ≥ 2. If the regressors in x_{it} are endogenous, like our case, in the sense that $E(x_{it}v_{is}) = 0$ for s>t and ≠0, otherwise, the moment conditions $E(x_{it-s}\boldsymbol{\Delta v_{it}}) = \mathbf{0}$ for t=3, ... ,T and s≥2 are available (Bond et al, 2001, pp.5). Hence, by utilizing these moment conditions, the differenced equation can be estimated consistently by GMM (thus the estimator is called DIF-GMM) using y_{it-s} *and* x_{it-s}, for s≥2, as instruments, since deeper lags of the regressors are uncorrelated with $\boldsymbol{\Delta v_{it}}$. In sum, the moment restrictions exploited by the standard linear first differenced GMM estimator, implying the use of lagged levels dated t-2 and earlier as instrument for equations like equation (15). This yields a consistent estimator of parameters as N→∞ with fixed T.

However, DIF-GMM estimator has some shortcomings which undermine the reliability of parameter estimates obtained from this estimator. As Blundell and Bond (1998) demonstrated when lagged dependent variables are persistent over time, lagged values of these variables are weak instruments for the regression equation in differences. In other words, past levels that are instruments in difference GMM convey little information about future changes and so that the untransformed lags are weak instruments for transformed variables even though they are uncorrelated with the transformed error term. This affects the asymptotic and small sample performance of the estimator.

In order to get an estimator with superior finite sample properties, Arellano and Bover (1995) and Bundell and Bond (1998) proposed the system GMM estimator. This estimator is based on asymptotic and small sample properties to diminish any potential bias in finite samples. In SYS-GMM estimation technique, the regression in differences and the regression in levels are jointly estimated. In order for exploit additional moment conditions to generate and use new instruments, Bundell and Bond (1998) consider an additional assumption[3] that $E(\mu_i \Delta y_{it}) = 0$ for i=1,..., N. This assumption yields T-2 further linear moment conditions given by

$E(U_{it}\boldsymbol{\Delta y}_{it-1}) = \mathbf{0}$ for i=1,..., N and t=3,..., T.

These allow the use of lagged first differences in the series as instruments for equation in levels while the lagged levels are considered as instrument for equations in first difference.

However, the instrumenting process of the lagged dependent variable in such sophisticated way doesn't solve the whole problem faced to estimate the dynamic model. Similar techniques should also be applied for other regressors too since they are not strictly exogenous. Here, we assume that x_{it} is correlated with μ_i and endogenous which allows both contemporaneous correlation between the current shocks v_{it} *and* x_{it}, and feedback from past shocks v_{it-s}, onto the current values of x_{it}. Taking first differences to eliminate the individual effect μ_i, the moment

[3] The assumptions made for difference GMM and the resulting moment restrictions are also maintained here.

conditions $E(x_{it-s}\Delta v_{it}) = 0$ for t=3,..., T and s≥2 are available here, in addition to the moment condition obtained for lagged dependent variables. Thus, lagged values of endogenous x_{it} variables dated t-2 and earlier can then be used as instruments for equations in first differences. In addition, it is assumed that there is no correlation between differences on the right hand variables and the country specific effects, $E(\Delta x_{it}\mu_i) = 0$ that allows the moment conditions $E(U_{it}\Delta x_{it-1}) = 0$ for t= 3, ..., T to be available. These conditions permits the use of both lagged Δy_{it} and lagged Δx_{it} as instrument in the level equations (Bond et al, 2001, pp. 12).

The GMM formula and estimating software still treat the system as a single equation estimation problem since the same linear functional relationship is believed to apply in both the transformed and untransformed variables (Roodman, 2006, pp. 29). The system GMM estimator not only improves the precision but also reduces the finite sample bias. (Baltagi, 2005, pp.147). The use of the system GMM estimator in empirical growth research is also strongly recommended by Bond et al (2001), Caselli *et al.* (1996) and Hoeffler (2002), among others. Following this superiority, in this study, therefore, we take the system GMM estimator as our preferred estimator to get the most reliable parameter estimates even though other estimating methods are also considered for comparison purpose.

In order to evaluate the appropriateness of the GMM estimator, we should consider two specification tests proposed by Arellano and Bond (1991), Arellano and Bover (1995) and Bundell and Bond (1998). The validity of the serially uncorrelated error term and the validity of the instruments are needed to be tested. To detect the problem of autocorrelation, we applied the Arellano - Bond autocorrelation test while the validity of the instruments were tested by means Hansen and difference –in- Hansen tests of over identifying restrictions.

3.2 The Data and Sampling Method

3.2.1 The Source and Nature of Data

As far as the economic and demographic variables (i.e., growth rate or level of per capita GDP, saving rate and population growth rate augmented with (δ+g)= 0.05) are concerned, we have utilized two main datasets which is important to keep consistency and in order not to mixing data from different sources. The first one the Penn World Table (PWT) version 6.3 which was first organized by Summers and Heston [1988] and then after updated from time to time and what we used is the 2009 edition (i.e Allen Heston *et al*(2009)). Many growth researchers like Barro(1989), Mankiw *et al(*1992) and Islam(1995), among others, used this dataset in their seminal articles. In this dataset economic variables we used were measured at Purchasing power parity (PPP) in 2005 international Dollar. The second dataset exploited to proxy economic variables is the 2008 World Development Indicator (WDI) data in which economic variables we utilized are measured in 2000 constant US Dollar.

Each of the equations specifies above was estimated using data constructed from these two alternative sources whenever possible. We opted to present alternative results from alternative data sources for a model (specification) for a number of reasons. *One*, it is argued that accounting for the role of health capital stock on economic conditions is sensitive for the variable used to proxy health, the data sources utilized and the type of the empirical model specified or estimated. Thus, having results from such comparable or alternative sources is important to see whether such arguments are valid.

Two, relying upon one of these sources was not found to be appropriate in our context since each of them are with considerable shortcomings that may be specific to either the problem at hand or the sample countries considered. For example, if we consider the WDI data, economic variables such as GDP per capita at purchasing power parity (PPP) is available only after 1980 ; and it is not uncommon to see some writers who try to address the problem at hand by considering time period from 1980 onwards. But, this time period is too short to reflect the macroeconomic role of health status since the benefit of improvement in health conditions is realized only in the long run. Weil(2007) and other writers have argued that the role of health human capital on macroeconomic conditions, such as GDP per capita, better reflects at least in 40 to 60 years. Following this argument we didn't use GDP per capita at PPP from this source rather we make use of GDP per capita that is available from 1960 on. However, this doesn't take the PPP in to consideration and many of the SSA countries data were missing that leads us towards low sample size and data points or observations. As a result, we looked for an alternative source-PWT version 6.3- in which GDP per capita at PPP and other economic variables are available for almost all SSA countries from 1950 on[4]. The most important problem that forced us not to exclusively rely upon this data source and the resulting findings is that of data quality. Allen Heston et al (2009) gave grades from A to D associated with quality of data of each country considered in their datasets. Surprisingly, the maximum grade achieved by few countries in SSA was 'C' and the rest have got 'D' grade which shows the quality of SSA countries data is very poor. Following these reasons, it is better to come up with alternative results from alternative data sources and see the difference, if any.

In a strict Solow regression, as in any production function, one should consider output and inputs in terms of workers, rather than the population level as a whole. Nonetheless, many writers find

[4] Regardless of this, we were not able to start the analysis from 1950 since data on other variables of the model, health and education, are available only after 1960 or 1970 even income data itself is unavailable for some countries of SSA before 1960.

that using per person data does not significantly affect the results of their equations, and Temple (1999) notes that the quality of available data on labor force participation and worker hours is measured with not insignificant error, particularly in the developing world. Thus we make use of the per capita rather than per worker variable in both datasets.

For health capital one possible approach is to proxy health by the proportion of income spent on health inputs. However, a given level of health spending can be associated with widely differing actual outcomes (e.g. in terms of life expectancy) across different countries, even after controlling for levels of income and schooling (World Bank, 1993, pp. 53-54). We follow the alternative approach of using proxies for the stock of health capital based on life expectancy at birth and infant mortality rate (which are likely to be health-status indicators more directly relevant to the production of output).

Life expectancy at Birth (LEB) is defined as the number of years a new born infant would live if prevailing factors of mortality at the time of birth were to stay the same throughout the child's life and the data for LEB was taken from WDI. Adopting the transformation used by Anand and Ravallion (1993) and Knowles and Owen (1995, 1997), we proxy $\ln(h^*)$, in this case, by $-\ln(80-LEB)$, where $(80-LEB)$ is the shortfall of average life expectancy at birth from 80 years. This proxy has been defended by Sen (1998), but can be criticised for making "no allowance for the quality of health beyond survival" (Knowles and Owen, 1995, p 102). Thus, it would be expected that changes in life expectancy would understate changes in health capital by not registering the morbidity affects.

Infant Mortality Rates (IMR) measures the death of children between 0-1 and measured out of 1000 live births. It measures the probability of dying between birth and exact age one. This proxy can be defended on the grounds that it offers an indicator of the current health status of the population through those most susceptible to deterioration in the general level of health within the population. As such it partially captures the 'quality of health' dimension, but it may overstate changes in health capital since it is arguable that a mother's health may have a greater impact upon infant mortality and there is evidence of a greater prevalence rate among women in countries with higher overall prevalence rates(McDonald and Roberts(2004). These two aggregate measures of health were used in econometric estimations presented in the fourth chapter. The third aggregate measure of health considered only for descriptive analysis of the next chapter is under-five mortality rate which can be defined as the probability of dying of a newly born child between birth and exact age five. Data IMR and U5MR were taken from united nation (UN) dataset. Neither proxy is ideal since all are likely to have involved some interpolation and hence may not fully reflect current health status and to a greater or lesser extent fail to capture 'quality' effects.

Following the two different types of equations, we collected two different types of education data. One is education data measure at level (as a stock variable) and the other is measured as a flow variable and used as a proxy for the rate of education capital accumulation. The first type of education variable was proxied by the average years of schooling for population of aged 15 and above (edu15) which was taken from Barro - Lee dataset on educational attainment which was first organized in 1993 and then updated until 2000. This data is reported in 5 year interval and currently it is available for many countries from 1960 to 2000 and also reported for aged 15 and above and 25 and above. We opted the 15 years and above data because it is generally accepted that worldwide those over 15 reflect the workforce more closely than those over the age of 25, the other generally available sample especially for LDCs like Sub-Saharan Africa

(SSA). This average years of schooling in the total population aged over age 15, which provides a direct measure of the *stock* of education human capital at the beginning of each five-year period in our data construction and estimation.

We used two variables to approximate the rate of education capital accumulation. The first one is, the gross secondary school enrolment rate, like McDonald and Roberts (2004), and raw data for this variable was taken from UNESCO. However, as Mankiw *et al(1992)* argued school enrolment rates are clearly imperfect measures of rates of investment in schooling. Following this argument, the second proxy we needed to use in place of school enrolment is investment (or expenditure) on education which is defined as total expenditure on schooling as a percentage of Gross National Income (GNI) which was taken from WDI.

3.2.3 Organizing the Data

In the datasets that provide data on human capital variables such as health variables discussed above from both UN and WDI data set and the average years of schooling from BL education data set are reported in five year interval. This may be because health and education variables are not expected to change yearly. The period considered in this study was from 1960-2005 or 1970-2007, depending upon the type of model being estimated (additional notes on it is provided in chapter four).

Following the nature and availability of data on our variables of interest the whole period was divided into five- yearly time spans. Even the yearly data are available and do make sense, it is argues that yearly time spans are too short to be appropriate for studying growth convergence. Short- term disturbances may loom large in such brief time spans. Instead, five-year time intervals are appropriate Islam (1995). Added to these, there may be potential covariation between business cycles and the explanatory variables, e.g. investment rate. It is well known that the investment rate is pro-cyclical. A relatively accepted remedy in the literature is to use data averaged over 5 years rather than annual data.

Following all these arguments, we divide the total periods in to five yearly time span as 1960-1964, 1965-1979,…, 2000-2005. The dependent variable throughout the econometrics analysis of the next chapter is the log differences of GDP per capita over each time span. All other variables discussed above are regressors of the model which were measured either at the beginning or the average over the time spans considered.

3.2.3 Sampling procedure

Sample countries from SSA were selected based on the availability of all and full period data required in the model. The number and types of sample countries may not be the same from one dataset prepared to estimate a model to another organized for another specification. For example, Eq. (13') and (14') requires different type of education data countries that have school enrolment data may not have average years of schooling data. Thus, independent samples were considered for each model specified above. While the sample countries included in either of the sample are listed in Appendix A, details regarding the observation generated for each model are discussed during estimation in the next chapter.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSIONS

This chapter presents the findings and discussion of this study in achieving the objectives aimed to address based on the methodology discussed in the previous chapter. The chapter has two main parts. The first part is devoted in exploring the data and making descriptive analysis about the variables of interest and their relationships. Particularly, in the descriptive analysis part, we emphasize on showing the health-wealth nexus by using simple statistical tools and graphical analysis. This would be an important starting point for the econometric methods adopted to address the issue more formally. The second part of this chapter presents the econometric results obtained based on the different empirical models specified in chapter 3. In that part, alternative estimating techniques are considered and their results as well as possible implications are thoroughly discussed. Different statistical tests and other econometric problems are some of the issues about which the chapter is concerned.

4.1. Descriptive Analysis

4.1.1. Introduction

In this part, we try to make some descriptive analysis which is believed to have a good reference for our modeling process and its results that come in the next part of this chapter. Before starting the analysis it is better to make a point about the datasets used in this part. As we discussed in chapter three, regarding the economic variables required to make the proposed analysis, we make use of two secondary data sources: The World Development indicator (WDI) and the Penn

World Table (PWT) version 6.3. For each of these sources, we prepared two estimable datasets on different number of samples and data points based on the definition and proxy we used for human capital variables especially *education*, which are discussed in the previous chapter.

Two main and widely used definitions as well as proxies of education human capital are considered in this study that are required to estimate different specifications outlined in chapter three. One, the average years of schooling for the population aged 15 years and above. This is a stock variable and we make use of it to estimate specifications like equation (13'). Data in five years interval for this variable is prepared by Barro and Lee and updated from time to time. The current Barro and Lee education Dataset is available for a large number of countries from 1960-2000. This proxy of education human capital is by far better than other proxies. The problem in this dataset is that most of the least developed counties lack this data and as a result it is difficult to consider large sample in cross country studies like ours. When the WDI data for economic variables is coupled with the Barro and Lee education attainment dataset, only few countries will be available to be considered in the study, thus we could not make separate analysis for this case to avoid low sample bias and to concentrate on cases where large observations can be generated.

The second method used to proxy education human capital is secondary school gross enrolment rate which is a flow variable and suitable to estimate specifications like equation (14'). As compared to the Barro and Lee average years of education data, the five year interval secondary school enrolment data are available to wide range of countries right from 1970 to 2005 and thus could be able to generate relatively more observations. In some cases, investment on education was used instead of this school enrolment variable.

Following advantage of having such large samples and data points, the summary statistics of all variables, but average years of education, discussed below are from this relatively large dataset. To avoid redundancy, the summary statistics for PWT data set is not discussed but we presented the summary table in the appendix B.

4.1.2. Summary statistics

Here, the summary statistics of economic variables like Gross Domestic Product per capita (both at level and growth), and gross domestic saving as a percentage of GDP; demographic variable, i.e, population growth rate augmented with the constant exogenous factor (amounting 5%) as well as health and education human capital variables, namely, life expectancy at birth, infant mortality rate, under-five mortality rate(u5mr), secondary school enrolment rate, expenditure on education, average years of schooling of population aged 15 years and above are considered for different samples and data points.

In Table 4.1 below, we reorganized the overall mean as well as the measure of overall, between, and within dispersions for sub-Saharan African (SSA). All economic variables are expressed in 2000 constant Dollar. As it can be seen from the table, for the year 1960 – 2007 the mean GDP per capita of 37 sample countries of SSA was found to be around 706 USD with overall standard deviation of 1047 and with significant amount of between and within variations. As far as the overall variations throughout the whole sample periods are concerned, the minimum GDP per capita was observed to be 83.5 USD which was registered by Democratic Republic of Congo (Zaire) over year 2000 -2004. During this period, the growth rate of her real GDP per capita was around -1.42 percent per annum. This low economic performance of Democratic Republic of Congo might be, among other things, because of its widespread civil war of the time which diverts resources from productive to non- productive activities and kills the investment sector of the nation. On the other hand, the maximum GDP per capita, amounting 6610.9 USD, was achieved by Gabon over the year 1975-1979. The most favorable time for Gabon economy was the year 1976 when its GDP per capita reached at 8576 USD and its annual growth was 32.13%. But after this period, the economy was not able to sustain its achievement and as a result of it the full period (1975-1979) average growth of its GDP per capita was only 1.03%.

When we look at the five -yearly average growth rates of GDP per capita, on average SSA has grown by 0.67% per annum with a standard deviation of 3.39%. The minimum and the maximum growth rates of GDP per capita were found to be -11.849 (by Democratic Republic of Congo over 1990-1994) and 16.1(by Botswana over 1970-1974). The highest performance of Botswana in this respect is associated with the discovery and appropriate use of its minerals. It is argued that when most of African nations discover important minerals, by the next day civil war and other conflicts are also posed by interested groups and thus the positive shocks owning to the discovery of these minerals can be outweighed by the negative shocks associated with the conflicts. On the net shell, the macroeconomic performance of such countries would be poor. Botswana is exceptional in this respect! When they discover their minerals, they saved the resulting money appropriately and they could be able to registered sustainable growth for the last 40 years. Over these periods (1970-2007), the average GDP per capita of Botswana has grown by 6.75% per annum.

Different economic, social and political factors are deemed to contribute for such low or high macroeconomic performance of countries. Narrowing down our concern in to the variables at hand (included in the specified models), saving is considered as an engine for economic growth

Table 4.1 the Summary Statistics for the Data of the SSA African Sample

Variable name		Mean	S.Deviation	Minimum	maximum	observation
Real GDP per capita	overall	83.5004	706.9388	1046.951	6610.9	N = 296
	between		1001.406	127.1668	4821.482	n = 37
	Within		342.1806	-1345.47	2861.417	T = 8
Growth rate	overall	0.6660865	3.389263	-11.83904	16.10324	N = 296
	Between		1.667029	-2.729027	6.750469	n = 37
	Within		2.962104	-8.443926	12.54427	T = 8
Saving rate	overall	9.572465	16.31387	-70.3408	62.43333	N = 296
	Between		14.45499	-43.53448	49.74892	n = 37
	Within		7.883772	-17.23386	43.9718	T = 8
Population growth	overall	7.61889	0.95544	-0.47	12.61	N = 296
	between		0.48283	6.125	8.5425	n = 37
	within		0.82781	-0.35361	12.72639	T = 8
Life expectancy	overall	51.30608	6.931556	23.7	72.1	N = 296
	Between		5.754953	41.45	68.425	n = 37
	Within		3.963947	32.69358	60.41858	T = 8
Infant mortality	Overall	100.5834	33.3063	14.6	194.8	N = 296
	Between		27.97529	26.65	148.85	n = 37
	Within		18.58126	49.30844	157.6084	T = 8
Under-five mortality	overall	167.8113	74.64725	0.41	400	N = 296
	Between		67.47252	1.39375	306.125	n = 37
	Within		33.58119	61.56132	290.3113	T = 8
2ry School enrolment	overall	21.42457	17.31206	1.055284	94.70489	N = 296
	Between		14.09556	5.062266	58.76079	n = 37
	Within		10.28287	-18.66174	58.43495	T = 8

Educational expenditure	overall	3.553707	1.534852	0 .85	9.2616	N = 288
	Between		0 .5511383	2.383363	4.568473	n = 36
	Within		1.43507	0.6803175	8.86516	T = 8
years of education	overall	2.545185	1.477556	0.22	6.28	N= 162
	between		1.121391	0.5266667	4.893333	n= 18
	within		0 .9940528	0.3696296	5.300741	T= 9

Source: own computation

growth and development while de-saving (negative saving) and high population growth hinders economic progresses. The average saving rate Africa had during the periods considered in this study was not more than 11%. In our data summarized above, the minimum gross domestic saving rate as a percentage of GDP was found to be about -70%, by Lesotho over 1975-1979. Surprising this country hasn't ever registered positive saving rates; -13% saving is its maximum value that Lesotho has achieved in the year 2007. On the other hand, the maximum saving, amounting 62%, was achieved by Gabon over the years 2005-2010. Similarly, when Gabon registered its as well as African highest GDP per capita over the year 1975-1979, its saving rate was about 60% of its GDP which is the again the third highest value of the whole data points considered in this study. This condition ensures that saving accelerates economic progresses. Likewise, the population growth rate of SSA was, on average, about 2.6% per annum.

When we see the nature of data for our variable of interest, health human capital, three substitutable measures of health capital are considered. These are life expectancy at birth (LEB), infant mortality rate (IMR) and under-five mortality rate (U5MR). These proxies of health human capital can be used interchangeably in the regression analysis of the problem at hand. But before that, we have to explore the data as we did for other variables of the model. It is clear that the higher life expectancy and the lower infant and under-five mortality rate are signs of better health status and better well being. It is also argued that a country with better health can easily achieve good economic outcomes and vice versa.

In the last 40 years, the average life expectancy of SSA was about 51 years. Our data on this variable shows that the worst health status indicated by life expectancy at birth was registered by Rwanda over the years 1990 to 1994 whose life expectancy was only 23.7 years. The then genocide or the severe widespread of HIV-AIDS may be some of the reason for this bad performance. During this time where health conditions were very poor, the level and growth of GDP per capita of Rwanda was about 223 USD and -7.23%, respectively, which are also severe. On the other hand, the recent (2005-2007) Mauritius life expectancy was about 72.1 years which is more than threefold of the Rwandan life expectancy mentioned above and near to two fold of Zimbabwean life expectancy (44 years) of the same period (2005-2007). Over this periods, the level and growth of real GDP per capita were about $4542 and 3.5%, for Mauritius, and $428 and -4.98%, for Zimbabwe, respectively.

Considering infant mortality and under-five mortality rates, as alternative measures of health status, the summary statistics of our data presented in table 4.1 entails us that in SSA, on average, out of 1000 live births, about 100 and 168 children died before the anniversary of their first year and fifth year's birth day, respectively. Mauritius is the most successful country in this respect since it could be able to reduce infant and under-five mortality rates in to 14.6 and 15, respectively, in recent years, during which the country has achieved a GDP per capita of 4542USD with annual growth rate of 3.5%. Opposed to this, the severe infant mortality and under-five mortality rates were observed over the same periods, 1970-1974, in Sierra Leone (amounting 195) and in Mali (amounting 400), respectively. In this period, Sierra Leone's GDP per capita was about 280 USD with annual growth rate of 1.3% while the GDP per capita of Mali was found to be 213 USD with 0.06% annual growth rate.

These extreme values of different health indicators and economic measures of the same period seem to have a consistent correlation. From these figures, it is possible to deduce that life expectancy at birth and economic conditions move in the same direction while both infant and under-five mortality rates are negatively correlated with measures of macroeconomic conditions. These relationships will further be explored in the next section.

Education human capital is another variable about which we are interested next to health human capital. Three different measures of education are considered in this paper: The secondary school enrolment, investment on education, and the average years of schooling. Like that of health human capital, better educational attainment is believed to facilitate economic growth. Data from 37 SSA countries shows that, on average, about 21% of adults were able to enroll in secondary schools, in the last 40 years, with huge between and within variations. The minimum and maximum enrolment ratio was achieved by Niger and South Africa, respectively. Added to this, about 3.5% of the sub-Saharan GNI has spent on education. Similarly, the Barro and Lee measures of average years of educational attainment, from 18 sample SSA nations, also shows that SSA average stock of education for population aged 15 and above is negligible, which is as low as 2.1 years. In both measures of schooling, African educational attainment is very low as compared to other regions of the world. Taking aged 15 and over average years of schooling, currently, the United States of America is the first in the worlds with 12.05 years of average school. The Asian tigers like Hong Kong(with 9.41 years of schooling), Taiwan(8.76 years), Korea(10.84 years), Singapore(7.05) and others are notable countries with their higher educational attainment and knowledge stocks which is believed to be the main engine for their miracle growth. This condition is somewhat informative about the correlation between education human capital and economic outcomes that will be addressed in subsequent sections of this chapter.

4.1.3. Trends in Economic Performance and Health Status

In table 4.2 below, we summarized the five yearly-averaged GDP per capita and the respective growth rate for sample countries from the whole Africa and sub –Saharan Africa to see trends in economic conditions over the period considered in this study. As it can be seen in the table 4.2, the economic improvements of sub- Saharan African across periods are negligible in terms of both the level and growth rate of GDP per capita. Even in some periods, deteriorations in economic status have been observed. The region cannot significantly improve its income over the last 40 years. But, in recent years, there is a sign that the economic conditions are getting better. If we look at the last time span considered, on average, the GDP per capita of SSA grew at 2.22% per annum which more than double of the previous period.

In order to have a clear understanding of it, in figure 4.1 and figure 4.2, drawn below, we have shown the trend of economic conditions in SSA over the last 40 years graphically. The vertical axis in figure 4.1 and 4.2 represents the annual average level of GDP per capita and its growth rate, respectively.

Table 4.2 Trends of economic and health conditions in sub-Saharan Africa (1970-2007)

Region	Variable	Year							
		1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2007
All Africa	Real GDP per capita	604	724	752	754	769	807	866	955
	Growth rate (%)	1.87	0.95	0.89	0.54	0.39	1.23	0.64	2.32
	life expectancy	46.5	48.6	50.2	51.4	51.6	52	52.7	54
	Infant mortality	132.5	119.7	111.9	105.7	102.1	97.5	88.6	82.6
Sub-Saharan Africa	GDP per capita	565	675	690	685	698	728	769	841
	Growth rate (%)	1.74	0.56	-0.39	0.47	-1.46	1.11	1.08	2.22
	life expectancyat birth	45.1	47.1	48.3	49.2	49.1	49.4	50	51.5
	Infant mortality rate	132.8	121.9	116.5	122	108.6	104.1	94.8	88.6

Source: Own computation from WDI dataset

Figure 4.1: trends in GDP per capita in the whole Africa and SSA (1970-2007)

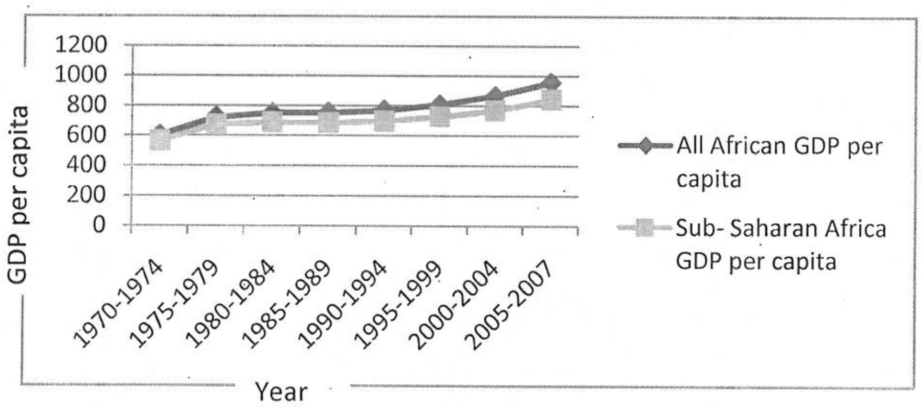
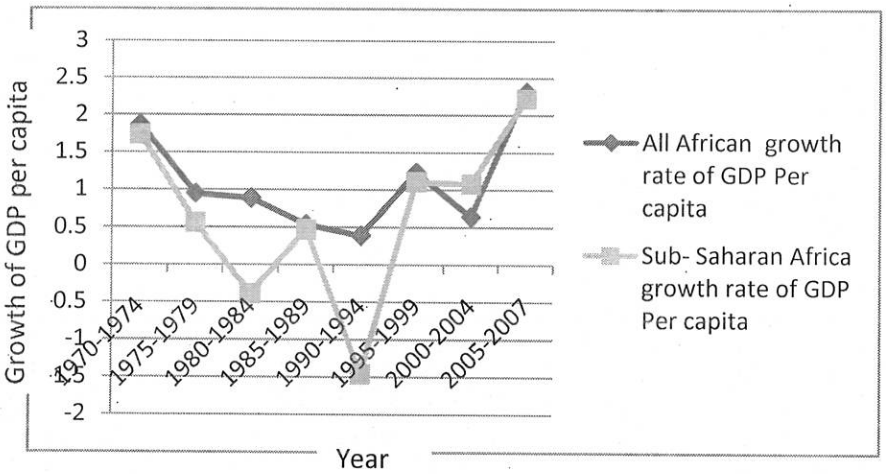


Figure 4.2 trends in growth rates of GDP per capita in the whole Africa and SSA(1970-2007)



When we see the trends in health conditions measured by life expectancy at birth (LEB) and infant mortality rate (IMR), our data presented in table 4.2 shows that there is improvements in health conditions of Africa. If we see this improvement by considering the increment in life expectancy at birth, the rate was found to be slower as compared to the rate of reduction in infant mortality. This is because a 1 year rise in the average life expectancy constitutes large improvements in the general health condition than what is implied by a unit reduction in infant mortality rate. Over the last 40 years, the life expectancy of SSA was increased by about 6 years (45.1 to 51.6 years) which is a bit higher than what Europeans could achieve over the same period. Over this period Europeans LEB has increased from 70.8 to 75.1 years. This supports the argument that gains on health investment is higher in LDCs than in developed ones. However, there is a remarkable difference in the level of achieved life expectancy between the two worlds as we show in figure 4.3 below.

As we can see in table 4.2 above and figure 4.4 below, remarkable achievements have been made in reducing infant mortality rates in SSA. The large progresses that have been made in the quality and coverage of vaccinations, especially after 1950s, which is mainly initiated and sponsored by UNICEF, may be one reason for this remarkable achievement. In order to show the improvements in health across time, we considered the UN health data from 1950 on and draw below. In showing the trend of LEB we also put the European case together for comparison purpose.

Figure 4.3: Trend of life expectancy at birth in different regions (1950-2007)

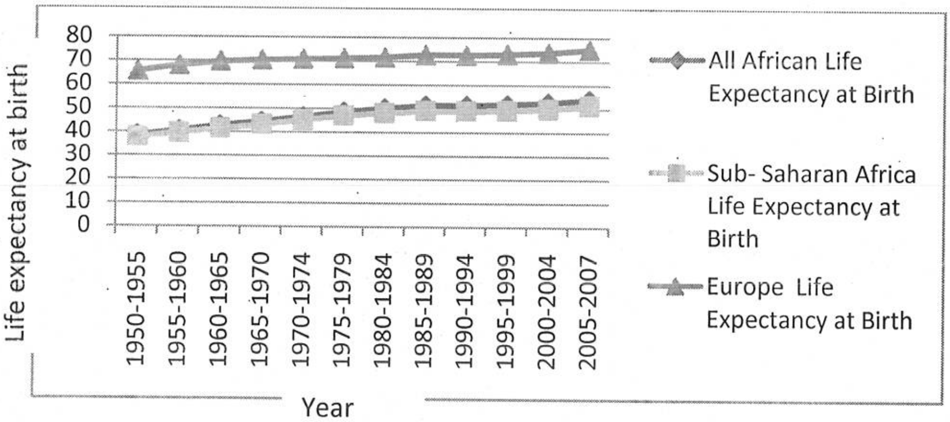
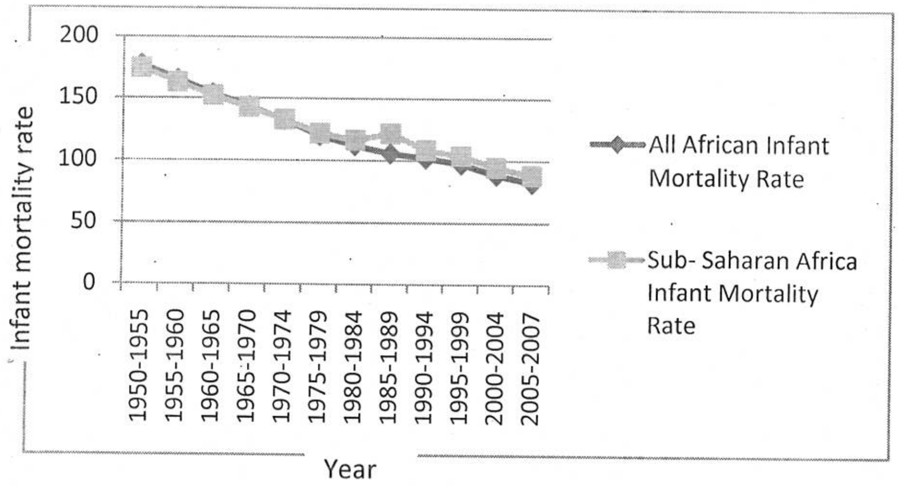


Figure 4.4: Trends of infant mortality rate in whole and Sub-Saharan Africa (1950-2007)

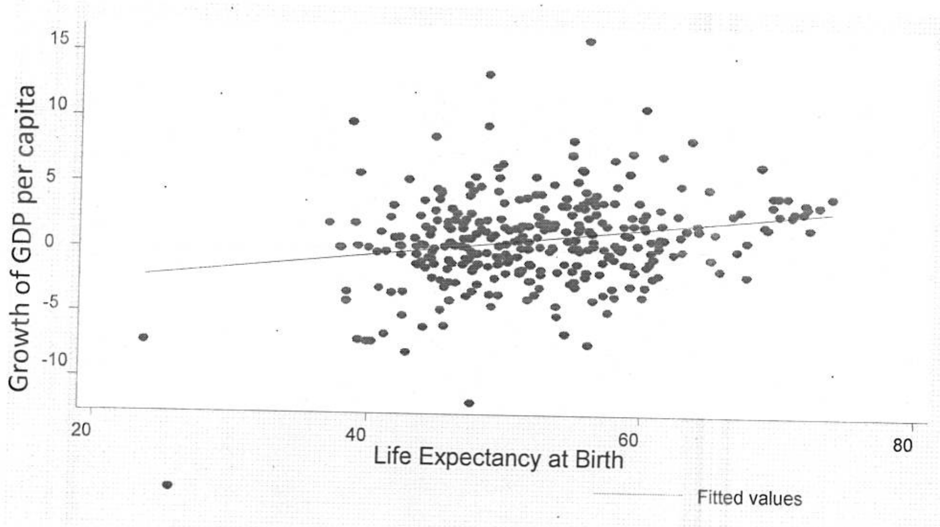


As it can be seen in figure 4.3 above there is a huge variation in the level of LEB between Africa and Europe which might have contributed to the existing economic differences between the two.

4.1.4. A Simple Correlation between Health and Economic Conditions

Before addressing the problem at hand by using econometric model, it is worthy to start with the simple correlation between our variable of interest, health, and economic conditions. We computed the pair-wise correlation matrix which is presented in appendix C and plotted different measures of health to see the simple correlation between the two. Whereas both real GDP per capita at level and its growth rate are considered to represent economic status, life expectancy at birth, infant and under five mortality rates are also selected to be proxies for health conditions. This can also be supported by the graph plotted below in which growth rate is represented in the vertical axis while LEB is the in the horizontal one.

Figure 4.5: the relationship between growth and life expectancy at birth



On the other hand, as it can be seen from the correlation matrix presented in Appendix C, both level of GDP per capita and growth rate of GDP per capita are negatively correlated with health status measured by life expectancy at birth whose correlation coefficients were calculated to be about 0.62 and 0.27 respectively. When we consider either infant mortality rate or under five mortality rate as a proxy for health, a negative correlation between the two was documented. For example, if we look at the correlation coefficient between infant and under-five mortality rates and growth rate it was found to be about -0.24 and -0.21, respectively. The same correlation can be obtained when per capita GDP at level is considered instead of its growth rate. This negative correlation between the two entails that the ability to reduce infant or under-five mortality rates will be end up by promoting growth or vice versa. Here again, we plotted the infant mortality rate against the growth of GDP per capita in order to see the association between the two in a clearest way (see figure 4.6 below). The plot in figure 4.6 also confirms the correlation obtained above.

Figure 4.6: Association between economic growth and infant mortality rate

In addition to these, we plotted other measure of health status, under-five mortality rate, and the above considered health proxies against the GDP per capita at level in Appendix E to see the association between them graphically.

Similarly, we tried to see the association between economic conditions and education human capital measured both at level and rate of accumulation. The average years of schooling for population aged 15 and above, as a measure of education capital stock, and secondary school enrolment and expenditure on education, as a measure of rate of education capital accumulation, are positively correlated with economic growth as it can be seen in correlation matrix of appendix C and graphical representation of the their associations in appendix E.

Even if this simple positive correlations give some clue about the solution towards the problem at hand, it neither inform the direction of causation nor assures whether this relationship can be maintained when other variables are considered simultaneously. Thus, we should analyze it by employing a more reliable and advanced econometric technique which is presents in the next subsequent sections.

4.2 ECONOMETRIC ANALYSIS

4.2.1. Introduction

In the previous part of the chapter we made some descriptive analysis to understand the nature of our data as well as to see the simple correlation between economic status and health conditions. In that simple analysis we showed that all measures of health are positively correlated with per capita GDP. However, simple visual correlation is not sufficient to show any causal link between the two and the sign of that simple correlation may not be maintained when others regressors are taken into consideration. Hence, econometric analysis can takes care of all this problems and give us the right information to build a right relationship between our variable of interest, health human capital stock, and economic status.

In order to address the problem at hand in a more reliable and conclusive way, we estimate two growth equations, Eq.(13') and (14'). As we tried to describe in the previous chapter, these two equations differ only in the nature of education variable considered in the regression. In Eq.(13') like health, education variable was modeled at level (as a stock variable) and proxied by the average years of schooling of Barro-Lee educational attainment data. Where as in Eq.(14') education variable was considered as a rate of accumulation- flow variable- which was proxied by either secondary school enrolment or investment(or expenditure) on education as a percentage of Gross National Income(GNI).

The econometric analysis of this chapter is organized in to two main parts associated with the two main equations, Eq. (13') and (14') to be estimated. The first part is for estimation of Eq. (13') where health and education variables are at level where as the second part is the case where health is measured at level but education is at rates of accumulation. In each of these parts, we considered four candidate estimators: the pooled OLS, the Within Group, the DIFF-GMM and the SYS-GMM estimators. The first three are for comparison purpose while the last estimator is our preferred estimating technique which corrects the problems associated with other estimators.

4.2.2. Measuring Health and Education at Level (as Stock variables)

In this part of the analysis, we estimate equation (13') by different estimating techniques. Our estimating process is started with pooled OLS and by further improvements it will be end up with system GMM estimator. In all of our estimating techniques of this part data for economic variables were taken from PWT v.6.3. Unlike in the next section, in this part, we are not able to present alternative results using WDI data since only few countries with full income and such education data are available. We considered the time period from 1960 to 2000 from which 9 five -yearly panel data points were generated for each country. Even if full economic data for most of SSA countries are available from this source, the average years of schooling data for many of these countries are missing from Barro-Lee data set. Thus, we were able to take only 23 sample SSA countries with all the necessary data for the whole period from which 197 observations were generated. In each of our models, the dependent variable is the log differences of GDP per capita over each five year span, that is nothing but the of growth rate of GDP per capita. All our models are estimated with time dummies, which are not reported to save space, and the reported standard errors are heteroskedastic robust.

4.2.2.1. The Pooled OLS estimator

Here, as a first attempt towards the solution of the problem, Eq. (13') was estimated by pooled OLS using the PWT dataset. We don't directly estimate the full model specified in Eq. (13') since we are interested to start with the original Solow model and step by step improve the model and reach at our final and full specification. As it can be seen from table 4.3, the result is summarized in to two panels. The first panel (above part) of the table is the estimates of the unrestricted model while the second panel is the estimates for the restricted version of different models. The five columns (exclude the variable name column when the number of columns are counted or referred) in each panel show five different models/specifications in which the first three are the nested models of Eq.(13') while the rest are the full ones. Now, let us discuss the results of these models column by column.

For both unrestricted and restricted version of estimates, the first regression of table 4.3 does represent estimates from the original Solow model in which neither education nor health human capital is included. This is the first version of Solow model in which the initial condition, population growth and saving rates are assumed to affect growth but estimated with convergence parameter. In this case, output in the Cobb- Douglass production function of our type is expressed as a function of only labor and physical capital. The estimating equation of the original Solow model can be obtained by setting both β and ψ equal to zero in equation (13').

The second column of the table is the MRW model in which the original Solow model is augmented by including education human capital. This is the type of augmented Solow model that most growth economist including Mankiw *et al* (1992) and Islam (1995) used in their empirical analysis. In the third column, we use the same model as the second one but here education human capital is replaced by health human capital proxied by life expectancy at birth. The estimating equations of the second and the third model can be obtained by setting $\psi=0$ and $\beta=0$, respectively, in Eq.(13'). The fourth and the fifth models presented in column four and five are the full model as specified in Eq. (13'). The only difference between the two is that in the fourth regression life expectancy at birth was used as a proxy for health capital stock while infant mortality rate was used for the fifth. Here, one should understand that both life expectancy and infant mortality rate are measures of stock of health status. We estimate the same equation for different proxies of health conditions to see whether results are sensitive for different proxies of the variable of interest.

In order to be able to calculate the structural parameters, such as α, β and ψ, we impose a restriction that the coefficients of saving rate and population growth (augmented with common exogenous factor amounting 0.05) are the same in magnitude but different in sign. In other words, the two coefficients in the regression sums zero, thus, we can call it the adding up restriction and we test the validity of this restriction by using Wald test throughout the whole analyses. These restricted estimates of pooled OLS of the model considered are presented in the second panel (lower part) of table 4.3 corresponding to each unrestricted estimates.

As it can be seen from table 4.3, the original Solow as well as other augmented models revealed a negative coefficient for the initial condition and the augmented models coefficients are also statistically significant at 1% significant level. The negative sign of the initial condition of income supports the existence of conditional convergence which states countries with low initial income grows faster than countries with higher initial income. The annual convergence rate implied by λ was calculated from the coefficients of initial conditions, that is, from the relation $\phi = 1 - e^{-\lambda\tau}$ for both restricted and unrestricted estimates[5]. The convergence parameter calculated from the restricted model is similar to the unrestricted ones in all versions of the model. The convergence rate was found to be low for nested models while it is high and near to the theoretical prediction, i.e, 2% per annum, for the full ones.

On the other hand, the elasticity of saving in all models for both restricted and unrestricted versions of estimates was found to be positive and significant at 1%. For instance, in the unrestricted estimates of the original Solow model of regression 1 and the full model presented in regression 1 of table 4.3 show that, other things are remaining constant, a 1% increment in saving rate, on average, leads to about 0.17% and 0.13% increment in annual growth of GDP per capita, respectively. This positive and significant relationship between saving and economic growth is in line with the theoretical prediction of the model. Before estimating the model in a restricted way, we undertake a Wald test for the adding up restriction. As the reported p-values of this test shows, we fail to reject the null hypotheses that the adding up restriction holds true.

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[5] Note that the value of τ in all of our estimates is equal to 5.

Table 4.3 Pooled OLS Results of PWT data when both education and health are measured at level(Eq.13')

Regression	(1)	(2)	(3)	(4)	(5)
Unrestricted					
$Ln(y_{it-1})$	-0.0216	-0.0235	-0.0590***	-0.0591***	-0.0854***
	(-1.40)	(-1.39)	(-2.64)	(-2.67)	(-3.13)
$Ln(s^K)$	0.1681***	0.1658***	0.1157***	0.1157***	0.1277***
	(3.74)	(3.68)	(2.64)	(2.68)	(3.23)
$Ln(n+g+\delta)$	0.0806	0.0757	0.0972	0.0971	0.1053
	(0.42)	(0.39)	(0.55)	(0.52)	(0.53)
$Ln(s^E)$	-	0.0048	-	0.0001	- 0.0400
		(0.25)		(0.01)	(-1.50)
$Ln (h^*)$	-	-	**0.1075****	**0.1075****	**0.1968*****
			(2.34)	**(2.21)**	**(-3.12)**
Constant	-0 .4186	-0.3933***	0.1326	0.3154	0.8803*
	(-1.02)	(-0.90)	(0.37)	(0.87)	(1.74)
Adjusted R^2	0.1790	0.1733	0.2055	0.2055	0.2309
Wald	0.1811	0.2109	0.2142	0.2358	0.2099
Implied λ	-0.0044	-0.0048	-0.0121	-0.0122	-0.0178
Restricted					
$Ln(y_{it-1})$	-0.0289*	-0.0341*	-0.0664***	-0.0683***	-0.0944***
	(-1.77)	(-1.90)	(-2.61)	(-2.69)	(-3.20)
$Ln(s^K) - Ln(n+g+\delta)$	0.1486***	0.1436***	0.0989**	0.0980**	0.1088**
	(3.03)	(2.92)	(2.06)	(2.06)	(2.52)
$Ln(e^*)$	-	0.0145	-	0.0076	- 0.0310
		(0.81)		(0.37)	(-1.28)
$Ln (h^*)$	-	-	**0.1109****	**0.1084****	**-0.1943*****
			(2.24)	**(2.11)**	**(-3.07)**
Constant	0.1448	0.1719	0.8221**	0.8265**	1.4227***
	(1.20)	(1.37)	(2.35)	(2.37)	(2.88)
Adjusted R^2	0.1605	0.1628	0.1925	0.1931	0.2160
Implied λ	- 0.0058	-0.007	-0.0137	-0.0142	-0.0198
Implied α	0.84	0.81	0.60	0.59	0.54
Implied β	-	0.08		0.05	-0.17
Implied ψ	-	-	0.67	0.65	0.95

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values.

Again, in the restricted estimates of all models, saving was significant and with expected sign. For example, considering the full model in which health is proxied by IMR, i.e regression 5, citrus paribus, a 1 % rise in saving rate leads to a near to 0.11% increment in growth. We impose such adding up restrictions in order to calculate the structural parameters from the resulting elasticities. The share of physical capital, implied by α, was as high as 84% in original Solow model regardless of the model prediction to be near to 33%. However, augmenting this model by including education and health human capital makes α fall to 54%.

As far as the population and economic growth rates are concerned, the theory predicts a negative relationship between the two. However, the unrestricted estimates of our models failed to support this argument since population growth rate was found to have positive but statistically insignificant coefficients. The positive coefficient for population growth is not uncommon in growth accounting of especially LDCs like African[6]. But, in the restricted estimates of our models, population growth rate was with the right sign, like the prediction of the theoretical model, and also statistically significant.

In the second column of table 4.3, we augment the original Solow model by including education human capital proxied by average years of schooling for the population aged 15 and above. Unfortunately, in both restricted and unrestricted models, the elasticity of education human capital was not statistically different from zero as it is implied by the individual test of significance. As a result of its negligible effect, this augmented model was not found to better perform as compared to the original Solow model which can be judged from the insignificant difference of $\overline{R}^2$, convergence rates, λ , as well as implied values of structural parameter, α,

[6] Authors who got positive coefficient for population growth in at least their LDCs sample of growth regression include: Ding and knight (2008, pp 36 table 6.2), Knowles and Owen (1995, pp 103, table 1) McDonald and Roberts (2004, pp22, table 2), among others.

between the two models. If education were significantly entered to the regression of the augmented model, the adjusted R^2 and the convergence rate would be higher while the share of physical capital, α, gets lower. Not only in the second regression where only education human capital is included but also in full models of regression (4) and (5) where health human capital is also coupled with it, education human capital was found to be insignificant, sometimes with negative coefficient. Similarly, the implied share of education capital, β, was found to be low or negative[7].

Now, let us discuss the estimates of our variable of interest, health. As it has been shown in table 4.3, the MRW model was further augmented and estimated by including health. In the third regression, health condition proxied by life expectancy at birth was used to augment the original Solow model and in which education was excluded. In that particular estimation, health was found to affect economic growth positively and also significant at 5%. Estimated elasticity of health entails that, other things are held constant, a 1% fall in the short fall of life expectancy makes growth rise, on average, by about 0.11%. In this case, the output share of health capital stock, implied by ψ, was found to be about 67% which is a bit higher than that of the physical capital's share, which was calculated to be about 60%. Now, we can compare regression (2) where only education was considered as human capital variable and regression (3) where only health was considered to know the relative importance or significance of these two human capital components: education and health. As we discussed above, the negligible differences between results of regression (1) and (2) on a number of grounds proves the less importance of education to explain growth. Similarly, if we compare the results of regression(1) and (3), we can see that the inclusion of health capital stock in to the original Solow model, increases the adjusted R^2 and

[7] Attempt has been made to interpret this negligible or negative contribution of education after it was proved to be the same in our preferred estimating technique.

the speed of convergence and decreases the share of physical capital by a larger magnitude than education does in regression two. All these situations show that health capital is more important than education capital to explain growth.

Regression (4) and (5) are our full models in which both education and health are included simultaneously. The effect of health condition, proxied by LEB and IMR, was found to be positive and significant at 5% and 1% significant level, respectively. This significant effect of health is maintained in both restricted and unrestricted version of our estimates. The estimated elasticities of these regression (4) and (5) suggests that, other things are remaining constant, a 1% fall in the short fall of life expectancy and infant mortality can increase economic growth by about 0.11% and 0.20%, respectively. In the case where LEB is used as a proxy for health in regression (4) the implied shares of physical capital, education human capital and health human capital 59%, 5% and 65%, respectively. But in regression (5) even if the physical capital share (α=54%) seems relatively reasonable, the negative elasticity, and thus share, of education which is out of the prediction of theoretical model makes the estimate of health human capital share, ψ, implausibly high. Because, the implied value of ψ dependents upon the values of α, β, ϕ and the health elasticity of growth, and hence, any implausible estimates of these parameters will be end up by estimating implausible share of health human capital.

Regardless of the rough approximation it renders, we cannot take these OLS results serious. Because as we already discussed in chapter three the existence of lagged dependent variable and the fixed effect, μ_i, coupled with the potential endogeneity of other regressors of the model renders the OLS estimates inconsistent and biased upward. In addition, OLS estimates yield slower speed of convergence rates since the lagged dependent variable, from which λ is calculated, is biased upward. Thus, we need to estimate our model by a better estimating technique to address the issue in a more appropriate way. The subsequent sections are devoted to improve these estimating issues.

4.2.2.2. The within Group (WG) Estimator

In the previous section, attempt was made to address the problem by using pooled OLS estimating technique. However, for reasons discussed above, the OLS estimates are biased and inconsistent. Added to this, the pooled OLS estimator doesn't utilize the panel variation and thus cannot realize the advantage of panel data. On the top of the pooled OLS, however, the fixed effect or within group (WG) estimator better gains the advantages of panel data since it relies on the within variation. Further, the within groups estimator eliminates the country specific effect, μ_i, which was one source of inconsistency in OLS estimator, by transforming the equation.

The within group estimates of equation (13') and its nested models are presented in table 4.4. The representation of the five columns and the two panels (upper and lower part) of the table is similar to table 4.3 that has been discussed in a detailed way. That is, the table summarizes the estimates of both restricted and unrestricted versions of five different models starting from the original Solow model. Like that of the OLS estimation, here again we imposed the adding-up restriction to re-estimate each model in a restricted way to be able to calculate the structural parameters. The restriction assumption itself was tested by using Wald test whose p-values are reported in the table.

As one can see from table 4.4, like that of the OLS one, the expected negative sign and significant coefficients of the initial income in all models support the conditional convergence hypothesis. However, the within-groups estimate is biased downwards in our short panel and associated with a higher convergence rate, sometimes about 6 percent per annum (see the last column of table 4.4, for instance). It is also observed that even though most of the adding up restrictions are rejected at 5% but not at 10% level of significance, the speed of convergence parameter, λ, remains comparable between the restricted and the unrestricted estimates.

Similar to the OLS estimates, saving rate in WG estimator was also found to have a positive and significant effect on economic growth in both restricted and unrestricted models of all type. But, the effect of population on economic growth is still insignificant and with wrong sign in unrestricted models though this situation was reversed in the restricted ones.

As we can see in the restricted estimates of all models in table 4.4 population growth is with expected negative sign and also statistically significant. For instance, the estimate of the fourth and full model where health is proxied by LEB shows that a 1% increment in population growth deters the economic growth by about 0.18%.

The puzzle for negative coefficient, though statistically insignificant, for education is still persisting after controlling for the heterogeneity of countries. This is true in all of the five specifications of both restricted and unrestricted estimates. Again here, the negligible contribution of education can further be proved by looking at the negligible differences in the performance of the original Solow model (regression 1) and the augmented model of MRW type (regression 2).

Table 4.4. The WG Results of PWT data when both education and health are measured at level.

Regression	(1)	(2)	(3)	(4)	(5)
		Unrestricted			
$Ln(y_{it-1})$	-0.1386***	-0.1540***	-0.1845***	-0.1844***	-0.2446***
	(-3.46)	(-3.69)	(-4.33)	(-4.29)	(-4.8)
$Ln(s^K)$	0.2485***	0.2301***	0.2385***	0.2385***	0.2251***
	(4.39)	(3.64)	(3.89)	(3.89)	(4.06)
$Ln(n+g+\delta)$	0.2446	0.1549	0.0813	0.0828	0.288
	(1.15)	(0.72)	(0.45)	(0.46)	(1.45)
$Ln(e^*)$	-	-0.0315	-	-0.0223	- 0.0691
		(-0.75)		(-0.55)	(-1.72)
$Ln(h^*)$	-	-	**0.1671****	**0.1641****	**-0.3799*****
			(2.00)	**(2.02)**	**(-4.08)**
Constant	-0 .1147	0.2030	1.0363**	1.0631	2.4145***
	(-0.76)	(0.36)	(2.03)	(2.03)	(3.62)
Adjusted R^2	0.2720	0.2439	0.2680	0.2691	0.3400
Wald	0.0209	0.0638	0.0747	0.0751	0.0099
Implied λ	-0.0298	-0.0334	-0.0408	-0.0408	-0.0561
Restricted					
$Ln(y_{i-1})$	-0.1624***	-0.1630***	-0.1973***	-0.1979***	-0.2519***
	(-3.56)	(-3.64)	(-4.28)	(-4.17)	(-4.57)
$Ln(s^K)$ - $Ln(n+g+\delta)$	0.1774**	0.1667**	0.1883**	0.1832***	0.1524**
	(2.53)	(2.23)	(3.03)	(2.72)	(2.52)
$Ln(e^*)$	-	- 0.0439	-	-0.0299	- 0.0727
		(-0.90)		(-0.70)	(-1.71)
$Ln(h^*)$	-	-	**0.2026***	**0.1993***	**-0.3465*****
			(1.95)	**(1.97)**	**(-3.69)**
Constant	1.0642***	1.1198***	1.9375***	1.9618	3.412***
	(3.13)	(3.25)	(3.61)	(3.49)	(4.51)
Adjusted R^2	0.2014	0.2058	0.2462	0.2448	0.2757
Implied λ	- 0.0354	-0.0356	-0.0439	-0.0446	-0.0580
Implied α	0.52	0.51	0.49	0.48	0.46
Implied β	-	-0.13	-	-0.08	-0.22
Implied ψ	-	-	0.53	0.52	-

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values.

Our variable of interest, health, keeps entering significantly to the growth regression whatever specification we follow and whichever proxies for health is being used. This positive and significant contribution of health to growth is maintained for both restricted and unrestricted estimates of our models. In addition, by comparing regression (2) and (3), it can be concluded that augmenting the original Solow model by adding health human capital performs better than a model augmented by adding education human capital. Due to the insignificance of education in our growth regression, there is no much differences between results obtained from regression (3) and (4) where only health and both health & education were considered, respectively. For example, the elasticity of LEB in these two specifications was 0.1671 and 0.1641 while adjusted R^2 was 0.2680 and 0.2691, respectively. The closeness of these two estimates in the above measures support the above argument. Elasticities of health conditions can be interpreted in the same way as we did for OLS estimates. For instance, the elasticity of IMR in the restricted estimates of model (5) reveals that, other things are remaining as they are, a 1% decline in infant mortality rate induces a 0.35% of economic growth.

By imposing the adding up restrictions we were able to calculate the structural parameter of the WG estimates as well. As it can be seen in lower parts of table 4.4, the share of physical capital, α, in original Solow model was found to be about 52% which is significantly lower, and also better, than its OLS counterpart[8]. The inclusion of human capital components reduced the share of physical capital to 46% (for example in the fifth regression). The direction of change in α is in line with the prediction of the theoretical model even though the magnitude of reduction is not that much significant. Following the sign for estimates of its elasticities, the output share of education human capital, β, was not found to be positive in all the three models where education

[8] This may be because WG estimator is better than OLS at least in eliminating the country specific fixed effects.

is included. Finally, the share of health capital stock, ψ, in the third and fourth regression, amounting 53% and 52%, respectively, seems relatively reasonable. However, in the fifth regression since the value of β is a big negative number (i.e. -22%) and, thus highly severe, the resulting estimates of ψ was implausibly high[9].

So far, by applying the WG estimates we got better results than its OLS counterparts. Regardless of the elimination of fixed effects in the WG estimating techniques, however, all the sources of bias, including the dynamic panel bias, are not yet solved and this makes the WG estimates downward biased. These situations call for a more appropriate method that can avoid all the sources of bias and inconsistency and generate more reliable parameter estimates. The system GMM estimator, which is presented in the next section, is our preferred estimator since it solves all these econometric problems.

4.2.2.3. The DIFF-GMM AND SYS-GMM Estimators

The OLS and WG estimates of the previous sections are merely for comparison purpose since the pre-estimating econometric issues are hardly fulfilled in these techniques. A first and good attempt that could be able to solve all the previously discussed biases and inconsistencies, via differencing the equation and also generating internal instruments for problematic regressors, is the difference GMM (DIFF-GMM). Here, the differenced endogenous variables are instrumented with the lag levels of the corresponding variable. Even if this estimator eliminates the fixed effect and dynamic panel biases, it is criticized for the weak linkage between the instrumented

[9] Such implausibly high estimates of health capital share are left out in the reported tables since they do not make sense.

regressors and the internally generated instruments. As a result of it, our preferred estimator is not DIFF-GMM rather the SYS-GMM that fills the gap of DIFF-GMM.

In this part of analysis, we presented results estimated by DIFF-GMM and SYS-GMM techniques in which the first is again for comparison purpose. Unlike in the previous sections, in this section, the original Solow model and the MRW type model, in which health capital is neglected, are not presented to save space and to concentrate on our variable of interest. Instead, for both DIFF and SYS-GMM, each of the two proxies of health conditions, LEB and IMR, are used twice to estimate equation (13'). One is without considering education capital and the other is with education. As it is implied in its headings, the first four of the eight columns of table 4.5 are results of the DIFF-GMM of which the first two (regression (1) and (2)) used LEB to proxy health capital while in the other two (regression (3) and (4)) IMR was used. The same classification was applied for last four columns of the table headed as SYS-GMM.

In table 4.5, the DIFF-GMM and SYS-GMM results of the unrestricted estimates of elasticities and the resulting structural parameters, calculated by imposing the adding up restriction, are presented. The corresponding restricted estimates are also presented in appendix D1. Both the reported difference and system estimates are of two step and robust which are estimated with time dummies. The instruments used are also reported with the restricted results in appendix D1.

Like that of the OLS and WG estimates, in both DIFF-GMM and SYS-GMM results depicted in table 4.5 also show that the initial condition in almost all models took the expected negative sign, in both restricted and unrestricted models, which again supports the existence of conditional convergence. Taking the restricted model estimate of the initials condition in to consideration, the implied value of the speed of convergence, λ, was found to be quite high for

DIFF-GMM estimates as compared to the SYS-GMM estimates. In our preferred estimating technique, SYS-GMM, the estimates of the speed convergence was very similar to the theoretical prediction of the model in all specifications except the third. The first regression reveals λ to be exactly 2% while the second and fourth regression of the system estimator predicts it to be around 3% per annum. This is comfortably between what was predicted by OLS and WG estimators.

As it has been discussed so far, the OLS estimate of the lagged dependent variable was biased upward since this lagged dependent variable is positively correlated with the error term and this leads to a low estimate of λ or slower speed of convergence rate. On the other hand, the WG estimate of the same variable was biased downward and as a result the estimated value of λ was high. Therefore, a good candidate estimate of the lagged dependent variable and the resulting speed of convergence parameter are expected to lie between the OLS and WG estimates of that variable or at least it should be near to these boundaries. That is what happened here for our preferred estimates of the restricted model (see appendix D1) especially when health is proxied by LEB.

In line with the theoretical prediction as well as the previous estimation, for both restricted and unrestricted models, the DIFF-GMM and the SYS-GMM estimators reveal that the effect of saving on growth was proved to be again positive. Most of the unrestricted estimates of saving were found to be statistically significant while the restricted ones were not. The interpretation of the elasticity of saving is the same as we did for OLS and WG estimates. The other neo-classical growth determinant, population growth, is still with the unexpected and positive signs for unrestricted models. In the restricted estimates this sign turns to be negative as expected but statistically insignificant.

One important improvement of the result of GMM estimators relative to the previous estimates of OLS and WG techniques is that the elasticity of education human capital. Unlike in the above two estimators, in all SYS-GMM estimates of both restricted and unrestricted model the coefficient or elasticity of education capital was with the expected positive sign. Regardless of this improvement/or change, education elasticity is still statistically indistinguishable from zero and its resulting output share is still negligible. Unlike in the previous cases, in DIFF-GMM and SYS-GMM the inclusion of education capital into the regression significantly affects the estimates of health elasticities and thus we may rely on the full model.

When we see the estimates of elasticities of health conditions, in the unrestricted system estimator, all are with their expected signs and the full model associated with LEB and the nested one related to IMR were also found to be statistically significant. For instance, taking the full models of system estimator in to consideration, a 1% reduction in the short fall of life expectancy and infant mortality rate ends up by stimulating growth by about 0.22% and 0.32% respectively. This again supports the argument that 'health is wealth'

Although most of them do not hold at 5% level of significance, we imposed the adding up restriction to calculate the implied structural parameters. As it can be seen in table 4.5, the difference GMM estimator yields the share of physical capital very close to the theoretical prediction of the model(α=23% to 28%). Whereas, in system GMM, this share was found to be a bit higher that 40% except in the first regression. Similarly, following the superiority of the GMM estimator, specifically the SYS-GMM, the output share of education turned to be positive, amounting 5%-22%, but its magnitude is still less considerable as compared to the shares of physical and health human capitals.

Table 4.5. DIFF-GMM and SYS-GMM Results of PWT data when both education and health are measured at level

	DIFF- GMM				SYS-GMM			
Health's proxy	LEB		IMR		LEB		IMR	
Regression	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Unrestricted				Unrestricted			
$Ln(y_{it-1})$	-0.1131	-0.4079	-0.2398	-0.5343	0.1226	-0.4056	-0.2908*	-0.2819
	(-0.38)	(-1.06)	(-0.83)	(-0.93)	(0.12)	(-1.45)	(-1.75)	(-1.31)
$Ln(s^K)$	0.3281*	0.1538	0.5263**	0.5630	0.3343**	0.2679	0.2255*	0.3672**
	(0.91)	(0.40)	(2.29)	(1.30)	(2.49)	(1.08)	(1.95)	(2.20)
$Ln(n+g+\delta)$	1.2738**	-0.0287	0.8467	0.0172	1.0453**	0.0324	0.5867	0.3364
	(2.31)	(-0.04)	(1.58)	(0.02)	(2.20)	(0.05)	(1.54)	(0.81)
Ln(e*)	-	-0.0163	-	0.0125	-	0.0429	-	0.0484
		(-0.07)	-	(0.04)		(0.26)		(0.39)
$Ln(h^*)$	**0.1101**	**-0.0184**	**-0.4867**	**-0.6507**	**0.0444**	**0.2277***	**-0.5354***	**-0.3267**
	(0.51)	**(-0.84)**	**(-1.34)**	**(-1.63)**	**(0.65)**	**(1.92)**	**(-1.97)**	**(-1.28)**
m1	0.045	0.322	0.025	0.267	0.008	0.110	0.020	0.013
m2	0.238	0.684	0.215	0.847	0.231	0.816	0.214	0.413
Han. Test	0.251	0.898	0.424	0.776	0.676	0.954	0.707	0.843
Diff. Han	-	-	-	-	1.000	0.629	1.000	0.686
Wald	0.0257	0.9027	0.0135	0.6055	0.0057	0.7081	0.0637	0.0761
Implied λ (unrest.)	-0.024	-0.1048	-0.0548	-0.1528	-0.0025	-0.1040	0.0687	- 0.066
Implied λ(rest.)	-0.2160	0.088	-0.218	-0.1776	-0.020	- 0.032	-0.076	-0.061
Implied α	0.51	0.23	0.34	0.28	0.65	0.44	0.40	0.52
Implied β	-	-0.003	-	0.012	-	0.05	-	0.22
Implied ψ	0.48	0.86	0.94	0.70	0.39	0.24	-	0.31

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values. m1 and m2 are the P-values for the first and the second order autocorrelation. Han.Test and Diff.Han are P-values of Hansen and difference in Hansen test. Used instruments reported in appendix D1. Rest. And Unrest. Stands for restricted and unrestricted. Resulting errors and thus the reported t-values are corrected by Windmeijer's finite-sample correction method. All estimates are two-step robust. Equations were estimated using xtabond2 procedure after installing the program in to STATA V.10.

When we look at the share of health capital stock, ψ, it seems a bit exaggerated in the DIFF-GMM, which is more than double of the physical capital share. However, we do not take these estimates seriously since DIFF-GMM estimates are merely presented for comparison purpose owing to its defects discussed so far. This share rather has been estimated more plausibly in our preferred estimator, the SYS-GMM. Surprisingly, the full model estimates of SYS-GMM yield very comparable share for health capital, that is ψ=24%-31%, when both proxies of health (LEB or IMR) are considered[10]. In case of nested model where LEB was used as a proxy for health, the share has raised to 39%. Our finding confirms the previous finding of some authors like McDonald and Roberts (2002) and Knowles and Owen (1995, 1997) in this respect.

Why some parameters lost their significance unusually?

In the reviewed and other literatures of growth regression, it is common to get the estimates of neoclassical growth determinants statistically significant. Likewise, in our OLS and WG estimators presented so far, we have seen that most of these regressors are statistically significant at conventional levels. However, in the GMM estimates of our model presented in table 4.5, most of these growth determinants were less significant, statistically. Here, it is worthwhile to ask why this is so in spite of the sophisticated econometric technique being applied. In our view, the unusual insignificancy of the usual regressors is merely due to the unusual, new but correct estimating method being applied. We said this because it has been already identified that though the two step SYS-GMM estimator is asymptotically more efficient, the reported two step standard errors tend to be severely downward biased (Arellano and Bond (1991), Blundell and Bond (1998), Roodman (2006)).

Regardless of this acknowledgement, the growth specialist who applied two step system GMM used to produce the severely downward biased standard errors of their estimates, since they had neither the theoretical derivation nor the estimating software to tackle this econometric problem. Therefore, it may be such downward biased standard errors, among others, that have contributed

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[10] Other writers' range of estimated value of ψ for their LDCs sub- samples was as follows: McDonald and Roberts(2002,pp 274, table 1) from 16%-42%; Knowles and Owen(1995, pp. 104, table 1 and 1997,pp 322, table 2) 38% and from 41.3% to 47.5%, respectively.

for the statistical significance of the estimated parameters in the previous studies.

However, in the year 2005, windmeijer has derived the theoretical two-step covariance matrix that is corrected for such final sample biases. Then after, Roodman has written the *xtabond2* program[11] (STATA command) that incorporates the Windmeijer's corrected covariance or standard errors and made it possible to the practical applications like ours. Our results reported in table 4.5 has taken the advantage of this new theoretical derivation as well as the estimating software while papers written before 2005, including the proponent of the technique, Bond *et al*(2001) themselves, were old enough to take this advantage and correct the bias. As a result, their conclusion regarding significance of the regressors may be incorrect.

In order to support our argument, we re-estimated the model without taking the Windmeijer's corrected covariance matrix into account, but other things are remaining identical. The result of this new estimate is presented in table 4.6. Now let us comparing table 4.5 and 4.6. As it can be seen in these tables, in both of the cases the estimated elasticities are identical as expected. As we discussed above, the only difference between the two is that the estimates their standard errors and thus the respective t-values reported in parentheses. Estimates of standard errors in table 4.6 are downward biased (small) since they are not corrected for this and as a result the t-value of each parameter was found to be significantly higher than its counterparts of estimates in table 4.5. This can be proved to be true for DIFF-GMM and SYS-GMM and/ or restricted models and unrestricted models. Referring the restricted estimates of table 4.5, one can that almost all coefficients of initial income, saving and health conditions are significant either at 1% or 5% significant level. This was not the case in our robust estimate of table 4.5. But, in our data, the reason for insignificance of education is not of methodology rather it is some other issues which will be discuss later. Therefore, for the rest of our variables in our data, we can say that the difference in the estimating technique makes the difference in significance of regressors between this estimate and the previous ones.

[11] Xtabond2 is not an official STATA command rather Roodman's own program but the ado file can be installed to make use of this command in STATA.

Table 4.6. Standard Error uncorrected DIFF-GMM and SYS-GMM Results of PWT data when both education and health are measured at level

	DIFF- GMM				SYS-GMM			
Health's proxy	LEB		IMR		LEB		IMR	
Regression	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Unrestricted								
$Ln(y_{it-1})$	-0.1131	-0.4079*	-0.2398*	-0.5343	0.1226	-0.4056*	-0.2908*	-0.2819**
	(-1.04)	(-1.79)	(-1.87)	(-1.63)	(0.14)	(-2.07)	(-1.91)	(-2.32)
$Ln(s^K)$	0.3281**	0.1538	0.5263***	0.5630*	0.3343***	0.2679	0.2258**	0.3672***
	(2.54)	(0.73)	(3.10)	(1.97)	(3.63)	(1.69)	(2.73)	(3.84)
$Ln(n+g+\delta)$	1.2738***	-0.0287	0.8467***	0.0172	1.0453**	0.0324	0.5867*	0.3364
	(8.14)	(-0.08)	(3.67)	(0.04)	(3.44)	(0.08)	(1.73)	(1.38)
$Ln(e^*)$	-	-0.0163	-	0.0125	-	0.0429	-	0.0484
		(-0.14)	-	(0.09)		(0.37)		(0.63)
$Ln(h^*)$	0.1101	-0.0184	-0.4867**	-0.6507***	0.0444	0.2277***	-0.5354*	-0.3267**
	(1.28)	(-0.21)	(-2.56)	(-3.57)	(1.05)	(2.89)	(-2.50)	(-2.15)
Restricted								
$Ln(y_{i0})$	-0.6609***	-0.3544***	-0.6635***	-0.5885***	-0.0957	-0.1465	-0.3176***	-0.2643***
	(-9.11)	(-3.07)	(-8.19)	(-7.28)	(-1.89)	(-1.59)	(-4.76)	(-5.67)
$Ln(s^K) - Ln(n+g+\delta)$	- 0.1189	0.1070	0.3358***	0.2341**	0.2246	0.3163**	0.2118***	0.3085***
	(-1.35)	(1.10)	(3.41)	(2.09)	(4.18)	(2.52)	(3.21)	(3.55)
$Ln(e^*)$	-	0.0012	-	0.0098	-	0.0371	-	0.1321
		(0.01)	-	(0.16)		(0.48)		(1.49)
$Ln(h^*)$	0.3943***	0.0545	-0.9357***	-0.5740***	0.1399***	0.1703**	0.5448***	-0.2065
	(19.02)	(0.67)	(-8.36)	(-3.93)	(3.51	(2.78)	(-3.66)	(-1.46)

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values. Tests and related information not reported because it is identical with table 4.3. All estimates are two-step uncorrected errors and t-values reported.

Tests to be considered

In order to ensure the validity of results obtained by our preferred estimator two main tests should be undertaken: the autocorrelation and the over identification tests. Because if there is autocorrelation problem, for example, some lags will be invalid instruments which, in turn, leads to a wrong estimates and conclusions. Arellano and Bond also develop an appropriate test for autocorrelation which we applied to the differenced residuals in order to purge the unobserved and perfectly autocorrelated μ_i. AR (1), reported as m1 in our tables, is expected in first differences because $\Delta v_{it} = v_{it} - v_{it-1}$ should correlate with $\Delta v_{it-1} = v_{it-1} - v_{it-2}$ since they share the v_{it-1} term. So to check for AR(1) in levels, look for AR(2) in differences, reported as m2 in our tables, on the idea that this will detect the relationship between the v_{it-1} in Δv_{it-1} and the v_{it-2} in Δv_{it-2}. For estimate reported in table 4.5, we undertook the Arellano – Bond autocorrelation test. As it can be seen from the p-values of this test, reported as m2 in that table, in all of our estimates we failed to reject that hypotheses that there is no autocorrelation problem. This shows that the instruments used in the estimation process are valid.

A crucial assumption for the validity of GMM is that the instruments are exogenous. If the model is exactly identified, detection of invalid instruments is impossible because even when $E[z\varepsilon] \neq 0$, where ε is the random variable; the estimator will choose the parameter estimator so that $Z'\hat{E} = 0$ exactly[12]. But if the model is over identified a test statistic for the joint validity of the moment conditions (identifying restrictions) falls naturally out of the GMM framework. Under the null of joint validity, the vector of empirical moments $\frac{1}{N} Z'\hat{E} = 0$, N is the number of

[12] Z and $\hat{E}$ denote the instrument matrix and the empirical residuals, respectively.

observations, is randomly distributed around 0 (Roodman, 2006). Therefore, in over identification test we test the null hypotheses that the instruments used in the model are appropriate.

The Surgan or Hansen over identification test can be used to test such hypotheses. For one-step, non-robust estimation, it is appropriate to report the Sargan statistic, which is the minimized value of the one-step GMM criterion function. The Sargan statistic is not robust to heteroskedasticity or autocorrelation. So, for one-step robust estimation (and for all two-step estimation, like ours), the Hansen J statistic, which is the minimized value of the two-step GMM criterion function is robust. Thus, we reported the p- values of Hansen test and difference in Hansen test in table 4.5 and other subsequent results/tables. The former is used to test the validity of overall instruments while the later is important to check the validity of the additional instruments used in level equations. As far as our estimation (table 4.5) is concerned, the reported P- values of both Hansen and difference in Hansen tests show that the instruments used in both differenced and level equations are valid which further proves the robustness of our result.

4.2.3. Measuring Health at Level and Education at Rate of Accumulation

In the last section, attempt was made to address the problem by estimating Eq. (13') in which both health and education human capitals were measured at level (stock variables). In this section, we try to see what if health is considered as a stock variable and measured at level while education human capital is taken as a flow variable and measured at rate of accumulation by estimating Eq. (14'). Note that the measurements and definitions of other regressors as well as the dependent variable used in this section remain the same as before, but here the rate of education capital accumulation is measured by secondary school enrolment.

Data for economic variables were taken from two independent sources-the PWT6.3 and WDI 2008- and we constructed two independent estimating datasets and could be able to present alternative results following our arguments discussed in section 4.2.1. Hereafter, when we say PWT data or WDI data it is to mean that economic and demographic variables are taken from that data source, but education and health variables are from the same source for both cases. In both datasets the period from 1970 to 2007 was considered to form a five-yearly balanced panel data of 8 data points for each country[13]. The number of sample countries taken from PWT and WDI were 34 and 27 from which 272 and 216 observations, respectively, were generated. Here, the number of sample size and observations are by far better than that of the previously used data (section 4.2.2) and because of which the results of this section can be preferred to the previous one.

Like we did in the last case, the model has been estimated four times for each dataset and the four estimating techniques, namely, OLS, WG, DIFF-GMM and SYS-GMM were considered for the same reason discussed so far. All results of all estimators were estimated with time dummies and the reported standard errors are robust.

4.2.3.1. The Pooled OLS estimator

The pooled OLS estimates of Eq. (14') from PWT and WDI datasets are presented in Table 4.7 and Appendix D2, respectively. In both cases, the five columns (regression (2) to (5)) represent the same thing as discussed in section 4.2.2. Here, we concentrate on directly discussing the

[13] We started from this period because school enrolment data are widely available since 1970. And the last period is constructed based on average of three years, not of five as others.

estimated elasticities and structural parameters since all the technical notes we made in the last part is also applicable to this part as well.

As one can see in table 4.7 and appendix D2, the two datasets revealed very comparable results regarding the estimates of the initial income and speed of convergence. In both cases, the initial condition is with the expected negatives sign (which shows conditional convergence) and the resulting speed of convergence was found to be slow as we got in the OLS estimate of the last section where education was measured at level. In all regressions of both datasets, the Wald test shows that the adding up restriction holds and as a result estimates of the unrestricted and restricted models are comparable. If we consider the restricted estimate of λ in the fifth regression, for instance, it is about 0.0069 and 0.0074 in PWT and WDI datasets, respectively.[14]

Although there is some variation in magnitudes, the elasticities of saving and population is similar in the two data sets in terms of the directions and statistical significance. As the theoretical prediction of the model, saving was positively and significantly correlated to growth. Similar to the previous section, the elasticities of population in the unrestricted models are with wrong signs but insignificant. However, this situation is corrected in the restricted estimates. Estimated elasticities of saving were found to be a higher when WDI data was used as compared to their PWT counterparts.

The insignificance and/or wrong sign of education in these pooled estimators of both dataset still persists. This is true for both restricted and unrestricted models. When we look at the elasticities of health conditions, unlike in the last estimates of the last section, here, we got very similar health elasticities whether LEB or IMR is used as a proxy for health capital. This is again true for both restricted and unrestricted estimates (see regression (4) and (5) in both dataset estimates).

[14] In his pooled estimator, Islam (1995, pp. 1151, table V) got λ to be 0.0069 for non-oil subsample, where many SSA countries are grouped and very comparable estimates of it was also obtained by Mankiw *et al(1992).*

Table 4.7.Pooled OLS Results from PWT data when school enrolment is used for education

Regression	(1)	(2)	(3)	(4)	(5)
		Unrestricted			
$Ln(y_{it-1})$	-0.0044	-0.0074	-0.0241*	-0.0243***	-0.0317*
	(-0.45)	(-0.46)	(-1.93)	(-1.41)	(-1.78)
$Ln(s^K)$	0.1212***	0.1199***	0.1047***	0.1046***	0.1027***
	(3.96)	(3.84)	(3.27)	(3.23)	(3.19)
$Ln(n+g+\delta)$	0.0449	0.0437	0.0340	0.0339	0.0685
	(0.40)	(0.39)	(0.33)	(0.33)	(0.61)
$Ln(s^E)$	-	0.0046	-	0.0005	- 0.0083
		(0.25)		(0.03)	(-0.44)
$Ln(h^*)$	-	-	**0.0646****	**0.0645****	**-0.0973*****
			(2.41)	**(2.38)**	**(-2.89)**
Constant	-0 .3513	-0.3656	0.0788	0.0324	0.2833*
	(-1.42)	(-1.44)	(0.35)	(0.14	(1.00)
Adjusted R^2	0.1319	0.1322	0.1516	0.1516	0.1558
Wald	0.1459	0.1429	0.1843	0.1846	0.1488
Implied λ	-0.0009	-0.0015	-0.0049	-0.0049	-0.0064
Restricted					
$Ln(y_{it-1})$	-0.0076	-0.0088	-0.0283**	-0.0270	-0.0344*
	(-0.75)	(-0.54)	(-2.02)	(-1.50)	(-1.87)
$Ln(s^K)$ - $Ln(n+g+\delta)$	0.1001***	0.0994**	0.0860**	0.0866**	0.0828**
	(3.17)	(3.09)	(2.58)	(2.58)	(2.45)
$Ln(s^E)$- $Ln(n+g+\delta)$	-	0.0019	-	- 0.0021	- 0.0111
		(0.10)		(-0.11)	(-0.59)
$Ln(h^*)$	-	-	**0.0702****	**0.0705****	**-0.0989*****
			(2.24)	**(2.30)**	**(-2.89)**
Constant	-0.006	0.0014	0.8221**	0.3663*	0.7135**
	(-0.07)	(0.01)	(2.33)	(1.81)	(2.57)
Adjusted R^2	0.1195	0.1195	0.1431	0.1431	0.1439
Implied λ	- 0.0015	-0.0018	-0.0057	-0.0055	-0.0068
Implied α	0.92	0.89	0.75	0.78	0.79
Implied β	-	0.03	-	-0.02	-0.11
Implied ψ	-	-	0.61	0.63	-

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values

Added to this, in all cases health conditions were found to affect economic conditions positively and significantly. Referring the restricted estimates of the WDI data in appendix D2, the OLS result suggests that, citrus paribus, a 1% fall in IMR leads to, on average, about 0.22% percent rise in economic growth which is comparable with the previous finding of the same elasticity, amounting 0.20%(see table 4.3), by the same estimator but from different data set .

As we did in section 4.2.2, here also we imposed the adding up restriction to be able to calculate the resulting structural parameters. But, one should note that in this case given education itself is a flow variable, the imposed restriction is that the elasticities of saving rate, population growth rate and school enrolment rate sum zero. This restriction does hold in this case as implied by the reported Wald test. In both dataset estimates, as expected in OLS estimator, the share of physical capital was found to be too high. Again here, the share of education human capital is negative and this is not in line with the theoretical prediction of the model. This wrong sign and magnitude of β, makes the plausible estimates of share of health capital, ψ, impossible. Because the estimates ψ is dependent upon the weather plausible estimates of α and β are obtained. In the result of PWT data presented in table 4.7, ψ is estimated to be around 60% while it is implausibly high in WDI data.

Following this non-comfortable elasticity and output share of education human capital, we also agree with the idea of Mankiw *et al (*1992) that school enrolment is imperfect measure of the rate of education capital accumulation. Regardless of the acknowledgment made for this imperfection, Mankiw *et al* (1992) used this school variable since they had no better option to proxy education human capital. But very recently, the World Bank has come up with the time series data of investment on education (or education expenditure) for a number of countries. This variable is also what exactly the theoretical model refers.

Taking this superiority in to consideration, we replaced secondary school enrolment by this new flow variable-investment on education- and re-estimated Eq. (14’). The OLS estimates associated with this new proxy of education, presented in Appendix D3, gives better result as far as sign of education elasticity is concerned. However, the statistical significant as well as the estimates of other parameter remain very similar the cases of table 4.7 and appendix D2.

Whatever proxies are being used for variables of the model, however, these OLS estimates cannot be taken seriously for its defects discussed in the last chapter and also in section 4.2.2.1. Hence we go to other better estimating methods as usual to end up with the better and conclusive results.

4.2.3.2. The within Group (WG) Estimator

In this part, we kept other things the same as the OLS estimates of section 4.2.3.1 above, but here, we moved from OLS to fixed effect or WG estimator which is thought to be better than the OLS one at least in handling the time invariant country fixed effect. The WG estimates of Eq. (14’) from PWT and WDI data are presented in table 4.8 and appendix D4, respectively. Here again the definition and measurement of variables as well as the representation of the five columns are the same as above.

Similar to the previous cases, the WG estimates of both data sets reveal that the initial income is negatively and significantly correlated with growth which again proves the existence of conditional convergence. In both restricted and unrestricted model estimates of both datasets the speed of convergence, λ, was estimated to be about 5% per annum. This estimate of λ is significantly higher that what was obtained in OLS estimates as the theory predicts.

As it is depicted in table 4.6 and appendix D3, Saving rate elasticities, in both datasets, were positive and significant as usual for unrestricted and restricted versions of the model. However, population growth rate and education elasticities are still statistically indistinguishable from zero in both restricted and unrestricted estimates of the model for both PWT and WDI datasets and mostly they are with wrong signs.

Finally, when we look at the elasticity of our variable of interest, health conditions, the WG estimates also confirms our OLS finding. In both data sets as well as proxies of health being used, it is again proved that health is positively correlated with income. In both restricted and unrestricted estimates the health elasticities were statistically significant either at 1% or 5% level (see table 4.8 and appendix D4). In this estimation technique also predicted different elasticities for LEB and IMR. The interpretation of the estimated elasticities is as usual.

Like we did in the case of OLS estimator above, here also, we imposed the adding up restriction and calculated the output shares of different forms of capital. As it can be seen in table 4.8 and appendix D4, the share of output for physical capital, α, was estimated to be about 44% in PWT data and 29% to 35% in WDI data. Both estimates are comparable and also near to the theoretical prediction of the model. Contrary to this, the estimate of education capital's share, β, was not comfortable with the theoretical prediction: in most of cases of both datasets, β was calculated to be about -3% to -7% which confirm our previous OLS and WG results[15].

[15] Other writer also got the negative share of education even larger than ours in absolute value. For example, Islam(1995, table V, PP 1151) in his panel estimation found β to be -19.9%; McDonald and Roberts(2002, table 1, pp 274), got -3% Caselli *et al(1996*, table 3,pp 376*)*, got negative significant, amounting -25%, among others.

Table 4.8.WG Results from PWT data when school enrolment is used for education

Regression	(1)	(2)	(3)	(4)	(5)
		Unrestricted			
$Ln(y_{it-1})$	-0.1809***	-0.1803***	-0.2127***	-0.2123***	-0.2327***
	(-4.83)	(-4.56)	(-5.62)	(-5.39)	(-5.84)
$Ln(s^K)$	0.1898***	0.1897***	0.1888***	0.1887***	0.2043***
	(3.91)	(3.87)	(3.86)	(3.82)	(4.02)
$Ln(n+g+\delta)$	0.0743	0.0745	-0.0154	-0.0153	0.0206
	(0.69)	(0.68)	(-0.17)	(-0.16)	(0.21)
$Ln(s^E)$	-	-0.0023	-	-0.0015	- 0.0110
		(-0.08)		(-0.05)	(-0.41)
$Ln(h^*)$	-	-	**0.1134*****	**0.1134****	**-0.2678****
			(2.81)	**(2.80)**	**(-3.16)**
Constant	-0 .7036*	0.6913*	1.4566***	1.4835***	2.4476***
	(1.80)	(1.77)	(3.68)	(2.73)	(4.16)
Adjusted R^2	0.2452	0.2452	0.2701	0.2701	0.2836
Wald	0.0210	0.0217	0.0851	0.0923	- 0.0099
Implied λ	-0.0399	-0.0398	-0.0478	-0.0477	-0.0561
Restricted					
$Ln(y_{it-1})$	-0.1890***	-0.1821***	-0.2239***	-0.2194***	-0.2388***
	(-4.93)	(-4.47)	(-5.85)	(-5.49)	(-5.82)
$Ln(s^K)$ - $Ln(n+g+\delta)$	0.1405***	0.1434**	0.1368***	0.1611***	0.1685**
	(2.96)	(3,01)	(2,97)	(3.55)	(2.52)
$Ln(s^E)$ –ln(n+g+d)	-	- 0.0229	-	-0.0136	- 0.0283
		(-0.75)		(-0.7)	(-1.03)
$Ln(h^*)$	-	-	**0.2026***	**0.1349*****	**-0.2916*****
			(1.95)	**(2.99)**	**(-3.31)**
Constant	1.3376***	1.2789***	1.9375***	1.9811***	3.0738***
	(4.67)	(4.29)	(3.61)	(5.57)	(5.23)
Adjusted R^2	0.2196	0.2219	0.2462	0.2611	0.2684
Implied λ	- 0.0419	-0.0402	-0.0439	-0.0495	-0.0546
Implied α	0.43	0.47	-0.07	0.44	0.44
Implied β	-	-0.08	-	-0.04	-0.07
Implied ψ	-	-	0.37	0.37	0.81

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values

Finally, if we see the share of health human capital, it doesn't seem to be much affected by the implausible estimate of β, since β was relatively small negative number, and hence, reasonable estimates of ψ could be obtained especially in cases where LEB was used to proxy health. Taking the cases where LEB was used as a proxy for health conditions, the share of health human capital stock, ψ, was found to be about 37% and 43%, in PWT and WDI data, respectively. However these shares increased to 61% and 81% when IMR is considered as a proxy for health. In the later case, too large values of ψ were obtained because the estimates of β in regression (5) of each dataset were relatively large negative and thus its implausible estimates transmitted to the estimates of health capital share. Once we presented the results of pooled OLS and WG estimators for comparison purpose, now let us look results of our preferred estimator-the GMM estimator.

As we did for OLS above, in this estimation technique, again, we re-estimated the model by employing investment on education, instead of secondary school enrolment, as a proxy for education capital accumulation rate; where as other things are kept as they are. And this result is presented in appendix D5. As it has been shown in appendix D5, still the elasticity of education is statistically indistinguishable from zero even if most cases signs are altered to the expected one. Following this change, the share of health capital stock became comparable for both of its proxies, which was calculated to be around 40%-42%. It can be also observed that the elasticity estimates of most regressors, including health, remains stable for WDI data whether education is proxied by school enrolment rate or investment rate on it.

4.2.3.3. The DIFF-GMM and SYS-GMM Estimators

The OLS and WG estimating techniques are subject to a number of econometric problems that are discussed so far. Thus, parametric estimates of these techniques are biased and inconsistent and because of this we cannot draw conclusion following the results associated with these methods. Rather, as we did in section 4.2.2, we have to rely on the GMM estimator, specifically on SYS-GMM, to come up with more appropriate parameter estimates which help us draw appropriate conclusions for the problem at hand.

Here again, we present alternative results from the PWT and WDI datasets. Unrestricted results and the structural parameters associated with the former data are presented in table 4.9 while the elasticities of the restricted estimates of the same source are also reported in appendix D6. As we did in table 4.5 for the previous case, we reported both the DIFF-GMM and SYS-GMM results of the PWT data and the explanation of the four columns or regression of each estimator indicated in table 4.9 is similar to what was discussed in section 4.2.2.3 for table 4.5 and once again note that while LEB and IMR are used to proxy health capital stock only secondary school enrolment is used as a proxy for accumulation of education human capital.

On the other hand, in appendix D7 we presented the SYS-GMM results of the full models for two different proxies, each, for both health and education human capitals.[16] That means, estimates associated with each proxy of health, LEB and IMR, has two columns and in the first and second columns (or regression (1) and (2)) of each, secondary school enrolment and investment on education, respectively, were used to proxy the rate of education capital accumulation (see appendix D7).

[16] The nested model and DIFF-GMM are not reported to save space and since our preferred estimates are the full model of the SYS-GMM ones.

Now, let us concentrate on our preferred estimator, SYS-GMM, in discussing our results depicted in table 4.9 and Appendix D7 and readers can also look at and compare these results with the DIFF-GMM ones. So far, we said that the OLS estimator of the lagged dependent variable is biased upward while the WG estimator is biased downward due to the existence of positive correlation (in the former estimator) and negative correlation (in the later one) between this variable and the error term. Therefore, a parameter estimate of a good candidate estimator, the SYS-GMM, is expected to lie between (or at least near to the range of) the above two.

If we look at the SYS-GMM estimate initial income, in the both restricted and unrestricted version of the model estimated from all data formation, it comfortably lies between its OLS and WG estimates and the revealed negative, and mostly significant, coefficient of this regressor again assures the existence of conditional convergence. When we consider the restricted full model where LEB was used to proxy health, the PWT and WDI data estimates predict the speed of convergence to be about 2.1% and 1.1% to 1.4%, respectively, per annum in which the former estimate coincides with what is usually obtained in growth literature. Using IMR as a proxy of health leads a bit higher convergence rate (see table 4.9 and appendix D7)

The positive and significant effect of saving rate on growth is again proved to be true in our preferred estimator, SYS-GMM, of both datasets as well as restricted and unrestricted versions of nested and full models. This again confirms our previous OLS and WG estimates as well as the widely available and accepted literature; thus, our evidence supports the neoclassical idea that saving is an engine for growth. This is consistently true whichever proxy health and/ or education takes.

Table 4.9 DIFF-GMM and SYS-GMM Results of PWT data when school enrolment is used to proxy education

	DIFF- GMM				SYS-GMM			
Health's proxy	LEB		IMR		LEB		IMR	
Regression	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
			Unrestricted					
$Ln(y_{it-1})$	-0.5519*	-0.4487*	-0.3778**	-0.3566***	-0.0636	-0.0748	-0.2248**	-0.2414***
	(-1.78)	(-1.70)	(-2.67)	(-3.20)	(-0.84)	(-0.91)	(-2.49)	(-2.89)
$Ln(s^K)$	-0.0549	-0.0419	0.2913**	0.2590**	0.2597**	0.2234*	0.3453***	0.3087***
	(-0.91)	(-0.25)	(2.09)	(2.06)	(2.30)	(1.94)	(3.70)	(3.16)
$Ln(n+g+\delta)$	0.1411	0.0889	-0.0891	-0.0504	-0.0507	- 0.0129	-0.1370	-0.1034
	(0.45)	(0.36)	(-0.46)	(-0.27)	(-0.27)	(-0.05)	(-1.03)	(-0.87)
$Ln(s^E)$	-	-0.0677	-	0.0049	-	0.0389	-	0.0590*
		(-0.93)		(0.07)		(1.14)		(1.87)
$Ln(h^*)$	**0.1732**	**0.1475**	**-0.6322*****	**-0.5942*****	**0.0740**	**0.0755**	**-0.3594*****	**-0.3470*****
	(1.22)	**(1.22)**	**(-3.64)**	**(-3.49)**	**(1.69)**	**(1.61)**	**(-3.19)**	**(-3.46)**
m1	0.317	0.174	0.012	0.004	0.004	0.004	0.004	0.002
m2	0.530	0.837	0.928	0.887	0.997	0.896	0.993	0.882
Han. test	0.427	0.569	0.458	0.546	0.126	0.228	0.383	0.499
Diff. Han	-	-	-	-	0.127	0.181	0.132	0.197
Wald	0.8036	0.9327	0.2950	0.2445	0.2063	0.1143	0.1654	0.0488
Implied λ(unrest.)	- 0.1605	-0.1191	-0.095	-0.02	-0.0130	-0.0156	- 0.0509	- 0.0553
Implied λ(restr.)	-0.1516	-0.1098	-0.0915	-0.0834	-0.0195	- 0.0211	-0.0608	-0.0606
Implied α	0.05	0.14	0.42	0.41	0.67	0.52	0.48	0.40
Implied β	-	-0.13	-	0.02	-	0.10	-	0.07
Implied ψ	0.26	0.29	0.85	0.87	0.25	0.27	0.75	0.77

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values. m1 and m2 are the P-values for the first and the second order autocorrelation. Han.Test and Diff.Han are P-values of Hansen and difference in Hansen test. Used instruments reported in appendix D6. Rest. And Unrest. Stands for restricted and unrestricted. Resulting errors and thus the reported t-values are corrected by Windmeijer's finite-sample correction method. All estimates are two-step robust. Equations were estimated using xtabond2 procedure after installing the program in to STATA V.10.

Unlike in the previous cases and estimating techniques, here, population growth rate is with the expected negatives sign not only in the restricted estimates but also in unrestricted ones in almost all regressions of both datasets. Regardless of this achievement in getting the right sign by using preferred estimator, still the unrestricted estimates, but not the restricted ones, of population elasticities are not still significantly different from zero.

As far as the findings on the contribution education human is concerned, the PWT and WDI data predicts a bit different things regarding the sign of education elasticity in our preferred estimator. The former reveals consistently expected positive for both restricted and unrestricted estimates (see table 4.9 and appendix D6) where as the later one gives mixed result in this regard (see appendix D7). Whatever sign it takes, however, the SYS-GMM results of both the datasets agree that education elasticity is statistically indistinguishable from zero whether school enrolment or educational expenditure is used as a proxy for rate of education capital accumulation.

Turning our concern to the variable of interest, health, our preferred estimator, using both datasets, reveals that health affects growth positively and significantly. When we look at the statistical significance of health proxies in restricted models, for instance, while LEB was found to be significant at 5% and 10% in WDI and PWT datasets, respectively, IMR in both cases was significant at 1% level. This finding confirms with the literature and again strengthens the view that health is wealth. Once we proved that health is wealth, it is worthwhile to account how much health is how much wealth. To answer this, we have to see the estimated values of health elasticities. As it can be seen in table 4.9 and appendix D6 and D7, while the estimate of elasticity of LEB is relatively unstable between the two datasets(about 0.07 in PWT and 0.25 in

WDI) estimates, the elasticities of IMR was relatively comparable in the two datasets[17] (amounting 0.38 and 0.31). The interpretation of these elasticities is similar to the previous sections and left out here to avoid redundancy.

Finally, let us see the shares of physical, education and health human capital that were calculated by imposing the adding up restriction and making use of the reliable estimator, SYS-GMM, and it can be also observed from the reported p-value of the Wald test of restrictions that the adding up restrictions hold in many of the cases. While the PWT data reveals a relatively fair share of physical capital, amounting 40% - 52%, the WDI data gives exaggerated value of α, which is more than 60%. The share of education human capital, β, in PWT data was found to be about 7%-10% and this share in WDI data was calculated to about 8%-11% in most of the cases.[18] When we look at the share of heath capital in both data sets, LEB and IMR predict different values of ψ as it happened in the estimates of health elasticities. When LEB is considered as a proxy for health, the output share of health capital stock was found to be about 27% in PWT and 34%-48% in its WDI counterpart. However, when IMR was used instead of LEB to proxy health, the share of health capital stock was found to be too high following the relatively higher elasticity estimate it had.

Last, but not least, it is worthy to verify the validity of our preferred estimator and the resulting outcomes by ensuring the appropriateness of the instruments used and fulfillment of some econometric issues of preconditions to take the result seriously. To this end, we have to check for the two important tests of this estimator: the autocorrelation and the over identification tests

[17] This is true for the case of restricted full model where school enrolment is used as a proxy for education. However, when investment on education is used as a proxy for education both LEB and IMR elasticities were found to higher, i.e, about 0.39 and -0.85,respectively(see appendix D7)

[18] It is Only in one case where IMR is coupled with investment on education(the last column of appendix D7) that β becomes negative, i.e , -21%, and that also makes the plausible estimate of ψ impossible in that particular case.

about which we discussed a lot in section 4.2.2.3. As it can be seen in table 4.9, appendix D6 and D7, the reported p-value (denoted as m2) of the Arellano-Bond autocorrelation test shows that there is no any problem of autocorrelation and thus no lag instrument is entered in the regression as an invalid instrument. Similarly, the Hansen and difference-in-Hansen over identification tests revealed that the used instruments, as a group, appear exogenous and the subsets of additional instruments used in the level equations are also valid instruments. Therefore, our result obtained by the system GMM estimator, in both datasets, is robust and can be taken seriously.

In almost all of our specifications and estimators discussed so far, we documented that good health conditions leads to improved economic conditions. This positive relationship between the two may be because of the merits of enhancing health conditions to increase productivity. A number of channels through which better health leads to a better wealth have been discuss in chapter two. For example, the increase in life expectancy or decline in infant mortality may promote saving, enhance educational achievement and cognitive development and reduces the burden of medical expenses both at individual and national levels. These further improve the economic growth of sub-Saharan Africa. Thus, our finding is in line with that widely discussed literature.

4.3. Few Words on Insignificance of Education

In the analyses we made so far, many of the education elasticities and the resulting output share, β, was found to be negative in OLS, WG and DIFF-GMM estimators of both datasets. However, in our preferred estimation technique-system GMM- and the PWT data, the expected positive sign of elasticity and thus output share of education were obtained. But, the estimated sign of this elasticity in WDI data was mixed regardless of the application of the best estimator, SYS-GMM. Therefore, the sign of its parameter estimates is somewhat inconclusive. On the top of all, all estimating technique results of both datasets conclusively agree that education elasticity is not statistically different from zero! This finding also confirms with many of the previous empirical findings as we tried to mention some of them in the footnotes of the previous sections. In growth literature, a number of reasons are provided for this.

The first possible reason for surfacing such insignificant or negative sign for education human capital is associated with model specification. It is argued that the Cobb-Douglas production functional form used in our modeling process assumes decreasing marginal returns to the stock of education and a log-log specification, whereas the standard Mincerian micro specification yields a log-linear form. The specification we followed also assumes perfect substitutability among workers with the same level of schooling, and the predominance of the quantitative aspects of education over its qualitative side. This type of specification error may explain the resulted negative coefficient. However, the Arcand *et al* (2007) didn't support this argument in his estimation of the log-linear macro specification undertaken to test the validity of this argument. Many growth specialists agree that a more complex specification than the usual one is required since it opens up multiple channels for human capital variable to have impact on growth, which then allows the theoretical properties of the human capital variable to be better reflected in the regression results (Islam, 1995).

The second possible reason for this problem is related to data. In one way it is argued that there is always a discrepancy between the theoretical variable education in the production function and the actual variable used in regressions. The enrollment rates were always very partial measures of the rate of investment in human capital and, more importantly, did not account for differences in the quality of schooling. Although, measured by such rates, the less developed countries, like SSA, appear to have made much progress, the true levels of human capital (and hence the output levels) in these countries have actually not increased by that much. Even after using the near to theoretical variable- expenditure on education- for education capital accumulation rate, we found very similar result which proves this new variable is still imperfect measure. The other education data we used, i. e. Barro-Lee (BL) data on average years of schooling, is also subject to measurement errors and other discrepancies. Because the BL variable was only partly generated using census information on school attainment, and missing observations were inferred from enrollment ratios which is of poor quality by itself (Arcand *et al* (2007). Regardless of these defects, these education variables are being used in empirical analysis and this may lead to insignificant or wrong sign.

Added to these, the low variability education variable can also be taken as one sources of the problem of surfacing the unexpected sign to it. Given the type of data/model we used is panel, the within transformation or the differencing process of equations leads to a dramatic reduction in variance of this variable. This substantial loss in variance could be the cause for insignificant coefficients associated with education human capital variables considered in the models. As it can be seen in the summary statistics presented in the first part of the chapter, this is particularly true for BL education data since its variability is lower as compared to other measures.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

5.1. Summary and Conclusions

There is a general consensus that the role of human capital in economic growth of a nation is indispensable. Many researchers also proved that the inability of the original or original Solow model to explain the existing cross- country income differences is owing to the failure to include this important variable in the process of growth modeling. Even if analytical and empirical analysts in their works of growth accounting made much more progress in modeling the role played by human capital, until recently, most studies defined human capital narrowly as educational achievement. But, currently, health is also understood as a key component of human capital and accounting its role in economic growth has been increasingly popular.

Although most of the empirical studies in this regard have confirmed that the relationship between health and economic growth is positive, very recently, some authors like Ruhm (2006) and Acemoglu and Johnson (2007) have come up with strong arguments for a reverse relationship between the two. Many empirical works were not also able to well address the endogeneity of health when it is inserted into growth regression. These inconclusive results regarding the health-wealth nexus and the methodological shortcomings observed in previous studies motivated us to reconsider the problem and to be able to address the issue, in SSA, by employing better analytical and econometric technique. To this end, we used the PWT v.6.3 and WDI 2008 datasets and estimated our specification for dynamic data model by using a more appropriate estimating technique-system GMM- that could be able to handle or solve the usual problem of the area- endogeneity of health.

In our analysis, we showed that the economic performance of SSA over the last 50 years was very poor. Over this period, the average real GDP per capita of SSA was found to be about 700UDS with a growth rate of less than 0.7% per annum. This sluggish economic performance can be partly explained by the low health status that the region has. In SSA, the average life expectancy at birth is around 51 years. About 10% and 17% of the newly born children die before the anniversary of their first and fifth years, respectively. In all measures employed in this study, health conditions of SSA were found to be the most severe like that of its economic performance.

Taking the system GMM as our preferred estimator, for both datasets being utilized and models specified or estimated, the result of this study proved the existence of conditional convergence. The predicted speed of convergence is a bit different, but comparable, across the proxies of human capital variables and datasets being used. Preferring the PWT estimates, since it was measured at PPP, and considering LEB as a measure of health status, typically the annual speed of convergence was estimated from 2.1% to 3.2%, which very near to the theoretical prediction of the model.

Our finding also confirms the neoclassical idea that accumulation of physical capital, measured by saving rate, is a crucial determinant of economic growth. Our evidence also shows that 40%-52% of total output goes to physical capita which is a bit higher than what theory suggests (near to 33%). On the other hand, evidence obtained in this study doesn't confidently support the theoretical argument that population growth is hindrance for economic progress. So here after, it is difficult to consider the population of a country as a liability rather than an asset.

When we summarize our finding regarding the role of education capital, our preferred estimator could be able to correct the wrong sign of education elasticity obtained by other estimators in almost all the cases except in situations where rate of education human capital was proxied by education expenditure. When education is measured at level, its effect on economic growth was found to be positive, but insignificant, with output share of around 5%-22%. Similarly, in cases where education is measured as a flow variable, by school enrolment, the expected positive, but insignificant, sign was obtained with an output share of 7%-10%. Given these results of our preferred estimator in our data, we can conclude that the contribution of education to economic growth is positive but insignificant.[19]

Finally, when we look at the finding regarding our main objective, effect of health on economic conditions, the two proxies of health used in this study predicted different elasticities and output shares of health. These values were also found have considerable differences in the two datasets. Generally, the estimated elasticities and the resulting values of output shares associated with IMR were relatively higher and sometimes implausible. In all the cases considered, LEB and IMR were positively and negatively, respectively, correlated with economic growth and most of our estimates revealed that LEB was statistically significant either at 5% or 10% level while the level of significance for IMR is typically 1%. The difference in variability of these health proxies makes this difference in significant level. Taking the couple of LEB and PWT data in to consideration, 24%-27% of the total output goes to health human capital.

Following this finding, therefore, we can conclude that the health elasticity and share of output is sensitive for the change in not only proxies of health itself but also the change for proxies and

[19] This conclusion leaves the negative estimates associated with education expenditure and WDI data aside since it was not supported by the PWT dataset estimates.

datasets of other regressors, like education. Regardless of these changes in magnitude of parameter estimates, our evidence consistently and conclusively shows that the role played by health capital stock to economic progress of SSA is positive and significant. This assures that health citizens are more productive since good health makes them effective and efficient which, in turn, contributes to fast economic growth. Moreover, the finding of this paper also proved that the impact of health human capital is by far higher than the impact of education human capital for economic growth of sub-Saharan Africa.

5.2. Policy Implications

In this paper, we have got important findings regarding economic conditions and health-wealth nexus in SSA and concrete conclusions have been made in this regard. Based on these findings and the resulting conclusions, the following policy recommendations can be drawn.

First, we have shown that economic conditions of SSA are unfavorable. The same is true for health status. Our empirical evidence also reveals that improving the existing bad health conditions can facilitate economic growth. To this end, countries should increase the accumulation of their health capital stock. This is possible by investing on health! Therefore, policy makers, government and non-governmental organizations who strive to promote growth and development should start at investing on health and accumulate this form of capital. Once they do this, health can be used as an engine for economic growth and development and practitioners can get their objectives achieved easily. Note that improving health status promotes development in two main channels: on one hand, it is by itself an end objective to enhance one component of development- non-material welfare. On the other hand, it contributes to development through increasing productivity which, in turn, increases material welfare. Thus, due emphasis should be given on health investment.

However, the accumulation of health capital and its contribution in promoting economic growth may be impeded by health care market failures. Efficiency of health care market is vital to enhance health conditions. But unfortunately, health care market is characterized by market failures like externality, uncertainty and information asymmetry whose extent is higher in health care markets than the other ones. Thus, a lot is expected from governments in correcting such market inefficiencies. State involvements to organize, finance and provide health services may be important.

Second, the insignificant role of education capital obtained in this study doesn't imply that we shouldn't invest on it since it is less productive. Rather, our finding has an implicit implication that the human capital development, in terms of education, made in SSA was not in such a way to support its growth. Thinking on its quality may be important to reap the benefit of education.

Finally, accumulation of physical capital via increasing the saving rate is also another engine available for countries to catalyze their growth. Policy makers can promote saving by increasing deposit rate and/or by educating people to develop the culture of saving.

Possible Areas of Further Research

Further researchers may focus on a more complex specification than we followed in modeling both health and education to account their role in growth. In doing so, the real effect of education will be reflected in the resulting growth regression. The correct estimation of parameters associated with education will enable one estimate the reasonable output share of health capital stock.

The proxies of health used in this study are crude measures which do allowance for quality of life. The possible existence of disability for the survival and its effect on the economy cannot be accounted by taking LEB or IMR as proxy for health. Thus, future researchers may reconsider the problem by a better measure of health that can also reflect the effect of morbidity or disability. Quality Adjusted Life Years (QALY) and Disability Adjusted Life Years (DALY) may be considered wherever possible.

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APPENDICES

Appendix A: List of sample countries considered in the study.

- Benin
- Botswana
- Burkina Faso
- Burundi
- Cameroon
- Cape Verde
- Central African Republic
- Chad
- Comoros
- Congo,Democratic Republic of
- Congo,Rep.
- Côte d'Ivoire
- Ethiopia
- Gabon
- Gambia
- Ghana
- Guinea
- Guinea-Bissau
- Kenya
- Lesotho
- Madagascar
- Malawi
- Mali
- Mauritania
- Mauritius
- Mozambique
- Namibia
- Niger
- Nigeria
- Rwanda
- Sao Tome and Principe
- Senegal
- Sierra Leone
- South Africa
- Sudan
- Swaziland
- Tanzania
- Togo
- Uganda
- Zambia
- Zimbabwe

Appendix B: summary statistics of variables used in the model from PWT dataset

Variable		Mean	Std. Dev.	Min	Max	Observations
gdppc	overall	2650.909	2594.675	353.484	19114.62	N = 336
	between		2422.568	596.4937	10851.52	n = 42
	within		993.0421	-3480.774	10914.01	T = 8
grgdppc	overall	.9050332	3.799582	-14.92	13.048	N = 336
	between		1.641558	-3.24525	5.545917	n = 42
	within		3.434883	-12.95005	14.1922	T = 8
saving	overall	11.38909	7.596529	-.774	45.93333	N = 336
	between		6.001074	3.808833	25.75483	n = 42
	within		4.737813	-2.79574	36.26126	T = 8
ngd	overall	7.62765	1.02476	-0.47	13.36	N = 336
	between		0.55163	6.125	9.235	n = 42
	within		0.86729	-0.34485	12.73515	T = 8
leb	overall	51.69821	7.171419	23.7	72.1	N = 336
	between		6.101085	41.45	68.425	n = 42
	within		3.870893	33.08571	60.81071	T = 8
imr	overall	99.73661	33.29229	14.6	194.8	N = 336
	between		28.11808	26.65	148.85	n = 42
	within		18.28307	48.4616	156.7616	T = 8
u5mr	overall	167.7054	68.13927	15	400	N = 336
	between		60.51961	37.375	306.125	n = 42
	within		32.50953	61.45536	290.2054	T = 8
Secschool	overall	21.25744	17.27216	1.055284	94.70489	N = 336
	between		13.78972	4.41338	58.76079	n = 42
	within		10.58982	-18.82887	60.75227	T = 8

APPENDIX C: CORREALTION MATRIX

	agdppc	grgdppc	leb	imr	u5mr	secschool	eduexpe	edu15
Agdppc	1.0000							
Grgdppc	0.2135	1.0000						
leb	0.6167	0.2736	1.0000					
imr	-0.6220	-0.2379	-0.8426	1.0000				
u5mr	-0.5779	-0.2050	-0.8406	0.9350	1.0000			
secschool	0.7364	0.1306	0.6919	-0.7612	-0.7213	1.0000		
eduexpe	0.4658	0.0973	0.4265	-0.5257	-0.4803	0.4805	1.00	
edu15	0.6017	0.0075	0.6314	-0.8036	-0.7903	0.8058	0.4361	1.000

Where for Appendix B and C,

gdppc=real GDP per capita

grgdppc=growth rate of GDP per capita

ngd= population growth rate augmented with 5%

secschool=secondary school enrolment rate

eduexpe= educational expenditure as a % of GNI

edu15= average years of education for population of age 15 and above.

Appendix D: regression results of different estimators and datasets.

Appendix D1: Restricted results of the DIFF-GMM and SYS GMM estimator of PWT data where both education and health are measured at level.

	DIFF- GMM				SYS-GMM			
Health's proxy	LEB		IMR		LEB		IMR	
Regression	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4
Restricted								
$Ln(y_{it-1})$	-0.6609**	-0.3544	-0.6635***	-0.5885***	-0.0957	-0.1465	-0.3176*	-0.2643**
	(-2.24)	(-1.59)	(-3.74)	(-3.20)	(-0.89)	(-1.59)	(-1.55)	(-2.15)
$Ln(s^K) - Ln(n+g+\delta)$	- 0.1189	0.1070	0.3358	0.2341	0.2246	0.3163	0.2118*	0.3085
	(-0.44)	(0.46)	(1.58)	(1.20)	(1.44)	(1.32)	(1.70)	(1.70)
Ln(e*)	-	0.0012	-	0.0098	-	0.0371	-	0.1321
		(0.01)	-	(0.08)		(0.33)		(0.95)
$Ln(h^*)$	0.3943	0.0545	-0.9357	-0.5740*	0.1399	0.1703	0.5448*	-0.2065
	(1.62)	(-0.44)	(-1.93)	(-1.76)	(1.35)	(1.26)	(-1.91)	(-0.83)
m1	0.684	0.140	0.109	0.179	0.025	0.027	0.059	0.033
m2	0.972	0.681	0.794	0.957	0.515	0.589	0.462	0.840
Han. test	0.418	0.664	0.358	0.828	0.303	0.773	0.104	0.854
Diff. Han	-	-	-	-	0.178	0.381	0.162	0.685

Note that the instruments used for each regressor are: for $Ln(y_{it-1})$, collapsed one to third period lag ; for $Ln(s^K)$ and $Ln(n+g+\delta)$, collapsed two period lag; for Ln(e*) and $Ln(h^*)$, collapsed one period and deeper lags.

Appendix D2: Pooled OLS Results from WDI data when school enrolment proxies education

Regression	(1)	(2)	(3)	(4)	(5)
		Unrestricted			
Ln(y_{it-1})	-0.0101	-0.008	-0.0341*	-0.0275***	-0.0444**
	(-0.59)	(-0.38)	(-1.93)	(-1.37)	(-2.18)
Ln(s^K)	0.2071**	0.2099**	0.2083**	0.2185**	0.2191***
	(2.21)	(2,24)	(2.32)	(2.38)	(2.60)
Ln($n+g+\delta$)	0.0044	0.0055	0.1624	-0.1653	0.0260
	(0.03)	(0.04)	(-1.16)	(0.33)	(0.20)
Ln(s^E)	-	- 0.0038	-	-0.0139	- 0.0304
		(-0.21)		(-0.706)	(-1.65)
Ln (h^*)	-	-	**0.2057*** **	**0.2143*** **	**-0.2199*** **
			(3.41)	**(3.42)**	**(-3.85)**
Constant	-0 .8878	-0.8367	0.2926	0.3226	0.3421
	(-0.96)	(-1.54)	(0.56)	(0.64)	(0.71)
Adjusted R^2	0.1439	0.1441	0.1957	0.1988	0.2172
Wald	0.1803	0.1821	0.7696	0.3086	0.1531
Implied λ	-0.0020	-0.0016	-0.0069	-0.0056	-0.0091
Restricted					
Ln(y_{it-1})	-0.0020	0.0001	-0.0333*	-0.0266	-0.0361*
	(-0.12)	(0.01)	(-1.91)	(-1.35)	(-1.78)
Ln(s^K) - Ln($n+g+\delta$)	0.1262	0.1289	0.1927**	0.2054**	0.1368*
	(1.60)	(1.64)	(2.39)	(2.50)	(1.81)
Ln(s^E)- Ln($n+g+\delta$)	-	0.0038	-	- 0.0142	- 0.0303
		(-0.21)		(-0.78)	(-1.63)
Ln (h^*)	-	-	**0.2119*** **	**0.2198*** **	**-0.2194*** **
			(3.58)	**(3.58)**	**(-3.84)**
Constant	-0.3040**	-0.2605	0.4411*	0.4474**	0.9244***
	(-2.02)	(1.53)	(1.91)	(1.97)	(3.11)
Adjusted R^2	0.1334	0.1336	0.1953	0.1984	0.2064
Implied λ	- 0.0004	0.000	-0.0068	-0.0054	-0.0074
Implied α	0.92	0.97	0.85	0.93	0.90
Implied β	-	-0.03	-	-0.08	-0.20
Implied ψ	-	-	0.91	-	-

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values

Appendix D3. Pooled OLS Results from WDI data when investment on education proxy education

Regression	(1)	(2)	(3)	(4)	(5)
		Unrestricted			
$Ln(y_{It-1})$	-0.0101	-0.0216	-0.0341*	-0.0412**	-0.0527***
	(-0.59)	(-1.12)	(-1.93)	(-2.09)	(-2.66)
$Ln(s^K)$	0.2071**	0.2200**	0.2083**	0.2169**	0.1974**
	(2.21)	(2,36)	(2.32)	(2.43)	(2.37)
$Ln(n+g+\delta)$	0.0044	-0.0032	0.1624	-0.1630	0.0157
	(0.03)	(-0.02)	(-1.16)	(-1.15)	(0.12)
$Ln(s^E)$	-	0.0267	-	0.0179	- 0.0022
		(0.98)		(0.17)	(-0.08)
$Ln(h^*)$	-	-	0.2057***	0.2002	-0.1872***
			(3.41)	(0.15)	(-3.44)
Constant	-0 .8878	0.8276*	0.2926	0.2925	0.2996
	(-0.96)	(-1.85)	(0.56)	(0.60)	(0.58)
Adjusted R^2	0.1439	0.1500	0.1957	0.1984	0.2043
Wald	0.1803	0.1197	0.7696	0.6355	0.1464
Implied λ	-0.0020	-0.0044	-0.0069	-0.0084	-0.0091
Restricted					
$Ln(y_{it-1})$	-0.0020	-0.0093	-0.0333*	-0.0389	-0.0291*
	(-0.12)	(-0.47)	(-1.91)	(-1.97)	(-1.48)
$Ln(s^K)$ - $Ln(n+g+\delta)$	0.1262	0.1266	0.1927**	0.1925**	0.1079
	(1.60)	(1.61)	(2.39)	(2.40)	(1.43)
$Ln(s^E)$ - $Ln(n+g+\delta)$	-	0.0190	-	0.0155	0.0047
		(0.70)		(0.60)	(0.18)
$Ln(h^*)$	-	-	0.2119***	0.2102***	-0.1230***
			(3.58)	(3.55)	(-3.09)
Constant	-0.3040**	0.2048	0.4411*	0.5076**	0.5080**
	(-2.02)	(-1.31)	(1.91)	(2.19)	(2.08)
Adjusted R^2	0.1334	0.1366	0.1953	0.1974	0.1746
Implied λ	- 0.0004	-0.0019	-0.0068	-0.0079	-0.0059
Implied α	0.92	0.75	0.85	0.77	0.65
Implied β	-	0.11	-	0.06	0.03
Implied ψ	-	-	0.91	0.83	0.75

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values

Appendix D4. WG Results from WDI data when school enrolment proxies education

Regression	(1)	(2)	(3)	(4)	(5)
		Unrestricted			
$Ln(y_{it-1})$	-0.2217***	-0.2238***	-0.2231***	-0.2253***	-0.2416***
	(-6.61)	(-5.60)	(-6.88)	(-5.81)	(-6.13)
$Ln(s^K)$	0.1898**	0.1918*	0.1710*	0.1730*	0.2120**
	(2.00)	(1.93)	(1.88)	(1.81)	(2.32)
$Ln(n+g+\delta)$	0.1076	0.1059	- 0.0384	-0.0401	0.0607
	(0.81)	(0.79)	(-0.24)	(-0.25)	(0.44)
$Ln(s^E)$	-	0.0046	-	0.0046	- 0.0067
		(0.16)		(0.17)	(-0.24)
$Ln (h^*)$	-	-	**0.1481****	**0.1481****	**-0.1940****
			(2.15)	**(2.14)**	**(-2.32)**
Constant	-0 .0256	0.2689	1.1597*	1.1825	1.3333**
	(-0.96)	(0.55)	(1.90)	(1.88)	(2.03)
Adjusted R^2	0.3441	0.3442	0.3615	0.3616	0.3676
Wald	0.0749	0.0813	0.4781	0.4783	0.1168
Implied λ	-0.0501	-0.0507	-0.0505	-0.0511	-0.0553
Restricted					
$Ln(y_{it-1})$	-0.2019***	-0.2064***	-0.2191***	-0.2194***	-0.2278***
	(-4.40)	(-5.41)	(-6.98)	(-5.97)	(-6.02)
$Ln(s^K)$ - $Ln(n+g+\delta)$	0.0503	0.0506	0.1200	0.1200	0.0906*
	(0.64)	(0.64)	(1.52)	(1.52)	(1.10)
$Ln(s^E)$ - $Ln(n+g+\delta)$	-	-0.0062	-	0.0008	- 0.0170
		(-0.23)		(0.03)	(-0.64)
$Ln (h^*)$	-	-	**0.1763*****	**0.1765*****	**-0.2091****
			(2.93)	**(2.90)**	**(-2.41)**
Constant	1.1513***	1.1298***	1.6208***	1.6592***	2.1658***
	(-5.84)	(5.37)	(6.96)	(6.36)	(5.30)
Adjusted R^2	0.3265	0.3267	0.3588	0.3588	0.3542
Implied λ	- 0.0451	-0.0462	-0.0495	-0.0495	-0.0517
Implied α	0.18	0.19	0.35	0.35	0.29
Implied β	-	-0.03	-	0.002	-0.05
Implied ψ	-	-	0.43	0.43	0.61

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values

Appendix D5: WG Results from WDI data when investment on education proxies education

Regression	(1)	(2)	(3)	(4)	(5)
		Unrestricted			
$Ln(y_{it-1})$	-0.2217***	-0.2339***	-0.2231***	-0.2384***	-0.2440***
	(-6.61)	(-6.07)	(-6.88)	(-6.46)	(-6.43)
$Ln(s^K)$	0.1898**	0.2162**	0.1710*	0.2032**	0.2208**
	(2.00)	(2.18)	(1.88)	(2.15)	(2.31)
$Ln(n+g+\delta)$	0.1076	0.1024	- 0.0384	-0.0519	0.0563
	(0.81)	(0.77)	(-0.24)	(-0.33)	(0.40)
$Ln(s^E)$	-	0.0251	-	0.0314	- 0.0230
		(0.71)		(0.95)	(0.67)
Ln (h^*)	-	-	**0.1481****	**0.1551****	**-0.1379****
			(2.15)	**(2.24)**	**(-2.03)**
Constant	-0 .0256	0.2212	1.1597*	1.1201*	0.9746**
	(-0.96)	(0.46)	(1.90)	(1.86)	(1.59)
Adjusted R^2	0.3441	0.3468	0.3615	0.3657	0.3603
Wald	0.0749	0.0465	0.4781	0.3324	0.0889
Implied λ	-0.0501	-0.0533	-0.0505	-0.0545	-0.0559
	Restricted				
$Ln(y_{it-1})$	-0.2019***	-0.2100***	-0.2191***	-0.2287***	-0.2242***
	(-4.40)	(-5.70)	(-6.98)	(-6.52)	(-6.11)
$Ln(s^K)$ - $Ln(n+g+\delta)$	0.0503	0.0503	0.1200	0.1300	0.0800
	(0.64)	(0.63)	(1.52)	(1.60)	(0.96)
$Ln(s^E)$ - $Ln(n+g+\delta)$	-	-0.0001	-	0.0219	0.0012
		(-0.00)		(0.69)	(0.04)
Ln (h^*)	-	-	**0.1763*****	**0.1887*****	**-0.1603****
			(2.93)	**(3.08)**	**(-2.45)**
Constant	1.1513***	1.1509***	1.6208***	1.7149***	1.8897***
	(-5.84)	(5.42)	(6.96)	(6.60)	(6.05)
Adjusted R^2	0.3265	0.3265	0.3588	0.3611	0.3452
Implied λ	- 0.0451	-0.0475	-0.0495	-0.0519	-0.0508
Implied α	0.18	0.18	0.35	0.33	0.25
Implied β	-	-0.00	-	0.06	0.00
Implied ψ	-	-	0.43	0.40	0.42

NB: ***, ** and * shows the 1%, 5% and 10% statistical significant of variables, respectively and numbers in parenthesis are t- values

Appendix D6: Restricted DIFF-GMM and SYS-GMM Results of PWT data when school enrolment is used to proxy education.

	DIFF- GMM				SYS-GMM			
Health's proxy	LEB		IMR		LEB		IMR	
Regression	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Restricted								
$Ln(y_{it-1})$	-0.5314*	-0.4227	-0.3672**	-0.3410***	-0.0930	-0.1002	-0.2622***	-0.2613***
	(-1.93)	(-1.69)	(-2.55)	(-3.02)	(-1.33)	(-1.54)	(-3.02)	(-3.13)
$Ln(s^K) - Ln(n+g+\delta)$	0.0278	0.0495	0.2710*	0.2491**	0.1911*	0.1387	0.2426**	0.1936
	(0.13)	(0.32)	(1.88)	(2.04)	(1.92)	(1.64)	(2.67)	(2.20)
$Ln(s^E) - Ln(n+g+\delta)$	-	- 0.0528	-	0.0126	-	0.0280	-	0.0363
		(-0.77)	-	(0.17)		(0.77)		(0.74)
$Ln(h^*)$	**0.1463**	**0.1243**	**-0.5460*****	**-0.5233*****	**0.0702***	**0.0722***	**0.3783*****	**-0.3784*****
	(1.19)	**(1.22)**	**(-3.00)**	**(-2.82)**	**(1.70)**	**(1.75)**	**(-3.40)**	**(-3.08)**
m1	0.262	0.130	0.010	0.003	0.003	0.002	0.003	0.002
m2	0.555	0.840	0.892	0.855	0.976	0.883	0.948	0.813
Han. test	0.495	0.576	0.372	0.458	0.198	0.347	0.554	0.639
Diff. Han	-	-	-	-	0.351	0.574	0.752	0.720

Instruments used in the estimation are: for $Ln(y_{it-1})$, collapsed lag three and deeper; for all other regressors, collapsed lag one to three.

Appendix D7: SYS-GMM Result from WDI dataset when either school enrolment (regression (1) in each) or investment on education (regression (2) in each health's proxy) are used to proxy education

Health's proxy	Life Expectancy		infant mortality	
Regression	(1)	(2)	(1)	(2)
		Unrestricted		
$Ln(y_{it-1})$	0.0237***	0.1426*	-0.1129	0.2215***
	(-0.49)	(-1.87)	(-1.43)	(-3.16)
$Ln(s^K)$	0.5123*	0.9252**	0.6810*	0.8903***
	(1.89)	(2.64)	(1.82)	(2.83)
$Ln(n+g+\delta)$	0.1483	-0.0468	- 0.1894	0.1294
	(0.58)	(-0.21)	(-0.95)	(0.57)
$Ln(s^E)$	-0.0057	0.0825	-0.0177	-0.0185
	(-0.19)	(1.07)	(-0.58)	(-0.27)
$Ln(h^*)$	**0.1216**	**0.2989**	**0.2983****	**-0.6978*****
	(1.07)	**(0.47)**	**(2.12)**	**(-3.30)**
m1	0.008	0.011	0.007	0.014
m2	0.747	0.788	0.893	0.959
Hansen test	0.803	0.342	0.565	0.685
Difference Hansen	1.000	0.366	0.855	0.649
Wald	0.0896	0.0391	0.0542	0.0252
Implied λ	-0.0048	-0.0308	-0.0239	-0.0500
Restricted				
$Ln(y_{it-1})$	-0.0535	- 0.0662	- 0.1275**	- 0.1924***
	(-1.25)	(-1.26)	(-2,33)	(-3.98)
$Ln(s^K)- Ln(n+g+\delta)$	0.2947*	0.4137**	0.2816*	0.4109***
	(1.79)	(2.29)	(1.87)	(3.43)
$Ln(s^E) - Ln(n+g+\delta)$	0.0321	0.0464	0.0526	-0.1113
	(0.80)	(0.92)	(0.99)	(-1.64)
$Ln(h^*)$	**0.2450****	**0.3936****	**-0.3080*****	**- 0.8536*****
	(2.02)	**(2.41)**	**(-3.08)**	**(-5.01)**
m1	0.008	0.007	0.007	0.010
m2	0.638	0 .663	0.600	0.851
Hansen test	0.364	0.104	0.319	0.823
Difference Hansen	403	0.363	0.245	0.730

Continued from appendix D7

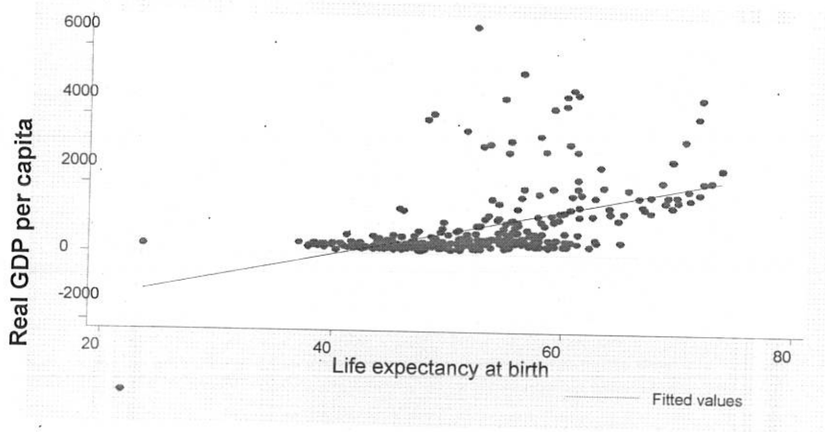
Implied λ	-0.0106	-0.0137	-0.0273	-0.0427
Implied α	0.77	0.69	0.61	0.79
Implied β	0.08	0 .08	0.11	-0.21
Implied ψ	0.34	0.48	0.66	-

Note that Instruments used are:

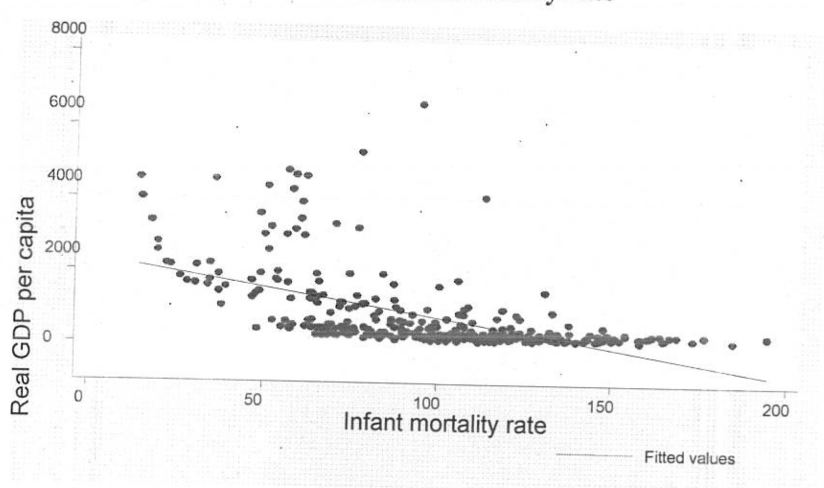
In regressions associated with enrolments used instruments are: for $Ln(y_{it-1})$ collapsed lag three and deeper; and for other regressors, collapsed first lags. In regressions associated with educational expenditure, for $Ln(y_{it-1})$ collapsed second and third lags, for others collapsed first lags.

Appendix E: Graphs Showing the Association Between Economic Conditions and Human Capital(Both Health and Education)

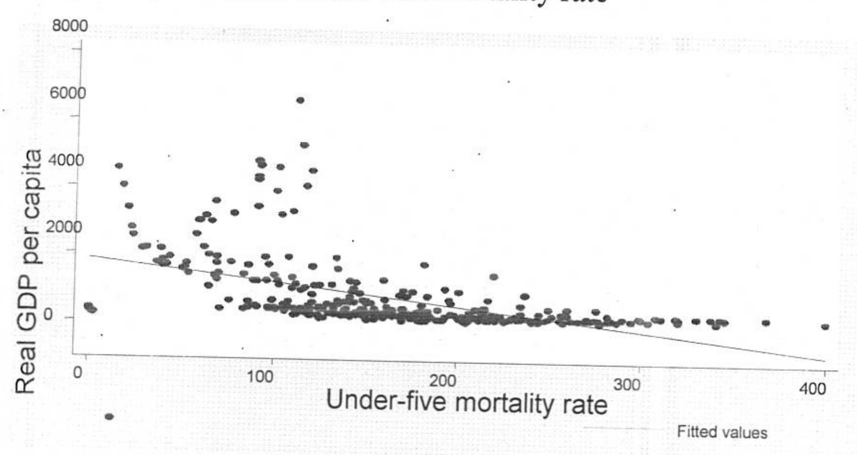
a) Real GDP per capita versus life expectancy at birth



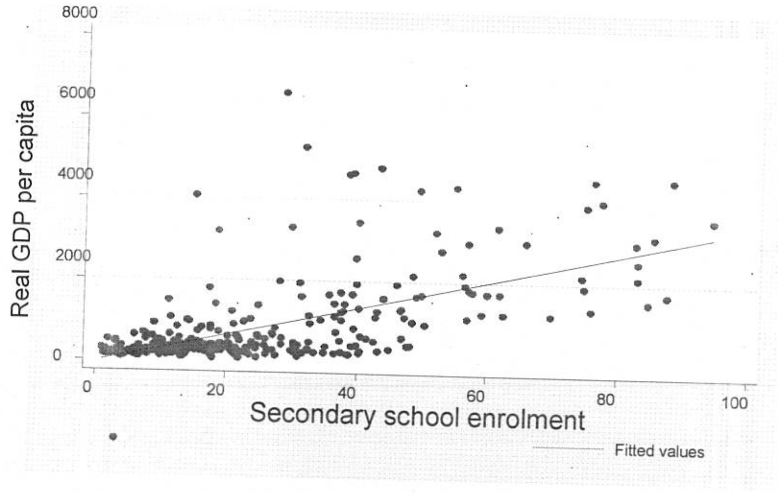
b) Real GDP per capita versus infant mortality rate



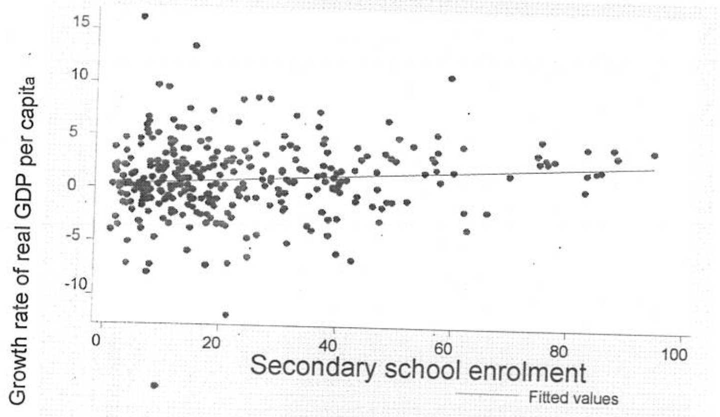
c) Real GDP per capita versus under-five mortality rate



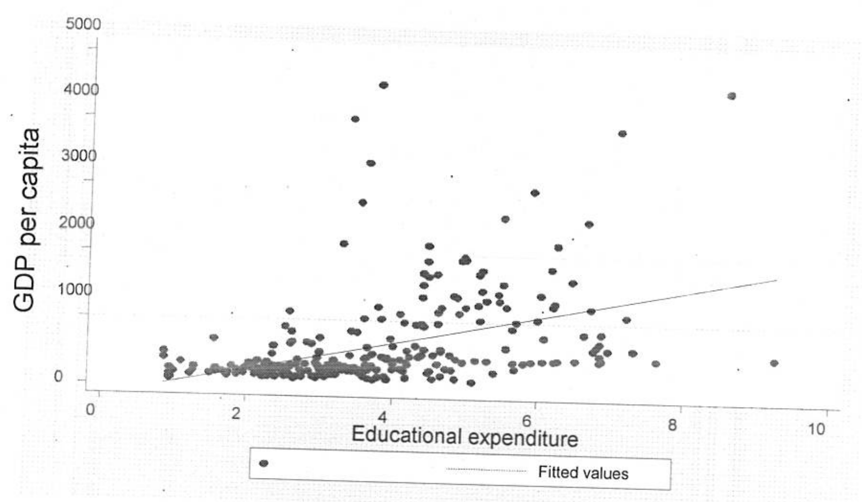
d) Real GDP per capita versus secondary school enrolment rate



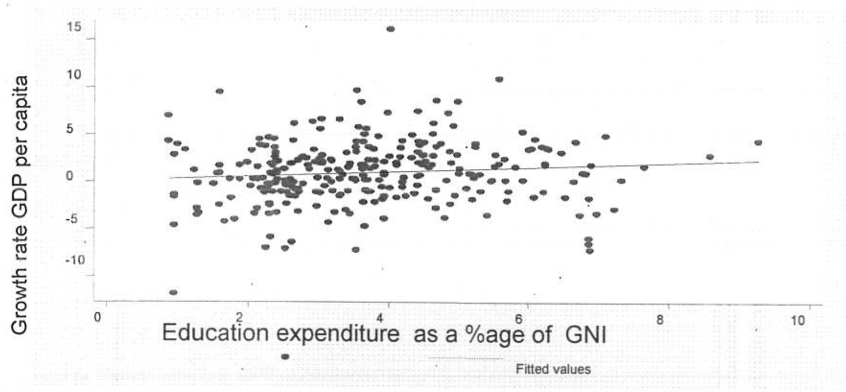
e) Growth rate of real GDP per capita Versus secondary school enrolment rate



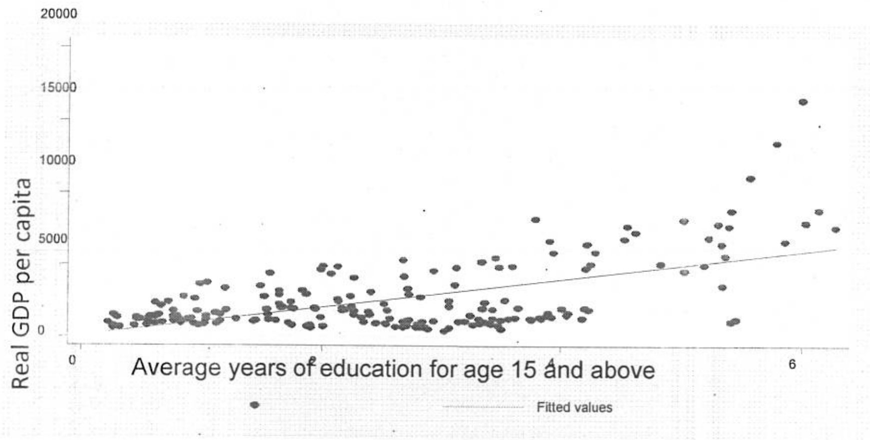
f) Real GDP per capita versus expenditure (or investment) on education



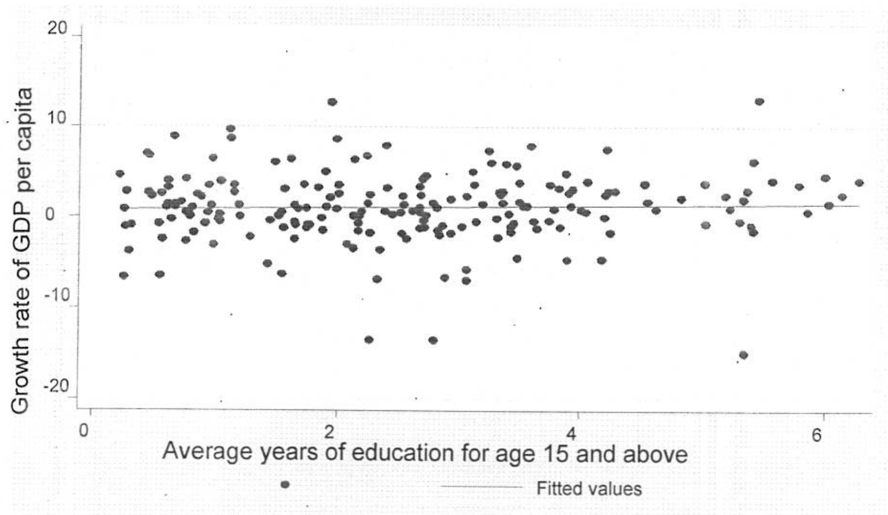
g) Growth of Real GDP per capita Versus Expenditure on education



h) Real GDP per capita versus average years of schooling for 15 years and above aged population



i) Growth of real GDP per capita versus average years of education



DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university, and that all sorts of materials used for this thesis have been duly acknowledged.

The examiners' comments have also been duly incorporated.

Declared by:

Name: Abeje Ambachew

Signature: ____________

Date: 25/06/10

Confirmed by Advisor:

Name: Tassew Woldehanna.

Signature: ____________

Date: 25 June 2010

Place and Date of Submission: Addis Ababa University