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An Integrated Framework of Growth and Human Capital: Application to Selected African Countries

Dissertation Submitted for the Degree of Doctor of Philosophy

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DECLARATION

I, Grace Goitsemodimo Kgakge-Tabengwa, declare that this research report is my own unaided work. It is submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg, South Africa. It has not been submitted before for any degree or examination in this or any other university.

SIGNATURE: 26/02/2010

DATE: 26th February 2010

NAME:Grace Goitsemodimo Kgakge-Tabengwa

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Abstract

The main thrust of my thesis is to develop an integrated framework of human capital and growth to investigate the role of the two major components of human capital, health and education on growth for a set of selected African countries[1] from 1980-2008. The descriptive analysis and stylized facts on human capital, fiscal dynamics and growth is carried out in Chapter 2. In Chapter 3, we assess the impact of health and education on per capita output. In our model, health and education determine labour effectiveness. In Chapter 4, we explicitly introduce the government budget constraint and the role of government expenditure in the model. This is mainly to capture fiscal constraints and challenges facing developing countries and to assess their possible implications for human capital development and growth. Our analysis and results show that both health and education play a positive role in promoting the effectiveness of labour and in influencing growth. The model features the role of the physical capital stock, which is found to have a significant positive role on health, education and growth. The dynamics of the model reveal that, in the long run, temporary and permanent positive shocks to health and education impact positively on labour effectiveness and growth. Increasing education and health on a permanent basis by 1% leads to on average, a permanent sustained increase in output of 1.2% and 0.8%, respectively. For some countries, the permanent shock to health and education raises output by 1.2% in both cases, indicating presence of increasing returns to scale from health and education on output growth. Similar findings are obtained with the human capital index which constitutes health and education mainly to capture the possible interactions between health and education.

With the government budget constraint in the model, the dynamics show that high stocks of the public debt depresses the effect of human capital on output growth through limiting government expenditure resources available for developing human capital. The impact of the public debt on human capital and growth varies in the selected countries depending on the public debt/GDP ratio and on whether the fiscal policy rule is more flexible in reacting to debt and government expenditure; maintains a balanced budget or maintains a zero growth rate in the public debt. Although for all the three fiscal policy rules we find consistency that an increase in the public debt adversely affects human capital and growth and that the impact is much more pronounced when the public debt/GDP ratio goes beyond 40%, our findings show that maintaining a flexible fiscal policy rule and the balanced budget rule gives better results compared to the other fiscal policy rule. There are pronounced lag effects on the impact of education and health on output as well as on how the public debt and government expenditure affects human capital and growth. We conclude that the implications of the public debt on human capital and growth indicate that some developing countries, especially those where the public debt remains high and face fiscal challenges such as poor unsustainable revenue prospects to back government expenditure on health and education cannot solely develop human capital based on the strength of their domestic resources. Also, while we find a significant positive role for education and health on growth in the model without the government budget constraint, incorporating fiscal dynamics reveals that the impact of health and education on growth becomes less pronounced. This underscores the importance of taking into account fiscal dynamics in assessing the impact of health and education on growth to avoid possibly over estimating their growth potential in countries where there are fiscal constraints such as those where the public debt remains high and recurs.

[1] *Botswana, South Africa, Zambia, Malawi, Tanzania, Uganda, Kenya, Cote d'Ivore, Ghana, Nigeria*

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Otherwise all errors and omissions are of course my sole responsibility.

Chapter 1: Introduction

1.2 Background to the Study

1.2.1 Research Problem

This thesis investigates the role of human capital on growth within an integrated framework of human capital and growth. The main focus is to develop a model that captures the two components of human capital, health and education, and assess their relative impact on output, measured in per capita terms. In our model, both health and education determine the effectiveness of labour. An important aspect of the analysis centers on investigating the reaction of output per capita to temporary and permanent shocks to education and health within the developed dynamic model. The other major aim in the thesis is to extend the analytical framework to capture the fiscal dynamics facing African countries in developing human capital. This is carried out by explicitly introducing the government budget constraint, fiscal policy rules and the role of government expenditure in the model and assessing their growth implications for human capital.

The motivation for the model developed in the thesis and analysis is that, while there is substantial literature on the role of human capital on growth, pioneered by the work of Romer (1990) and Barro (1990), a number of studies identify human capital only with education, leaving out health as a component of human capital. A number of cross-country studies that explain income differences, for example studies by Mankiw, Romer and Weil (1992), Caselli, Esquivel and Lefort (1996), Klenow and Rodriguez (1997), Barro (1991, 1997), Benhabib and Spiegel (1994), Barro and Sala-i-Martin (1995), Sala-i-Martin (1997), Easterly and Renelt (1997) use education as an indicator of human capital. They find that human capital has a significant positive effect on economic growth. These studies do not include health as part of human capital. Also, health and education are not captured as factors that determine labour effectiveness in the analysis.

Although human capital, in the form of education, contributes significantly to economic growth, these studies identify human capital narrowly with education[2]. For developing countries, health problems are as important as education problems. It is therefore, important to consider health as a crucial aspect of human capital and a critical ingredient of economic growth. Furthermore, even if education levels are high, a deteriorating state of health of the labour force reduces life expectancy and productivity gains. As a result, the growth rate of labour productivity will fall over time, and this will reduce long run economic growth. As pointed out by Weil (2006) and the World Bank (1988), absence from work due to health problems affects productivity. Most importantly, for African countries with major health challenges, the studies point out that the prevalence of HIV-AIDS is high among the ages of 20-50 years. This is the most productive segment of the population from the standpoint of the life cycle income hypothesis. This has direct implications for productivity and long-run growth.

It is thus imperative that an assessment of the role of human capital on growth in developing countries integrates health as one of the components of human capital. Leaving out health as a component of human capital encounters obvious difficulties, such as the variable omission bias and the possible overestimation or underestimation of the contribution of human capital to growth. In Chapter 3 of the thesis, therefore, a dynamic model in which human capital is jointly determined by the levels of education and health of the labour force, following Romer (1990), is formulated and estimated. In this model, health and education impact on the effectiveness of labour and productivity. In order to deal with possible interactions between health and education, we formulate an index of human capital which constitutes of health and education index for the selected set of countries. A second major aspect of the research in Chapter 3 of the thesis is investigating the dynamic reaction of output in to temporary and permanent shocks to health and education and measuring their relative impact on economic growth, measured in per capita terms.

The thesis also features the role of fiscal dynamics in human capital development and growth in Chapter 4. Developing countries are encouraged to prioritize human capital improvements as part of meeting the Millennium Development Goals. However, the fiscal sustainability of

[2] For example Romer (1990) Barro, (1990, 1991, 1996), Mankiw, Romer and Weil (1992), Easterly and Levine (1997),Benhabib and Spiegel (1997) Barro and Sala-i-Martin (1995, Sala-i-Martin (1997) Greiner, Semmler and Gong (2004)

such policy proposals remains an issue that requires further research. The upshot of the analysis may be that because of major gaps in human capital levels, some developing countries may be unable to close these gaps within reasonable time on the strength of their domestic resources. Surprisingly, few studies integrate endogenous growth with the government budget constraint and the role of fiscal policy rules. For example, Romer (1990) features government spending but does not explore the implications of the government budget constraint. The study that comes close to ours is the one by Greiner et.al. (2004). This study features the government budget constraint, but human capital is modeled as education. Against this backdrop, we introduce the government budget constraint in the model developed in Chapter 4 of the thesis where the main is to assess the extent to which expenditure on human capital delivers long run fiscal sustainability. The impact of the public debt and fiscal policy rules on human capital and growth is also investigated.

The relevance of considering the growth effects of fiscal policy on human capital and growth through introducing the government budget constraint within the model are predicated, of course, on the basic proposition that policy matters for long run growth. The importance of the government budget constraint in growth models has been highlighted by Turnovsky (1975) and Kneller, Bleany and Gemmell (1999). They posit that it is important to capture the variables that enter the government budget constraint for a meaningful analysis of the long run growth effects of fiscal policy. Christ (1968) and Aizenman *et. al.* (2007) also state that econometric models used for policy analysis should be careful to keep track of the implications of the government budget constraint in order to avoid being subject to potential biases arising from omitting variables that enter the government budget constraint.

The framework and analysis presented in this thesis is based on three guiding hypotheses. The first is that health and education impact positively on economic growth and that health has a greater impact on labour effectiveness and output. The second hypothesis is that an increase in the public debt depresses human capital development by lowering health and education. When testing this hypothesis, we adopt different fiscal policy rules to assess the impact of the public debt on human capital, growth, government expenditure and the public deficit to capture aspects of fiscal sustainability under different fiscal policy rules often

adopted by countries to maintain a sound fiscal stance and macroeconomic stability[3]. The three different fiscal policy rules explored are (i) a flexible fiscal policy rule where government reacts to the public debt and government expenditure to maintain them at sustainable proportions (ii) a fiscal policy rule where a balanced budget is maintained and (iii) a fiscal policy rule where a zero growth rate in the public debt is maintained. Thirdly, we test the impact of government expenditure on health and education[4]. This hypothesis is tested under two scenarios where in the first scenario we assess the impact of government expenditure on one of the components of human capital holding one component constant. In the second scenario, the hypothesis is tested where the change in government expenditure is on all the components of human capital. The theoretical and empirical considerations for these hypotheses are given in more detail in the respective chapters of the thesis.

1.1 Selected African Countries

The study focuses on a set of 10 selected developing countries in Africa, notably *Botswana, South Africa, Zambia, Malawi, Kenya, Tanzania, Uganda, Cote d'Ivore, Ghana and Nigeria*. The selection gives a reasonable representation of African countries with varying macroeconomic conditions and performance, development stages and growth rates as well as differing fiscal challenges, health and education profiles. The selection of the countries is largely informed by the need to ensure representatively of a wide range of countries from Africa, but also the availability of data for the analysis in the thesis particularly a time series of data on the health and education indicators. The inclusion of several African countries for such a study provides an opportunity for comparisons among African countries.

The selection also gives a mix of countries that represents most of the regions of Africa such as countries from Southern Africa, East Africa Countries and those from North/West Africa. In this regard, the selection is hoped to give results that show dynamics in various African countries and the possible human capital, growth and debt dynamics that may emerge.

---

[3] The role of fiscal policy and fiscal policy rules is emphasized in studies for example by Anniccharíarico and Giammarioli (2004), Funte (1997), Miller and Russek (1997), King and Rebelo (1990), Blinder and Solow (1993) and Christ (1979).

[4] Studies emphasizing the role of government expenditure on growth and development include those of Barro and Lee (1994), Barro (1990, 1991), Bose, Haque and Osborn (2003), Cashin (1995) Aschauer (1989), Ladau (1983, 1985, 1989) and Shantayanaan, Swaroop and Zou (1996)

Table 1:Summary Characteristics of the Selected African Countries

Regional Groupings	High/Middle Income Countries	Low Debt/GDP Ratio- 0-40%	Low/Least Developed Countries (1)	High-growth countries (2)	Low Growth Countries (3)
Southern African Countries: Botswana, South Africa, Malawi, Zambia	Botswana South Africa	Botswana South Africa	Zambia Malawi	Botswana	Nigeria Malawi
East African Countries: Kenya, Uganda, Tanzania		Kenya	Cote d'Ivore Tanzania		Cote d'Ivore
Other Africa Countries (North/West): Cote d' Ivore, Ghana, Nigeria			Uganda Ghana		Zambia Uganda

Notes 1. The low and lease developed countries have an average Debt/GDP ratio exceeding 60% from 1980-2008- These are countries mostly among the highly indebted poor countries that have benefited from the IMF/World Bank HIPC Initiative and Multilateral Debt Relief Initiative.

2. The high growth countries here have experienced GDP growth exceeding 6% on average between *1980-2008* GDP growth less than 5% between 1980-2008

3. Low growth countries have experienced GDP averaging less than 5% between 1980-2008 period

We also selected a combination that has high growth countries such as Botswana and South Africa, less developed and highly indebted countries (Zambia, Malawi, Cote'd Ivore). A summary table outlining some of the characteristics of the selected Africa countries is provided in *Table 1* for ease of reference. Some of the countries, such as Zambia, Malawi, and Tanzania, Uganda and Cote d'Ivore have had high debt to GDP ratios and debt service obligations which may serve to constrain government resource allocation to social development, mainly in areas of health and education. Even with multilateral interventions to arrest the high debt in the highly indebted poor countries (HIPC) by international organization such as the International Monetary Fund (IMF) under the Highly Indebted Poor Countries Initiative (HPIC) and the Multilateral Debt Relief Initiative (MDRI), some countries still remain trapped in the high debt or tend to slip back into debt after the debt

cancellation, for example, in the cases of the highly indebted countries[5] (e.g. Zambia, Malawi, Cote d'Ivore).

It is therefore, of interest to look at how the fiscal dynamics such as the public debt in these countries may shape and impact on the development of human capital and growth prospects within our analytical framework when we introduce the government budget constraint to capture the role of the public debt, fiscal policy rules and government spending. Also, the sample gives countries where government expenditure faces challenges of prioritization amongst competing priority sectors but also with limited sustainable revenue sources to back up continued expenditure on social development areas such as those of health and education. For example, while Botswana has had high revenues compared to other countries in the sample, the challenge is that the revenue is dominated by mineral revenues and the economy is not diversified. Nigeria is highly dependent on oil production as a source of revenue which the country is not able to plough back into social development due to political instabilities and poor governance. Generally, taxes are higher in African countries and collection is inefficient (Bose et. al (2003). This leads to poor prospects for revenue generation and limited tax bases to generate resources for sustained expenditures on education and health and other priority development objectives.

In Chapter 2, a detailed comparative analysis of economic performance based on macroeconomic indicators in the selected countries is provided and discussed which provides more information on the set of countries of focus.

1.2 Objectives of the Study

As already highlighted in the preceding sections, the main aim in this thesis is to develop a model that assesses the relative impacts of the two components of human capital, health and education on output per capita. A second focus is to extend the macro-model to introduce the role of the public debt, government expenditure and fiscal rules by explicitly introducing the government budget constraint in the analytical framework developed. This is intended to

[5] See for supporting evidence in studies by Chowhoudry (2001),Clements et. Al (2004), Denis e.t al (2008) Sachs (1986,1989)

capture the fiscal dynamics and their implications on growth and human capital development. The two main issues being investigated within the integrated growth framework developed in the thesis center on the following aspects:

1. Examining the growth effects of the two components of human capital with particular focus on health and education. In this case, the analysis disaggregates human capital into two components, health and education, where health and education determines labour effectiveness and assessing their relative impact on growth.

2. Assessing the fiscal policy implications of the government budget constraint, government expenditure and the public debt on health, education, public deficit and growth. That is, the analysis introduces a government budget constraint into the model framework to capture the fiscal dynamics and their implications for fiscal policy sustainability, human capital development and growth. Here, we assess how the public debt under different fiscal policy rules affects human capital and growth and how the government expenditure impacts on growth and human capital development.

A number of research questions are asked in the main chapters which guide the formulation of the model, the specific research interest questions and analysis. The issues being investigated in each of the chapters are elaborated below:

- ***Chapter 2:***

This Chapter presents the descriptive analysis and stylized facts on the state of health, education and growth in the selected African countries. We look at the various indicators of health (including life expectancy and mortality rates) and compare them. With regard to education, we compare the indicators of education, notably, adult literacy rates, enrollment ratios in the set of selected countries. We also carry out a comparison of the economic performance based on GDP per capita and average growth rates. Developing countries face challenges in developing human capital, particularly health and education. One of the main challenges is the allocation of resources to education and health amidst the competing priority goals for government on a sustainable basis. This is compounded by the poor revenue prospects of developing countries which constrain government spending on various

sectors of the economy. We therefore compare the debt/GDP ratios and debt service obligations, and indicators of aid dependency and discuss government expenditure resource allocations for health and education. The role played by multilateral institutions like the World Bank and donor agencies in addressing constraints on human capital development and the fiscal constraints such as the high debt through for example the Highly Indebted Poor Countries (HIPC) Initiative and the Multilateral Debt Relief Initiative is also captured in this chapter. A number of stylized facts, mainly on the interactions between health and education, global intervention policy initiatives and dynamics, the lag and delayed effects of human capital on growth and between fiscal policy variables on human capital and growth which are of importance and have a bearing on the analysis carried out in this thesis are also highlighted in this chapter. This Chapter aims to give a solid background of the issues of focus in the thesis from a descriptive analytical perspective.

- ***Chapter 3:***

A number of research questions are at the core of the analysis in this section of the thesis. The main research question being addressed in this chapter include: What is the impact of the two components of health and education on economic output? What is the impact of health and education on labour effectiveness? What is the reaction of output per capita to persistent and permanent shocks to education and health? What is the relative impact of the components of human capital on growth of output? In order to address the possible of interaction of health and education, the analysis pertaining to these research questions is carried out on health and education individually but also with the formulated index of human capital which constitutes of health and education.

Therefore, the specific objectives in this chapter are to:

i. Formulate a macro model framework where health and education determine the effectiveness of labour.
ii. Assess the dynamic response of output to persistent and permanent shocks to education and health.
iii. Measure the relative impacts of the two major components of human capital-health and education on growth

iv. Measure the impact of permanent shocks to human capital on output.

- ***Chapter 4:***

The main research questions here center on how fiscal dynamics affect the development of human capital and growth. For example, some questions being asked include: How does an increase in the public debt affect human capital (health and education), the public deficit, government spending and growth under different fiscal policy rules? What is the reaction of output to persistent and temporary shocks to the public debt is this framework? How does government spending on health and education affect human capital, growth and the public debt? What is the impact of government spending on one of the components of human capital holding one component constant? What is the impact of government spending on all the components of human capital, public debt and growth?

With these research questions, the specific issues of research in this chapter are therefore, to:

i. Extend the model framework in Chapter 3 to integrate the government budget constraint, government spending, public debt and fiscal policy rules in the model.
ii. Assess the dynamic behavior of output, health, education, public deficit to shocks on the public debt in this framework.
iii. Assess the impacts of increased government spending on health and education
iv. Assess the impact of increasing public debt on health, education, government expenditure and growth.

1.3 Rationale and Justification of the Study

It is no doubt that the role of human capital in the process of development has received much attention in the development literature in recent years. However, the existing research focusing on cross-country income differences largely identifies human capital with education. Also, the studies do not integrate the role of fiscal dynamics in the frameworks

adopted. This study will therefore contribute to the existing research gap by explicitly including health as one of the components of human capital as well integrating the role of fiscal dynamics by integrating the government budget constraint. The framework adopted allows for an understanding of how health and education determine labour effectiveness and output. This study, through an assessment of the impacts of the major components of human capital on growth and integrating the role of fiscal dynamics in the analytical framework developed will fill the current existing research gap with regard to:

- Improving on previous research on this topic by explicitly including both components of human capital, health and education in the growth model adopted to assess the implications of human capital on growth. In this regard, the present paper will fill an important gap that currently exists in the literature in as far as the role of health and education as components of human capital on growth are concerned

- Contributing to an understanding of the role of human capital on growth given fiscal constraints for developing countries. Existing research on human capital and growth studies[6] have not considered the implications of the fiscal policy sustainability in their analysis through including the government budget constraint in the analytical framework used. As such, these studies, through neglecting the role of health on human capital and the government budget constraint are subject to potential biases because they omit health as one of the components of human capital and the variables for fiscal policy sustainability. Our study therefore captures the role of fiscal dynamics and how they affect human capital development which is justified for an understanding of the dynamic effects of government expenditure, fiscal rules and public debt on human capital and growth.

The research therefore serves as a contribution to the recent methods of analysis through looking at the dynamics of the model over the long run, but also from a time series perspective compared to cross section analysis on human capital and growth which dominates the existing literature in this subject matter. This analysis is also enriched by a comparative analysis of the state of human capital, fiscal dynamics and growth of the selected African countries which gives scope for an in-depth understanding of the issues of

[6] Studies referred to in the introduction and problem statement on human capital and growth.

research interest in this thesis. Further, the study contributes to the current existing research gap on an integrated growth framework of the role of human capital on growth within a model that captures all the components of human capital and addresses the problems of omission variable bias. It also forms a human capital index to address problems of possible interactions between health and education which have a bearing on the interpretation of estimations. The analysis, through its focus on a set of selected[7] developing countries using recent time series data (1980-2008) from Africa where development of human capital remains a challenge and fiscal dynamics affect human capital and growth prospects, will contribute to the current ongoing policy and academic debates on human capital development in these countries.

1.4 Limitations of the Study

The data collected here has limitations especially where there is need for a wide number of indicators to proxy for the health and education indicators when dealing with endogeneity. We encountered weak instruments but also non-availability on a consistent basis for some education and health indicators which limited using the instrument variable (IV) technique to test for endogeneity in some suspect variables particularly between health and education. The explanation given by the World Bank is that statistical systems in many developing countries, particularly Africa are still weak and the coverage and variable definitions differ widely among countries. For these reasons, the World Bank warns that although the sources from which the data are drawn are authoritative, they should be construed only as indicating trends. Temple (1998) also notes that indicators may change markedly as a result of change to either the numerator or denominator.

There were limitations in finding the physical capital stock data for all the countries in our sample. We therefore had to derive the physical capital stock series for each country using the perpetual inventory method following Limam and Miller (2004).

[7] Botswana, South Africa, Zimbabwe, Zambia, Uganda, Kenya, Tanzania, Nigeria, Ghana and Ivory Coast

There are possible interactions between health and education which need to be taken into account. The analysis on health and education cannot always be separated and hence, this posed some limitations in that one has to come with an index of human capital which attempts to address these possible interactions. In this regard, the research attempts to develop an index that captures the two components. As such, the interactions between health and education in the analysis are mainly driven by the way the human capital index is formulated in this thesis, hence being limited where other approaches to interact health and education may be deemed critical.

There are also issues of the delayed effects of human capital as it relates to health and education. The impact of health and education on labour effectiveness and output may take time to take effect. Hence, these time effects and lag effects have to be considered when interpreting the results. The impulse response functions indicating the response to permanent and temporary shocks is a tool that allows one to discern the lag and delayed time responses between variables following the shocks. A limiting factor to measuring the exact lag/delayed effects from the functions is not always 100 percent accurately measured and the length of the lag is treated as indicative of the time period taken for the impact to take effect.

1.5 Organization of the Thesis

The thesis is divided into five chapters. Chapter 1 introduces the study, giving the background of the thesis and research problem, the research objectives as well as the rationale of the study. This is followed by the three main inter-related chapters of the thesis (Chapter 2, 3 and 4) one building on the findings of the preceding one. Chapter 2 presents the descriptive evidence and stylized facts on human capital, growth and public debt and gives a comparative analysis of the indicators and macroeconomic data in the selected sample of countries. It also highlights the stylized facts on human capital, growth and the public debt and provides the literature review underpinning the research.

In Chapter 3, we formulate a macroeconomic model for assessing the relative impact of the two major components of human capital, health and education, on economic growth and investigate the response of output to shocks on education and health within a dynamic

analytical framework. In Chapter 4 we introduce the government budget constraint in the model developed in the preceding chapter where we assess the extent to which expenditure on human capital delivers long run fiscal sustainability. Here we integrate the role of the fiscal dynamics on human capital and growth. The conclusions and implications of the study are given in Chapter 5.

Chapter 2: Descriptive Evidence and Stylized Facts on Human Capital and Growth

2.1 Introduction

In the early 1960s, Africa's growth potential prospects were much better than those of East Asia (Easterly and Levine, 1997). But during the period 1965–1990, real GDP per capita for East Asian countries increased by 5% per year while that in Africa stagnated. Most African countries experienced negative growth in this indicator (World Bank, 1993). With the declining trends in economic performance and growth in African countries, a number of factors have therefore been identified to spur growth and development. One of the sectors that can help accelerate development and be an engine for economic growth in Africa is the development of its human capital base. However, there are some challenges in African countries that have served to limit the potential of the role of human capital on growth. According to Bose *e.t al* (2004), these challenges include fiscal challenges, notably the limited government resources to be allocated among competing development priorities. Research by Clements *e.t al* (2001) underscores the adverse effects of the high public debt in developing countries on growth and development initiatives which crowds out available resources for use on other sectors of the economy.

This chapter therefore, carries out a descriptive analysis to examine the relationship between the indicators of human capital pertaining to health and education in the sample of African countries from a qualitative context. It gives a comparative analysis of the indicators relating to economic performance and growth, health, education, public debt, debt service and aid dependency measures amongst the set of countries which constitutes, high growth, middle income and less developed low income countries. Also, the expenditure patterns on the health and education sectors are compared. This is mainly to assess the health and education profiles in the various African countries and resource allocation and commitments by governments in the development of human capital. The analysis will shed light on the

possible relationships between for example, trends in education indicators and the role of government policy through resource provision in the form of government expenditures.

Including the public debt and other fiscal indicators in the descriptive analysis will shed light on whether countries with high public debt are constrained by fiscal dynamics in developing human capital. This is because it is possible for a high debt to limit resources available for priority sectors such as on education and health[8]. The extent of the public debt and debt service obligations in these countries is given to assess the debt burden of the countries and perhaps to gauge the extent to which debt service obligations might affect the ability of countries to develop health and education and provide resources such as the infrastructure in these sectors.

The literature review is provided in *Section 2.2* which gives the theoretical and empirical review on human capital, growth and fiscal policy.

2.2 Literature Review

This section focuses on summarizing the relevant theoretical and empirical literature on human capital and growth. A review of the literature on the role of fiscal policy in shaping human capital and growth is also carried out. This review informs the theoretical foundations of the analytical framework followed in this thesis. The framework we develop is based on the conventional endogenous growth models as popularized by Romer (1986, 1990) and Lucas (1988), and then by Barro (1990). Recently, Barro and Sala-i-Martin (1992) extended the framework of optimizing economic agents that allows for the inclusion of a public sector variable in the production function.

[8] There is evidence on the adverse effects of a high public debt on growth and resource allocation. For example, Pattillo *et al.* (2002) finds evidence of debt overhang. Using a panel data set comprised of 93 developing countries for the period 1969-1998, they suggest that at a debt stock of 35-40 percent of GDP, the average effect of debt on per capita growth becomes negative. Clements *et al.* (2003) confirm their results of a debt overhang. Furthermore, they find that debt service has a "crowding out" effect on public investment, thereby lowering the overall growth rate of a developing country. They argue that if resources freed up by debt service relief can be directed towards public investment, growth rates in some HIPC countries would increase by half a percentage point annually. Similarly, Chowdhury (2001) finds evidence for debt overhang in his sample

As such, in the two sub sections that follow below, I review the literature relating to human capital and growth along the Romer (1990) and Barro (1990) which lays the theoretical and empirical considerations of the analysis being carried out in the thesis. The other review focuses on the role of the public sector in developing human capital which follows along the Barro (1990) and Barro and Sala-i-Martin (1992), laying the theoretical background for extending the analytical framework to introduce government spending and the government budget constraint in the growth and human capital framework we develop. In chapter 3 and 4 where the model framework in the respective chapters is laid down, I draw extensively from the literature review carried out in the following subsections and use it to guide the analytical framework.

2.2.1 Human Capital and Economic Growth

As already highlighted in the earlier sections of the thesis, the role of human capital in the process of development has received much attention in the growth literature in recent time. The literature on human capital occupies a prominent place in both the macroeconomic and microeconomic growth literature.

There are two main debates in the macro growth literature: the traditional growth models of Solow and Swan (1956), Cass (1965), and Koopmans (1965) and the new endogenous growth theories. While the former disregards human capital, the later incorporates it. In the traditional growth models physical capital drives growth. They are based on the crucial assumption of diminishing marginal returns to capital, which leads the growth process of an economy to eventually arrive at the steady state where the rate of technological progress is exogenously given (Bassanini and Scarpetta, 2001). Whereas in the new endogenous growth models, human capital occupies a central role in spurring growth as knowledge spillovers and human capital externalities aid in delaying the tendency for diminishing returns to capital accumulation (Barro and Sala-i-Martin, 2004).

As such, in the last 20 years the new endogenous growth theory has increasingly influenced the economic growth literature. It emphasizes the role played by human capital accumulation in boosting growth through stimulating technological creation and invention, eventually

leading to increased productivity (Barro, 1990). The endogenous model by Romer (1990) assumes that the creation of new ideas is a direct function of human capital which manifests in the form of knowledge. While in the Lucas (1988) model, human capital is inserted as a factor of production, in the Romer (1990) model it is used as a facilitator of technological growth. As such, in modern growth theory, the accumulation of human capital is an important contributor to economic growth (Romer, 1990). The main advantage of the new growth theories is that they incorporate explanations for long run growth (human capital and technological growth) into the model. In this way it is theoretically possible to determine the importance for growth of technology and human capital accumulation. The endogenous growth theory therefore provides explanations on why human capital investments are important to economic growth (Barro and Sala-i-Martin, 1995).

Lately, Aghion and Howitt (1998) have observed that the modeling of the role of human capital in new endogenous growth theories can be further divided into two approaches: the Nelson-Phelps (NP) (1966) and the Lucas approach (1988). The NP approach argues that the stock of human capital directly influences growth by enhancing the innovation capability of the country and indirectly influences growth through its ability to facilitate technology adoption and 'catch up' with other leading countries. In contrast, the Lucas (1988) approach, which is also broadly consistent with the Mincerian earnings function literature, assumes that growth is driven by the accumulation of human capital.

These approaches have different implications for human capital investments on the long-run growth of a country. Under the NP approach, raising human capital levels will affect the country's level of output while the Lucas approach predicts that raising the level of human capital will affect the country's permanent growth rate (Aghion and Howitt, 1998). Therefore, empirical results of testing the importance of human capital for economic growth are mixed. Some studies have found no relation between human capital and growth under the Lucas approach (see Benhabib and Spiegal, 1994).

In this regard, there have been numerous cross-country studies, which have extensively explored whether the attainment of education can contribute significantly to the generation of overall output in economy. The theoretical framework which has widely been followed to model the effects of human capital in growth follows the endogenous growth models of

Barro (1990), Romer (1990) Barro and Sala-i-Martin (1995, 2004). This framework is based on a production function of the constant returns to scale with output being a function of capital, labour and human capital. Examples of studies that also found support for human capital as source of growth include those by Barro and Lee (1994) Romer (1991), Benhabib and Spigel (1994) and Mankiw, Weil and Romer (1992) and Barro and Sala-i-Martin (1995, 2004).

A number of indicators of education have been adopted for the analysis of human capital on growth. These include indicators such as enrollment ratios, average years of schooling and adult literacy rates. Mankiw, Romer and Weil (1992), Caselli, Esquivel and Lefort (199); Easterly and Levine (1992) Klenow and Rodriguez (1997; Barro (1991, 1997), Benhabib and Spiegel (1994), Barro and Xavier Sala-i-Martin (1995), Sala-i-Martin (1997), and many others find schooling to be positively correlated with the growth rate of per capita GDP across countries. Barro and Sala-i-Martin (1995) employ data on years of schooling attainment in a country's working-age population to test the hypothesis that schooling promotes growth and find that growth is highly correlated with school enrollment. These studies, however, define human capital to constitute of education and do not include health as a component of human capital.

Having examined the literature, it is clear that in a number of studies[9] quantifying the contribution of human capital to growth, only education indicators are used to define human capital. There is therefore a need to re-examine the growth effects of human capital on growth where human capital is determined by both health and education. Also, it is important that the role of health and education are considered as the main drivers of labour effectiveness. Human capital is a multifaceted concept which comprises various types of investments in people. Its definition has evolved over years of research on it. Although, initially it was simply considered as skills and knowledge acquired by people (Schultz 1961), Strauss and Thomas (1998) have expanded it to incorporate individual competencies, non-market activities, innate abilities, and individual attributes that facilitate the creation of social, personal and economic wellbeing as well . It is against this backdrop that my thesis is

[9] Refer to studies by Mankiw, Romer and Weil (1992), Caselli, Esquivel and Lefort (1999); Easterly and Levine (1992) Klenow and Rodriguez (1997; Barro (1991, 1997), Benhabib and Spiegel (1994), Barro and Sala-i-Martin (1995), Sala-i-Martin (1997),

an empirical examination of the two most important indicators of human capital, health and education.

2.2.2 Fiscal Dynamics, Human Capital and Growth

Although the new endogenous growth theory emphasizes the role of knowledge spillovers in macroeconomic growth, it tends to neglect the role of the government budget constraint. For example while in Barro (1990) the role government spending is emphasized in the endogenous growth framework by including a variable for the government sector, the components of the government budget constraint are not captured. This has led to a wide number of studies such as those cited in the previous section only assessing the role of human capital as education without considering the role of fiscal dynamics by capturing all variables that enter the government budget constraint. (see for example studies referred to above of Mankiw *e.t.al* (1992), Barro (1990), Barro and Sala-i-Martin (1990, 1995) Benhabib and Spiegel (2004).

The government budget constraint captures the fiscal resources in terms of revenues at the disposal of the government to pursue development projects and expenditures (Turnovsky, 1975). The constraint also features the use government revenues through government expenditure on various sectors of the economy and the debt repayments. Given that developing countries tend to have poor fiscal profiles due to the high debt burden which limit resource allocation and spending[10], it is therefore important to capture the government budget constraint in the analytical frameworks to assess how fiscal dynamics shape human capital and growth.

The literature analyzing the effects of fiscal policy on growth is also based on the theory of endogenous economic growth (Barro 1990, Barro and Sala-i-Martin 1990) where the impact of public expenditures on economic growth is formalized in a simple endogenous growth model following Barro (1990) and Barro and Sala-i-Martin (1990) where output is a function

[10] Clements *e.t.al* (2003)

of technology, labour, the capital stock and government spending. Other than the literature[11] which tests for the relationships between fiscal policy and growth following the work of King and Rebelo (1990), Easterly and Rebelo (1993), Kneller, Bleany and Gemmell (1999), there is no empirical evidence capturing both aspects of human capital and their effects on growth in an integrated growth framework which also captures the fiscal policy implications by including the government budget constraint. Studies that capture the government budget constraint, although not focusing on the implications for human capital, include those of Christ (1979) Christopher (1995), Leeper and Sims (1994) which test the empirical implications of the government budget constraint. Therefore, this paper will thus fill this gap in the literature.

One study that is of particular importance in our work which we draw from in the approach to setting up the dynamics of the model framework we develop is the recent study by Greiner, Semmler and Gong (2004) which capture the government budget constraint under different fiscal policy rules in assessing the role of human capital on growth for a set of developed countries. However, in this work, human capital is only identified as education compared to our work where human capital constitutes health and education. Later in Greiner (2008) in an assessment of human capital formation, public debt and economic growth, an endogenous growth model where human capital formation is the result of public education and the government finances expenditures in the schooling sector by the tax revenue and by public deficit is presented. Also, the government sets the primary surplus such that it is a positive linear function of public debt which guarantees that public debt is sustainable. The paper analyzes the structure of the growth model and derives implications of public debt and carries out a sensitivity analysis of the dynamics of the model.

Greiner (2008) finds that a loose fiscal policy, where the government does not pay great attention to stabilizing debt, does not permit sustained growth in the long-run, unless the government is a creditor. In this case, there is a crowding-out of private investment and sustained growth is not feasible, unless the government is a creditor and lends to the private sector, so that the latter can finance necessary investment On the other hand, if the government puts a large weight on debt stabilization and does not invest sufficiently in the

[11] Kneller R, Bleaney and Gemmell (1999), Landau (1983, 1985), Easterly and Rebelo (1993), Davarajan *e.t al* (1996), Cashin (1995), Barro (1990).

formation of human capital, sustained growth is not possible either, unless the government is again a creditor. In this case, the government must use its wealth in order to finance necessary investment in the formation of human capital (Greiner, 2008). In this study, it is found that a strong rise in the primary surplus as a reaction to higher public debt stabilizes the economy. Greiner argues that for certain values of the reaction coefficient, cyclical growth occurs. If the reaction coefficient is set to a larger value, the economy stabilizes and converges to the constant balanced growth rate, if the reaction coefficient is set to a lower value, the economy becomes unstable. This analysis highlights the role of public debt and fiscal policy in developing human capital. However, in this case also, human capital is identified as education.

A few studies, which I have reviewed below, are of interest since they feature some of the issues of interest in this thesis on fiscal policy aspects and rules, the impact effects of dissaggretaed government expenditure on sectors including health and education but also the role of the public debt on growth and the public deficit which are issues that are related to some of the analysis we carry out. Such studies include the recent work by Bose, Haque and Osborn (2003), Aizenman, Kletzer and Pinto (2007) Clements *e.t al* (2003) and Patillo *e.t al* (2002).

Fernández-Huertas Moraga and Vidal (2007) investigate fiscal sustainability in an overlapping generation's economy with endogenous growth coming from human capital formation through educational spending. This paper conducts an assessment of the implications of budgetary imbalances and undesirable debt dynamics for fiscal sustainability in a model where both interest rates and economic growth are affected by fiscal developments. The study carries an assessment of how budgetary imbalances affect economic dynamics and the outlook for economic growth, thereby providing a rationale for fiscal rules ensuring sustainability. The results obtained in the study show that the appropriate response of fiscal policy to temporary shocks is not trivial in the absence of fiscal rules. According to Fernández-Huertas Moraga and Vidal (2007) fiscal rules allow for a timely reaction, thereby avoiding possibly disruptive fiscal adjustment in the future: the more adjustment is delayed, the larger is its necessary scale. They also perform a rough calibration of the model to simulate the effects of a demographic shock (change in the population growth rate) under different fiscal policy scenarios. The main conclusion reached is that fiscal sustainability can

be extremely fragile in the absence of fiscal rules. On the contrary, fiscal rules make the economic equilibrium stable and ensure that public debt does not endanger fiscal sustainability. Furthermore, fiscal rules allow for a timely reaction, thereby avoiding disruptive fiscal adjustment in the future: the more adjustment is delayed, the larger is its necessary scale

Bose *e.t al* (2003) examine the growth effects of government expenditure for a panel of thirty developing countries over the decades of the 1970s and 1980s, with a particular focus on sectoral expenditures using the seemingly unrelated regressions (SURE) method. Compared to other previous works which do not recognize the role of the budget constraint, the analysis conducted by Bose *e.t.al* (2003) improves on previous research on this topic by explicitly recognizing the role of the government budget constraint and the possible biases arising from omitted variables. The study finds that the share of government capital expenditure in GDP is positively and significantly correlated with economic growth, but current expenditure is insignificant. The share of government capital expenditure in GDP is positively and significantly correlated with economic growth, while the growth effect of current expenditure is insignificant for the group of countries. At the sectoral level, government investment and total expenditures in education are the only outlays that remain significantly associated with growth throughout the analysis. The other findings of the analysis are that although public investments and expenditures in other sectors (transport and communication, defense) initially have significant associations with growth, these do not survive the government budget constraint and other sectoral expenditures are incorporated into the analysis. The study finds that the private investment share of GDP is associated with economic growth in a significant and positive manner and there is strong evidence that a government budget deficit gives rise to adverse growth effects.

Aizenman, Kletzer and Pinto (2007) analyzes the impact of limited tax and debt capacity on growth. The study evaluates optimal public investment and fiscal policy for countries characterized by limited tax and debt capacities. The study adopts a non stochastic CRS endogenous growth model where public expenditure is an input in the production process, in countries where distortions and limited enforceability result in limited fiscal capacities, as captured by a maximal effective tax rate. The study finds that although the flow of public expenditure raises productivity, government should not borrow to finance it as the resulting

increase in public debt would lower welfare and the growth rate. For countries with outstanding public debt, the optimal fiscal policy should keep the debt-to-GDP ratio constant in the economy with or without a binding constraint on tax revenues as a share of GDP. The analysis shows that the effects of debt limits on economic growth depend on the nature of the externality associated with public goods spending. Aizeman *et. al* (2007) conclude that higher debt is associated with lower long-run growth rates which are reached in finite time in the model economy. Also, a country with a lower debt-to-GDP ratio will have a higher balanced growth rate than a country with identical characteristics and higher debt.

The empirical research on how the stock of debt affects growth provides mixed evidence. Some studies find a negative impact of debt on growth when the debt ratio reaches a certain threshold. These studies include those of Clements *et al.* 2003 and Pattillo *et al.* 2002. The studies emphasize the crowding out effects on a stock of debt particularly when it exceeds 60% of GDP. They also note that the high stock of debt takes away resources that can be alloocated for other development initiatives. Other studies that have found empirical support for the adverse effects of the public debt on growth and development include those by Bigsten *et al* (2001), Boote *e.t al* (1997 Chowhoudry (2001) and Ebaldawi *et.al* (1997). These are important for this research where the analysis gives an assessment of the possible impact of the public debt on human capital development, mainly on health and education.

2.2.3 Summary

From the review of the theoretical and empirical research on human capital, education has been acknowledged as generating externalities that increase the quantity and quality of labor force and contributing to growth. The most often used indicator is the panel dataset of Barro and Lee (1993; 2001) average years of education which consists of five-yearly country-level data on average years of schooling in the population. These data are used in many empirical applications of the new growth theories, with the growth of per capita GDP as the dependent variable, but generally result in implausibly low human capital coefficients (see for example studies by Benhabib and Spiegel 1994; Barro and Sala-i-Martin, 1995; Barro 1997, 2001; and Temple 1998).

More interestingly, these analyses generally find that it is the level and not the growth of human capital that yields a slightly positive and significant coefficient. This points to the theory of Romer (1990) in which human capital is seen as a facilitator of technology. Many of the current proxies are based on educational enrolments. The general finding is that more educated individuals tend to produce more output. This has provided a strong rationale for improving human capital through education in both the developing and developed countries to realize further growth from increased human capital. However, it also emerges that most of the research work define human capital as education.

While the literature contributes to the understanding of the role of human capital on growth and development through knowledge accumulation and the ensuing spillover effects, it still remains important to understand how other components of human capital contribute to growth. The human capital theory emphasizes health as one of the components of human capital besides education. The main argument is that healthy individuals are less absent from work and this will have positive implications for productivity and growth (Weil, 2006). Also, healthy individuals are also at an advantage to learn and acquire education compared to less healthy. These two variables interact in that a more educated labour force is also more aware and more healthy. It is therefore important to provide some analysis of the impact of health and education as determinants of human capital are captured to fill the gap that exists in the literature.

Also, this review has shown that existing studies on human capital and growth have not explicitly considered the role of the government budget constraint in a framework that captures the human capital as health and education. The possible implications of the public debt are mainly on growth and do not explicitly analyze the impact of the public debt on the development of human capital as it relates to health and education in developing countries where the high debt still remains a challenge. This presents an information gap which can be filled through analysis that integrates these aspects. Our research therefore aims to fill these gaps and contribute to the ongoing debate and policy dialogues on the role of human capital on growth and development where we capture the main components of human capital but also feature the role of the public debt, government spending and fiscal policy rules in the analytical framework.

We note from the empirical applications that a number of studies have been cross country in nature, where the impact of human capital is assumed to be homogenous across countries. The sample selected in the cross country regressions is also usually a mix of developing and developed countries. Also in some cases, the literature on human capital has focused on a set of developed countries since there have been data limitations for developing countries with poor quality data on human capital indicators such as education. Cross country studies hide large parameter heterogeneity which may be the case in developing countries where there are widespread variations in economic performance and levels of development. Equally, the relation between human capital and economic growth may be nonlinear, i.e. for example depending on the level of human capital already attained and in most of the cross country studies, a linear specification is adopted which does not permit non-linearities in the parameter estimations process.

It is therefore of interest in this thesis to also give a time series perspective to the analysis since the data on education and health has improved and is available for some of the education and health indicators on a consistent basis. Moreover, the set of selected countries is specifically from Africa and it captures a wide number of countries from various regions in the continent. Also, the estimation process allows for non-lineraities in the country specific parameters estimated which are used to assess the dynamics of human capital within the model framework developed. In this way, we fill one of the gaps in the literature with regards to another methodological approach for analysis, estimation technique within a time series perspective.

2.3. Macroeconomic, Health and Education Profiles of Selected Countries

This section focuses on a descriptive analysis of the macroeconomic, health and education profiles in the selected set of African countries. This is mainly to shed light on trends in developing countries before doing the empirical analysis. The descriptive evidence allows for an appreciation of the macroeconomic backgrounds of the sample of countries in terms GDP growth, levels of development and economic performance in the focus countries. The indicators of health and education provide a snapshot of the current profiles on the trends and

changes in health and education. This information allows for a comparison among the countries, where there is representation of middle income countries and low income countries. This is one aspect which is lacking from the previous studies which shows the macroeconomic, health and education profiles in the analysis. Such information can also add to our understanding and appreciation of the parameters estimated in a heterogeneous estimation setting.

2.3.1 Comparative Analysis: Macroeconomic and Fiscal Dynamics

Table 2 reports selected macroeconomic indicators which include the population which serves as a guide of the size of the economy and its market size. An indicator of economic performance and extent of income, mainly the GDP per capita is also highlighted for selected years. The GDP growth rate giving a snapshot of trends in the growth over time since 1980 is reported as well as a measure of development based on the human development index. A select of fiscal indicators with insight on the issues of research interest reported include the debt/GDP ratio and the debt service ratio to show the extent of the public debt in the selected countries. The extent of aid dependency is also reported.

Table 2: Macroeconomic Indicators for Selected Years

		Botswana	*South Africa*	*Zambia*	*Malawi*	*Kenya*	*Tanzania*	*Uganda*	*Cote D'Ivore*	*Ghana*	*Nigeria*
Population (millions)	1980	1.0	27.6	6.1	6.3	16.3	18.9	12.6	8.3	11.3	68.4
	1990	1.4	35.2	8.4	9.5	23.4	26.2	17.8	12.7	15.5	90.6
	2000	1.8	44.0	10.7	11.8	30.7	34.8	24.3	16.7	19.9	117.6
	2008	1.8	46.0	11.6	14.3	34.8	37.6	29.0	17.9	22.5	185.0
GDP per capita (US$)	1980	1077	3463	450.5		435.2	.. 255.7	173.5	923.5	233.6	425.3
	1990	2222	3152	361.4		450.6	271.8	174.0	653.7	211.0	357.5
	2000	2994	3020	302.5		414.0	312.9	243.8	623.0	250.5	357.8
	2008	4284	3447	339.5	257.0	443.9		278.2	597.5	289.8	405.6
GDP growth (real annual %)	1980	12.0	6.6	3.0	0.0	5.6	3.8	5.7	-11.0	0.5	4.2
	1990	6.8	-0.3	-0.5	6.0	4.7	2.1	6.5	-1.1	3.3	8.2
	2000	7.6	2.7	3.6	2.0	0.6	5.1	5.4	-3.3	3.7	4.2
	2008	5.4	3.6	2.3	5.0	4.3	1.2	4.7	1.6	2.8	5.7
Human Development Index (HDI)	1980	0.624	0.67	0.478	0.379	0.514	..	0.42	0.448	0.471	0.391
	1990	0.674	0.731	0.477	0.390	0.556	0.421	0.434	0.450	0.517	0.411
	2000	0.658	0.707	0.431	0.478	0.529	0.433	0.480	0.432	0.568	0.445
	2005	0.664	0.67	0.437	0.484	0.521	0.467	0.505	0.432	0.553	0.470

Source: World Development Indicators (2008) and UNDP Human Development Reports for various years.

From the selected sample, some countries such as Nigeria are large in terms of having one of the largest population estimated at over 180 million. South Africa follows as one of the larger countries in Southern Africa compared to Zambia and Malawi. In the East Africa, Tanzania and Kenya are also quite big countries with a population of about 40 million people. Botswana has the smallest pollution of less than 2 million. It is, however, interesting to note the highest GDP per capita and the annual growth rate achieved in Botswana over the 1980-2008 period compared to other countries which also exceeds that of developed countries. Botswana and South Africa are more developed as indicated by the higher human development index, which also shows that they have made significant strides on indicators of human development such as on social indicators of education and health.

The human development index shows that for some countries, there has been a decline on growth and development over time in the cases of Zambia and Cote d'Ivore while only modest strides have been attained in Malawi, Kenya, Tanzania, Ghana and Nigeria. For these countries, where social development has regressed and lagged behind, it also emerges that

the per capita GDP has remained low (below US$500 in most countries) and in some countries declining, notably in Zambia, Cote d'Ivore and Nigeria. The decline in the per capita income is associated with increasing poverty in these countries since social improvement through resources has been constrained by the lack of government resources to be committed on a sustainable basis in the social sector[12]. This may show that such countries have also not made significant progress on health and education indicators. On the other hand, Botswana and South Africa have made substantial progress on the human development front with the index being well over 60% since the 1980s. Also, the per capita GDP in these countries is higher, standing at more than US$3000 compared to other countries with per capita income of less than US$400 on average.

There are stack differences in the macroeconomic environment in terms of growth performance in the selected countries which indicates that human capital development and its impact on growth and development will vary based on the strength of the economy and domestic resources. The annual GDP growth rates differ across these countries with some countries experiencing faster growth and slower growth in some periods. Generally, growth is slower and sometimes negative in Zambia, Cote d'Ivore, Ghana and Tanzania. Botswana records the highest growth rate in the sample period compared to other countries. This points to higher levels of economic and social development attained in the country over the years which has led to the high development of human capital in the form of health and education.

With regards to the reliance on aid and external resources, there is an eminent increase in the dependency on aid for countries that have experienced slower growth and declining human development and per capita income (*refer to Table 3*). This is observed in the case of the Zambian economy, Cote d'Ivore, Tanzania, Uganda Ghana and Nigeria. The rise in the dependency on aid is quite substantial in the case of Zambia. This possibly indicates that the country had to rely on external sources to mitigate against the effects of declining incomes and growth. Less developed countries tend to depend on aid for financing of social programmes and other development programmes since they cannot count on the strength of their domestic resources for continued sustenance and growth. Research by Rogoff (2004) and Roodman (2004) have also found that less developed countries have a higher significant dependence on aid to support growth although it cannot be an engine of growth.

[12] Rogoff (2003) Gupta (2003), Easterly Levine and Roodman (2003)

From *Table 3* below, it is also notable that the debt/GDP ratio in the lesser developed countries with lower growth rates and development is quite high, exceeding over 40% of GDP on average since the 1980's. The debt/GDP ratio also tends to fluctuate, going up and down, reflecting that as the debt goes down it also recurs in the future. This reflects the trend in the past where countries that have been characterized by high public debt have received assistance through debt imitative programmes, but following decision point and cancellation, they have often slid back into the debt[13] since domestic resources have not carried the economy through soundly to ensure fiscal sustainability.

Table 3: Aid per Capita, Debt/GDP Ratio and Total Debt Service for Selected Years

		Botswana	*South Africa*	*Zambia*	*Malawi*	*Kenya*	*Tanzania*	*Uganda*	*Cote d'Ivore*	*Ghana*	*Nigeria*
Aid per capita	1980	101.4	..	52.6	23.2	24.4	36.0	9.0	25.2	17.0	0.5
	1990	102.8	7.3	57.3	53.1	50.6	44.7	37.6	54.3	36.3	2.9
	2000	17.5	11.1	74.3	38.8	16.7	29.1	25.1	21.0	31.7	1.6
	2007	22.1	13.7	95.1	87.8	19.7	46.4	41.7	14.3	62.7	4.5
Debt/GDP (%)	1980	..	..	..		35.4	..	..	..	..	..
	1990	..	..	244.4	115.5	24.2	..	..	198.2	..	..
	2000	11.4	45.3	176.2	83.6	27.9	..	57.0	105.1	..	..
	2006	..	36.9	..	30.0	27.6	..	44.9	..	..	..
Total Debt Service (% of exports and income)	1980	1.9	..	25.2	28.0	21.0	21.1	17.3	38.7	13.1	4.1
	1990	44.3	9.4	14.7	29.0	35.4	32.9	81.4	35.4	38.1	22.6
	2000	2.0	9.8	19.4	13.0	20.9	12.8	7.8	22.6	15.6	8.2
	2003	1.2	8.8	20.2	..	16.1	5.3	6.9	6.9	6.6	8.2

Source: World Development Indicators (2008) and UNDP Human Development Reports for various years.

The high debt/GDP percent also links to the high total debt service measured in terms of the percentage of exports and income. This ratio is found to be high for countries with a high

[13] Clements *e.t al* (2003), Patillo *e.t al (2002) l* and Chowhodry (2001) finds evidence that developing countries that have been assisted though the Highly Indebted Poor Country Initiative and other debt facilities such as the Multilateral Debt Relief Initiative, they appear to be more prone to the persistence of debt and often stay in the debt trap for many years. Even following cancellation of the debt, the county is more likely to slide back into debt shortly after since the resources are not adequate, the fiscal stance and space remains weak and volatile to ensure sustainability

debt/GDP ratio which simply indicates the toll of the high debt burden carried by the highly indebted countries. South Africa and Botswana do not have high debt/GDP ratios as well a high debt burden. A high debt burden has been found in numerous studies to adversely affect growth and development. The high debt also takes away resources that could be committed to priority sectors such as social development of human capital. It is possible that the slower and declining human development in countries with high debt shows that the high public debt is diverting resources on the improvement of health and education. For example in Zambia, Cote d'Ivore and Malawi, human development has declined and the public debt has been high with a high debt service. In such countries, one may find that even the indicators for health and education are lower and declining since domestic resources are not adequate or sustainable to maintain and develop health and education.

2.3.2. Comparative Analysis: Health and Education Patterns

A number of health and education indicators and their patterns for selected years are presented in *Table 4* and *5,* respectively. These indicators are compared in the selected set of Africa countries but they are also compared with those for developed regions and emerging market economies such in East Asian Countries, United Kingdom and United States of America.

There is a general decline in the health and education indicators especially in those countries where we have observed poor macroeconomic performance based on indicators of human development, economic performance and GDP growth rates. In *Table 3*, I provide patterns and trends in a number of health indicators notably for life expectancy at birth in total years, human development index of life expectancy, infant mortality rate per 1000 live birth as well as the mortality rate for under 5 years per 1000. There is a marked decline in life expectancy across all the countries which is also associated with declining average growth rates since the early 1980's observed in all the countries in the sample. This shows a possible positive correlation between life expectancy and economic growth. It is also important to note that the decline in life expectancy in African countries during this period has largely been compounded by the HIV/AIDS pandemic, where the prevalence rate in countries such as

Botswana which had one of the highest life expectancies in the 1980's in the region due to the advances made on social development, experienced significant declines in this indicator.

However, the provision of anti-retroviral drugs for free has served to reverse the negative impact of the HIV/AIDS pandemic on life expectancy as seen from the increase in life expectancy observed in Botswana since 2006. There is an observed improvement in life expectancy in Uganda, also an economy that was at the forefront of the use of anti-retroviral drugs in the treatment of HIV/AIDS which had also significantly affected the country. It is clear that in general, there is a turnaround in the life expectancy measure which shows an increase in recent years across countries. The life expectancy index shows very low performance for less developed countries which also fall into the class of highly indebted countries. In these countries, there is also evidence of poor economic performance in terms of lower growth, per capita GDP and overall social development achieved. Mortality rate show a decline in the early 1990's with some recovery in the late 2000.

In general, the trend between the indicators point to a possible positive correlation between GDP growths, the human development index and health measures. That is, it appears that when growth and social development is lower, indicators of health also fall or are on the lower side. In the case of the public debt, there is a discernible pattern indicating that countries with higher public debt and higher debt service obligations are those that are characterized by the lower health indicators. This indicates a possible negative correlation between the public debt, debt service and some health indicators. In the empirical estimations, more formal estimations are carried out to test the association between health, using life expectancy as an indicator of health and output to assess its impact on growth. This is mainly to determine quantitatively the relationship.

Table 4: Health Indicators and Patterns for Selected Years

		Botswana	South Africa	Zambia	Malawi	Kenya	Tanzania	Uganda	Cote D"Ivore	Ghana	Nigeria
Life expectancy at birth, total (years)	1980	61.8	57.1	51.6	45.0	57.8	53.7	50.1	53.4	53.0	45.3
	1990	64.5	61.9	45.8	49.0	57.1	53.5	45.7	51.7	56.2	46.4
	2000	42.7	47.8	37.9	46.3	47.7	46.8	45.1	46.6	56.6	43.8
	2008	48.9	44.6	40.5	48.0	48.3	46.2	48.9	47.4	57.2	43.7
HDI life expectancy index	1980										
	1990										
	2000										
	2007	0.385	0.430	0.259	0.456	0.451	0.434	0.412	0.373	0.568	0.359
Mortality rate, infant (per 1000 live births)	1980	62	64	90	115	73	106	107	114	96	117
	1990	45	45	101	110	64	102	93	103	75	120
	2000	74	50	102	103	77	88	85	115	68	107
	2008	84	54	102	89	79	78	80	117	68	102
Mortality rate, under-5 yrs (per 1000)	1980	84	91	155	255	115	175	185	172	157	228
	1990	58	60	180	209	97	161	160	157	122	230
	2000	101	63	182	170	117	141	145	188	112	207
	2004	116	67	182	110	120	126	139	194	122	197

Source: World Development Indicators (2008) and UNDP Human Development Reports for various years.

Similar observations in terms of the qualitative analysis of education indicators are observed as in the case of health indicators. We observe that high growth countries such as Botswana and South Africa have significantly higher adult literacy rates compared to the low and less developed countries in the sample. These countries also have higher levels of social development as indicated by the human development index which portrays the strides made on the improvement of social indicators which include health and education. The same pattern is seen in the case of the average years of schooling which pertains to individuals over 25 years of age. These average years of schooling are derived following Barro and Lee (1990) and the data is not consistent available for the selected years.

Table 5: Education Indicators and Patterns for Selected Years

		Botswana	South Africa	Zambia	Malawi	Kenya	Tanzania	Uganda	Cote d'Ivore	Ghana	Nigeria
Adult literacy rates (% over 15 years)	1980										
	1990	68.1	81.2	68.2	66.0	70.2	62.9	56.1	38.5	58.5	48.7
	2000										
	2008	81.2	82.4	68	71.2	73.6	69.4	66.8	48.7	57.9	58.0
Average years of schooling (over 25 years)	1990	4	4.8	4.1	2.4	2.8	..	1.4	..	2.8	..
	2000										
	2005										
Total combined enrollment ratio (%)	1980										
	1990										
	2000										
	2008	69.5	77	60.5	63.1	60.6	50.4	63	39.6	50.7	56.2
HDI Education Index	1990										
	2000										
	2008	0.773	0.806	0.655	0.638	0.693	0.631	0.655	0.457	0.555	0.648

Source: World Development Indicators (2008) and UNDP Human Development Reports for various years.

The enrollment ratio is also markedly higher in Botswana and South Africa at more than 70% while it stands at about 60% for Zambia, Malawi, and Uganda. Countries such as Cote d'Ivore, Ghana, Tanzania, Kenya and Nigeria have relatively lower total combined enrollment ratio. Again, there is an observed positive correlation between the performance of education indicators and the indicators of economic performance and social development. Higher growth and economic performance seem to be associated with higher education outcomes while lower economic and social performance is associated with lower education outcomes. Formal tests of these relationships are left for the chapters where I carry out the empirical analysis on the relationships between growth, health and education.

Studies show that countries with higher levels of education and skill have on average, higher levels of productivity and economic growth (Barro 1990, Barro and Sala-i-Martin, 1995). Since the 1970s most African countries, especially those within the sub-Saharan region have registered dismal or negative economic growth as measured by changes in the gross national

product (GNP) per capita (Easterly and Levine, 1997). Many of the countries in Africa have also registered low human development index. As evident from a sample of countries presented in the above tables, only Botswana and South Africa experienced reasonable social development and have attained notable improvements in the indicators of health and education compared to other countries. Other countries perform moderately while for some countries such as Zambia, Ghana, Nigeria, Cote d'Ivore and Tanzania, the performance on health and education indicators is rather on the lower side.

It is likely that most of the lesser developed countries found it even more difficult to deal effectively with improving health and education due to the high debt and debt service. Studies by Clements *e.t al* (2003), Chowhoudry (2001) and Stijn *e.t al* (1997) note that the high public debt in developing countries crowd out resources and divert them from use in priority sectors since countries have to service the debt[14]. A number of factors are highlighted as causing the poor economic performance in African countries and these include drought, poorly developed infrastructures, lack of both human and physical capital, bad governance, political violence and ethnic wars, and diseases such as HIV Aids and large dependence on primary products which cannot be exported to generate sustainable resources for growth and development (Easterly and Levine, 1997).

2.3.3 Comparative Analysis: Expenditure Patterns on Health and Education

The role of infrastructure in the development of health and education has been emphasized in the literature (World Bank, 1988, Shantayanan, Swaroop and Zou, 1996). Government expenditures, through the provision of resources for the development of the social sector such as in the health and education sectors also plays an important role in providing resources to enhance the performance of the health and education sectors so that they can effectively boost growth (World Bank, 2004). Human capital development is essential for attracting investment and providing the necessary skills required to promote productivity and labour effectiveness which should impact positively on growth. This is the main reason why many countries, both developed and developing have found it vital to provide resources,

[14] Other studies include those of Sachs (1986, 1989), Patillo *e.t al* (2002, 2004)

infrastructure in the health and education sectors to facilitate and promote their development since they confer positive benefits for growth and development. Other countries have also relied of external resources to develop the social sector where there are resource constraints or when resources are limited.

A number of selected expenditure resources in the education and health sectors are presented in *Table 5* and *6* for the sample countries. There is a high and pronounced reliance on external resources for health in Zambia, Cote d'Ivore, Tanzania, Uganda, Ghana and Nigeria. It is interesting to note that these are the countries where in the preceding sections we have found to be characterized by poor economic performance, high debt/GDP ratio and debt service as well as being highly dependent on aid. The indicators of both health and education were also found to be lower in these countries. There is very low insignificant reliance on external resources in the case on Botswana and South Africa economies.

Table 5: Expenditure Indicators and Patterns on Health for Selected Years

		Botswana	*South Africa*	*Zambia*	*Malawi*	*Kenya*	*Tanzania*	*Uganda*	*Cote D'Ivore*	*Ghana*	*Nigeria*
External resources for health (% of total expenditure on health)	1998	2.4	0.2	24.2	29.0	12.8	31.0	30.9	2.3	6.7	13.1
	2000	1.8	0.4	18.2	18.5	13.2	32.1	28.3	2.9	12.8	16.2
	2007	2.9	0.5	44.7	25.6	15.3	21.9	28.5	30.4	15.8	5.3
Health expenditure per capita (current US$)	1998	133	271	21	14	19	9	15	47	20	16
	2000	152	236	17	13	18	12	16	30	13	18
	2008	232	295	21	15	20	12	18	28	16	22
Health expenditure, total (% of GDP)	1998	4.8	8.9	6.5	8.3	4.9	3.7	5.3	5.8	5.1	5.5
	2000	5.4	8.1	5.5	6.8	4.3	4.4	6.6	4.7	5.4	4.3
	2007	5.6	8.1	5.4	5.4	4.3	4.3	7.3	3.6	4.5	5.0

Source: World Development Indicators (2008) and UNDP Human Development Reports for various years.

Health expenditures per capita in Botswana and South Africa are higher at more than US$200 while for other countries the average is only less than US$30. This shows that there is higher commitment of resources to the health sector in Botswana and South Africa compared to other countries and this may serve to justify the marked high indicators of health

and social development observed in these countries. Health expenditure as percent of total GDP is comparatively higher for these two economies, indicative of the government resource commitment to health. The same finding holds in the case of education expenditure indicators. Less developed countries commit lower resources to education on average as shown by the lower expenditure as percent of GDP committed by government in this sector.

Table 6: Expenditure Indicators and Patterns on Education for Selected Years

		Botswana	*South Africa*	*Zambia*	*Malawi*	*Kenya*	*Tanzania*	*Uganda*	*Cote D"Ivore*	*Ghana*	*Nigeria*
Total Public spending on education (% of GDP)	1991	6.2	6.0	2.8	..	6.7	2.8	1.5	5.3	..	0.9
	2001	2.2	5.3	2.0		6.3	2.2	2.5	4.6		..
	2004		5.4	2.8		7.0		5.2			..
Total public education spending (% of government expenditure)	1991	17.	22.2	7.1	11.1	17.0	11.4	11.5	25.5	..	..
	2000	25.6	23.4	..		22.6	..	..	21.5	..	..
	2004		18.1	14.8	15.0	22.1	..	18.3			

Source: World Development Indicators (2008) and UNDP Human Development Reports for various years.

What emerges from the quantitative analysis of macroeconomic, health and education indicators in the set of selected Africa countries is that lesser developed countries are characterized by poorer economic performance and lower GDP growth rates and they lag behind in terms of social development. Such countries also have a high debt burden and the debt service ratio is higher and thus there is extensive reliance on external resources to sustain other development goals. In these countries, the education and health indicators perform poorly compared to those found in high growth countries such as in the case on Botswana and South Africa where there is better economic performance, low reliance on aid and lower debt burdens. There are limited resources being committed to the development of health and education in less developed countries.

These findings show that there are constraints to developing human capital such as the high debt which could take away resources that may be committed to the development of these sectors. Also, limited government resources among competing priority sectors may also not

be adequate to pursue the development of human capital and hence such countries end up lagging behind in terms of social development and overall economic performance. In general, from the descriptive analysis of the data, there appears to be is a positive association between the indicators of economic performance, health and education indicators. There also appears to be a negative association between high debt in a country and the indicators of health and education. This stems from the observation that poorer and less developed countries tend to be characterized by lower performing indicators of health and education. At the same time, high performing economies such as South Africa and Botswana with good economic performance have higher and better education and health indicators. In this case there seems to be a positive correlation between indicators of economic performance, health and education. Also, countries with higher public debts are also the same countries characterized by a high dependence on external resources, poor education and health performance. On the other hand, for low debt countries, reliance on aid and external resources is also very low and negligible while the education and health indicators perform better. This points to a possible negative correlation between high debt burden and education/health. From this qualitative assessment, it is clear that there is a need to substantiate this descriptive evidence with a more rigorous empirical assessment. Against this background, chapter 3 and 4 aim to explore these issues in greater detail to answer the emerging questions from this qualitative assessment which include:

- What is the relative impact of health and education on growth?
- What are the magnitudes of this impact?
- How would output react to increases in health and education temporarily and permanently?
- What are the possible implications of the public debt to health and education under different fiscal policy rules for sustainability?
- How would committing more resources to health and education through increasing government spending in these sectors affect health, education and output?
- Are there interactions between health and education?

This qualitative assessment in this regard, sets the main research questions for the thesis as elaborated in the introductory section where the aims are to investigate the relative impact of health and education on output and measure the magnitude of the impact. In the second stage,

therefore, the interest is to assess the possible implications of the public debt on human capital development and growth. The qualitative assessment here is being given the empirical dimension in Chapter 3 where we formulate a macroeconomic model to assess the relative impacts of health and education as well as in Chapter 4 where the analytical framework is extended to capture the government budget constraint to bring forth the issues of the public debt and government spending in the model. Issues relating to interactions between health and education are discussed in *Section 2.4* on the stylized facts.

2.3.4 Correlation Matrices: Growth, Health and Education Indicators

The correlation matrix show the possible association between variables on interest, whether they move together positively, or negatively. In *Table 7*, a summary of the correlations between an indicator of macroeconomic performance and growth (GDP) and some health and education indicators are given for the selected countries. For those countries where data was available for the physical capital stock in the health and education sectors, this data is reported in the matrix, particularly for South Africa and Botswana. The variables included in the correlation matrices are as defined below:

- GDP: Growth in real GDP
- PHYCAP: Total Physical Capital Stock
- ED_PHYCAP: Physical capital stock in the education sector
- HE_PHYCAP: Physical capital stock in the health sector
- LIFEX: Life expectancy in years
- TE_Ratio: Total enrollment ratio
- LITRATE: literacy ratio

Table 7 Correlations between GDP, Health and Education Indicators

Correlation Matrices for Economic Permance, Health and Education Indicators

Botswana

	GDP	PHYCAP	ED_PHYCAP	HE_PHYCAP	LIFEX	LITRATE	TE_RATIO
GDP	1.000						
PHYCAP	0.983	1.000					
ED_PHYCAP	0.951	0.930	1.000				
HE_PHYCAP	0.681	0.586	0.699	1.000			
LIFEX	0.806	0.707	0.796	0.886	1.000		
LITRATE	0.973	0.988	0.912	0.833	0.764	1.000	
TE_RATIO	0.982	0.954	0.943	0.778	0.836	0.937	1.000

South Africa

	GDP	PHYCAP	ED_PHYCAP	HE_PHYCAP	LIFEX	LITRAT	TE_RATIO
GDP	1.000						
PHYCAP	0.965	1.000					
ED_PHYCAP	0.961	0.910	1.000				
HE_PHYCAP	0.781	0.586	0.799	1.000			
LIFEX	0.927	0.692	0.696	0.786	1.000		
LITRAT	0.264	0.901	0.912	0.583	0.918	1.000	
TE_RATIO	0.495	0.895	0.943	0.778	0.606	0.900	1.000

Malawi

	GDP	PHYCAP	LIFEX	TE_RATIO	LITRATE
GDP	1.000				
PHYCAP	0.706	1.000			
LIFEX	0.772	0.751	1.000		
TE_RATIO	0.880	0.694	0.960	1.000	
LITRATE	0.800	0.608	0.865	0.938	1.000

Zambia

	GDP	PHYCAP	LIFEX	TE_RATIO	LITRATE
GDP	1.000				
PHYCAP	0.826	1.000			
LIFEX	0.715	0.803	1.000		
TE_RATIO	0.794	0.603	0.748	1.000	
LITRATE	0.881	0.706	0.825	0.721	1.000

Kenya

	GDP	PHYCAP	LITRATE	LIFEX	TE_RATIO
GDP	1.000				
PHYCAP	0.723	1.000			
LITRATE	0.890	0.934	1.000		
LIFEX	0.779	0.841	0.684	1.000	
TE_RATIO	0.876	0.757	0.800	0.868	1.000

Tanzania

	GDP	PHYCAP	TE_RATIO	LIFEX	LITRATE
GDP	1.000				
PHYCAP	0.790	1.000			
TE_RATIO	0.929	0.907	1.000		
LIFEX	0.775	0.877	0.842	1.000	
LITRATE	0.889	0.966	0.954	0.913	1.000

Uganda

	GDP	PHYCAP	TE_RATIO	LIFEX
GDP	1.000			
PHYCAP	0.893	1.000		
TE_RATIO	0.968	0.912	1.000	
LIFEX	0.714	0.787	0.814	1.000

Cote d'Ivore

	GDP	PHYCAP	TE_RATIO	LIFEX	LITRATE
GDP	1.000				
PHYCAP	0.704	1.000			
TE_RATIO	0.891	0.617	1.000		
LIFEX	0.781	0.603	0.966	1.000	
LITRATE	0.836	0.573	0.986	0.990	1.000

Ghana

	GDP	PHYCAP	TE_RATIO	LIFEX	LITRATE
GDP	1.000				
PHYCAP	0.855	1.000			
TE_RATIO	0.689	0.886	1.000		
LIFEX	0.660	0.858	0.778	1.000	
LITRATE	0.783	0.797	0.739	0.973	1.000

Nigeria

	GDP	PHYCAP	TE_RATIO	LIFEX
GDP	1.000			
PHYCAP	0.741	1.000		
TE_RATIO	0.710	0.801	1.000	
LIFEX	0.701	0.612	0.702	1.000

There is an apparent strong positive association between the performance of GDP and the physical capital stock. In the case of Botswana and South Africa, where there is data for the physical capital stock in the health and education sectors, it can also be observed that health and education indicators such as life expectancy, literacy rates and the enrollment rations are positively correlated with the physical capital stock in these sectors. While this offers a guide and insight into the associations or correlations based on the data, correlation matrices are useful in that they also serve to highlight what possible relationships may be between variables though not giving information on the directions of causality.

The observations from the correlation matrix are in line what has come out of the discussions and descriptive analysis where we conduct some comparisons. Mainly, there seems to be some notable pattern of the macroeconomic environment in terms of its performance and the existing health and education profiles based on some of the indicators. The strength of the correlations seems to be lower for example between growth, health and education for lesser developed countries such as in the cases of Zambia, Cote d'Ivore, Malawi, Uganda and Tanzania and Nigeria. This evidence is complemented by more rigorous analysis in Chapter 3 and 4.

2.3 Stylized Facts on Human Capital, Public Debt and Growth

A number of stylized facts in relation to human capital and growth are worth highlighting and discussing in this thesis since they have a direct bearing on both the qualitative and quantitative assessment of the role of health and education on growth. These include the issues of possible interactions between health and education, the delayed effects between variables and policy initiatives with a bearing on the fiscal dynamics. In the next sub-sections, we focus greater detail to discussing these stylized facts. The issues are not exhaustive and the ones we chose to focus our attention on here are those deemed critical within the scope of the thesis and empirical analysis at hand.

2.4.1 Interactions between Health and Education

There are possible links and interactions between health and education worth understanding in the context of this thesis which may have implications for the analysis. These links have a bearing on the impact assessment in the empirical framework we develop.

A number of studies on health outcomes on health indicators and measures have been carried out and reveal possible links and channels through which health and education interact. This literature is mainly dominated by the micro literature[15] on biological and social sciences which examines the effects of varying health inputs on health outcomes themselves, human capital attributes that are contingent on health outcomes, and wages which show benefits of better health on productivity. They find that better nutrition leads to improvements in school completion, IQ, height, and wages. Studies of the effect of adult nutrition (Strauss, 1986, Strauss, 1997, Basta *et al.* 1979, Thomas *et al.* 2004) similarly find positive effects on labor input and wages. Other panel data assessments by Barro and Sala-i-Martin (1995) and Barro (1997) use indicators of health to elucidate the economic relationships between health and growth.

The mechanisms by which education influences health are also complex and are likely to include (but are not limited to) interrelationships between demographic and family background indicators, effects of poor health in childhood, greater resources associated with higher levels of education, a learned appreciation for the importance of good health behaviors, and one's social networks (Cutler and Lleras-Muney, 2007).

For many health outcomes, there are positive health consequences related to increased education. There are several possible reasons for this: 1) less educated people are less likely to survive into older age, but those who do are relatively healthy and hence less different from the more educated; 2) education may have become more important to health outcomes in recent years; and/or 3) the relationship between education and health may be less significant once adults retire

According to Cutler and Lleras-Muney (2007), there are three broad explanations for the association between health and education, although they recognize that these do not represent

[15] Refer to a review by Weil (2006)

an exhaustive list. The first is that poor health leads to lower levels of schooling, since poor health in childhood is linked to poor health in adulthood. However, it is unlikely that the correlation between child health and adult health fully explains the relationship between adult health and completed education. The second potential explanation is that additional factors, such as family background or individual differences, both increase schooling and improve health. Some researchers suggest that the relationship between education and health can be explained by unobserved factors and skills, such as the ability to delay gratification, that make better educated individuals healthier.

The third potential explanation for the link between education and health is that increased education directly improves health. Quasi-natural experiments have demonstrated causal influences of various changes in educational policies and of maternal education on health outcomes and also that increasing own education improves one's own health. There are other potential mechanisms that could also affect the relationship between health and education. One important mechanism is income, as greater financial resources may enable more access to health care.

Such links and interactions have implications on the treatment of health and education in isolation of each other, that is, assuming that they can be modeled separately as components of human capital. In this regard, it becomes imperative to highlight the channels and mechanism and shed light on how this issues of non-separability or separability and possible interactions between health and education is being handled and addressed from both a qualitative and quantitative angle in this thesis. Having noted the possible interactions between health and education, the approach therefore adopted in this thesis is to develop an index of human capital which constitutes of health and education as components of human capital. The estimations are then carried out for the case where we assess the relative impact of the two when they are separate and re-estimate the dynamics of the model using the human capital index to take care of the possible limitations of treating them as two separate entities. Hence, the approach taken to formulate the human capital index would largely influence the results obtained in this framework.

2.4.2 Endogeneity between Health and Education

Endogeniety between variables, if it exists, can bias the estimations obtained, resulting in inconsistent parameter estimates. In this case, the results of hypothesis testing will be misleading. This therefore, requires away of separating genuine exogenous variations in variables that might be endogenous. Also, this requires testing to what extent endogeneity is a problem in the data and adopting solutions to deal with the endogeneity problem. There are two ways of dealing with endogeneity which are being followed in the literature. One method is variable instrumentation where one carries the estimations with a number of variables instrumenting for one of the variables (Hausman, (1978). This is the IV method where proxies that do not suffer from the same endogeneity problem as the suspect variable are used (Wooldridge, 2002). This technique is often limited in that it requires data for a number of indicators of a variable. For example in the case of our analysis, adopting the technique is limited by the data unavailability on a number of health indicators consistently for all the countries in the sample. Similarly in the case of education indicators, there is limited information on other variables which can be used to instrument for enrollment ratios in the set of selected African countries. Adult literacy rates are available for a few countries, notably in Botswana and South Africa while in other countries the data it is not available consistently for the period under consideration.

One common approach is to lag the suspect variables by one or more periods. The argument is that although current values of a variable might be endogenous, it is unlikely that past values will suffer from the same problem (Wooldridge, 2002) This approach is found to be intuitively appealing in the context of our research in that the use of lags also enriches our results in dealing with the argument that there is a time lag on the impact effects of health and education on growth. In this regard, using lags of these variables to address the endogeniety problem also enriches the issues being assessed since we also assess the role of past health or education in the model. Also, given the data limitations in having other proxies for these variable and on a consistent basis for the selected set of African countries, this approach reduces the problem of additional data requirements the data problem. Also, given that the framework developed in the thesis is dynamic in its setting, testing many proxies in the IV method is cumbersome and hence, the use of lags to resolve the possible endogeneity

problem health and education variables is much simpler to implement and still maintain both the logical tractability of the model.

The other test is to directly test for the extent of the endogeniety problem. This entails testing the null hypothesis of exogeneity against and alternative hypothesis of endogeniety using the Hausman test. A higher value of the test statistic implies a more serious endogeniety problem especially if the null is rejected at 10% level of significance (Hausmann, 1978). The procedure followed is to first estimate the equation with the suspect variables, save the residuals, then running the regression with the residuals and then and testing the joint significance of the first stage residuals.

2.4.3 The Role of Lags and Effects

There are also stylized facts with regard to the issue of the lag effects of the impact of health and education on growth as well as on the impact effects of government spending and the public debt on health, education and growth. Lag effects are mainly related to the delayed time for the feed through mechanism which operates between these variables to take effect immediately. As such, some impacts may not be automatically be direct, but take time to take effect. Lag effects determine how quickly or slowly, for example, a shock to one variable takes for its effect to be felt or seen in another variable. These are important particularly with regards to human capital where knowledge is accumulated over time. As such, current education would take time to impact on growth or health, hence the delayed effect on output and growth. Similarly, in the cases of the impact of government spending and the public debt on human capital, there are lag effects in that current spending may be used to first build the infrastructure for education and health before being utilized leading to the impact on health and education to be fed through the dynamics of the model with a time lag.

In the model framework and approach adopted in the thesis, mainly where we test for the reaction of output to temporary and persistent shocks on health and education, it is possible to discern the delayed impact from the impulse response functions. Similarly, when conducting the empirical investigations of the impact of the public debt or government

spending on health, education and growth, the delayed effects can be seen in the reaction functions following the dynamic simulations of both temporary and permanent shocks.

What is important for the analysis is that the results obtained from empirical estimations where there are delayed effects, require caution in their interpretations. Also, in these analyses, the conclusions drawn should be treated as indicative over time. It is also critical to observe the time it takes for the impact to take effect, for example how many years the impact lasts and how many years a change in one variable takes to impact on the targeted variable. The length of decay, which shows on average how long shocks take to die out, is also an important aspect in this analysis where the impacts take time to feed through and impact on output, health or education.

2.4 Summary

From the survey of the literature on the role of human capital and growth, it is clear that human capital remains largely identified with education[16]. Also, a number of studies from the survey do not include the government budget constraint to capture some of the fiscal dynamics and challenges such as the high public debt prevalent in developing countries for an integrated assessment. A number of empirical applications on human capital and growth have been cross country in nature with the impact of human capital being assumed to be homogenous across countries. The studies have also been dominated by developed country case studies due to poor quality data for developing countries. In this regard, it still remains important to understand how other components of human capital, such as health, contribute to growth where these aspects are captured to contribute to both the academic and policy debates on the subject matter. The data will be time series in nature within a dynamic empirical framework. Moreover, the set of selected countries is specifically from Africa and with a wide number of countries from various regions in the continent.

The descriptive evidence which gives a comparative analysis of the macroeconomic backgrounds, health and education patterns in the selected set of countries has served to set

[16] Refer to studies discussed ealier in the body of the literature among others . Romer (1990), Barro (1990) Mankiw *e.t al* (1992) Barro and Sala-i-Martin (1990, 1995)

and define questions for the empirical estimations being carried out in the next chapters of the thesis (chapter 3 and 4). The quantitative assessment reveals that there are constraints to developing human capital such as the high debt which could take away resources that may be committed to the development of these sectors. Also, limited government resources among competing priority sectors may also not be adequate to pursue the development of human capital. Therefore, countries where there are fiscal challenges lag behind in terms of social development and overall economic performance. What emerges from the descriptive evidence is that there appears to be a positive association between the indicators of economic performance, health and education indicators.

Also, high public debt in a country appears to be negatively associated economic performance indicators as well as the indicators of health and education. This is backed by the observations that the poorer and less developed countries tend to be characterized by lower performing indicators of health and education. At the same time, high performing economies such as South Africa and Botswana with good economic performance have higher and better education and health indicators. Countries with higher public debt are also the same countries characterized by a high dependence on external resources, poor education and health performance. On the other hand, for low debt countries, reliance on aid and external resources is also very low and negligible while the education and health indicators perform better. This perhaps indicates possible negative correlation between high debt burden and education/health. From this qualitative assessment, an important aspect is to substantiate this descriptive evidence with more rigorous empirical assessment.

We however, note the emerging stylized facts in with regard to the role of interactions between health and education which are important for our analysis. The links and interactions between health and education have a bearing on the empirical framework we develop. It is, therefore, important to ensure that the treatment of health and education in isolation of each other is based on the assumption that the two can be modeled separately as components of human capital. Bearing these interactions in mind, a step further to address this stylized fact is to develop a human capital index where the two, health and education are not treated independent of each other and the empirical estimations are conducted under a scenario where health and education enter the model as separate indicators in a function and the case

where they are non-separable and enter the function as an index which constitutes the two together to address the possibility of interactions between the two..

Chapter 3: A Macro-Model for Assessing the Relative Effects of Health and Education on Economic Growth

3.1 Introduction

This paper presents an integrated framework of growth and human capital. The main aim centers on assessing the impact of the two major components of human capital, health and education on growth. At the core of the model is an investigation of the response of output to permanent and persistent shocks to education and health within a dynamic analytical framework. The model formulated and analysis is motivated by the fact while there is substantial literature on the role of human capital on growth pioneered by the work of Romer (1990) and Barro (1990), a number of studies identify human capital only with education, leaving out health as a component of human capital.

A number of cross-country studies that explain income differences across countries for example by Mankiw, Romer and Weil (1992), Caselli, Esquivel and Lefort (1996), Klenow and Rodriguez (1997), Barro, (1991, 1997), Benhabib and Spiegel (1994), Barro and Sala-i-Martin (1995), Sala-i-Martin (1997) and Easterly and Renelt (1997) use education as an indicator of human capital and find that human capital has a positive effect on economic growth. This is despite the traditional human capital theory emphasis on education, health and aspects of social capital as components of human capital and inputs to economic production (Barro 1998).

The role of human capital in the form of education has received much attention in the growth literature in recent years. Barro (1991) and Mankiw *e.t. al* (1992) and Levine and Renelt (1992) among others use school enrollment rates and average years of schooling as a proxy for human capital and find that the growth rate of real per capita GDP is positively related to human capital. Other authors such as Barro (2001) use the Barro and Lee (1994) school attainment for the population 25 years and older as a measure of human capital and also conclude that human capital impacts positively on growth for a number of countries. The

adult literacy rate in the population aged 15 years and above has also been used to proxy for human capital with similar findings of the positive implications of human capital on growth (Azariadis and Drazen, 1990 and Romer, 1990).

Although human capital, in the form of education, contributes significantly to economic growth, these studies[17], and the cross country empirical studies identify human capital narrowly with education. For developing countries with health problems, it is important to consider health as a crucial aspect of human capital, and therefore a critical ingredient of economic growth. Furthermore, even if education levels are high, a deteriorating state of health of the labour force reduces life expectancy and productivity gains. As a result, the growth rate of labour productivity will fall over time, and this will reduce long run economic growth. As pointed out by Thurlow (2007) and Weil (2006) and the recent study by the World Bank (2007), absence from work due to illnesses and health problems have been found to significantly affect productivity and growth in developing countries. Most importantly, for African countries with major health challenges, the studies point out that the prevalence of HIV-AIDS is high among the ages of 20-50 years. This is the most productive segment of the population from the standpoint of the life cycle income hypothesis which has direct implications for productivity and long-run growth. It is thus imperative that an assessment of the role of human capital on growth in developing countries integrates health as one of the components of human capital in the analytical framework given the positive role of health on productivity and growth.

Bloom, Canning and Servila (2004) argue that healthier workers are physically and mentally more energetic and thus tend to be more productive with positive implications for growth while poor health of workers has negative implications for growth.

With the prevalence of health problems in many developing countries, leaving out health as a component of human capital encounters obvious difficulties such as omission variable bias and the possible overestimation or underestimation of the contribution of human capital to growth. Thus, this study finds it important to model both components of human capital, health and education to assess the role of human capital on growth within an integrated

[17] For example Romer (1990) Barro, (1990, 1991, 1996), Mankiw, Romer and Weil (1992), Easterly and Levine (1992),Benhabib and Spiegel (1994) Barro and Sala-i-Martin (1995, Sala-i-Martin (1997) Greiner, Semmler and Gong (2004)

growth framework. The model developed is different from Bloom et al (2004) in its approach to integrate health and education in the model framework developed in that we adopt a more macro perspective compared to Bloom *et al's* micro approach in capturing health and education in the production function. This paper therefore formulates a dynamic model in which human capital is jointly determined by the levels of education and health of the labour force following Romer (1990). In this model, health and education impact on the effectiveness of labour and productivity. A second major aspect of this study is to investigate the dynamic behavior of output response to persistent and permanent shocks to health and education through dynamic simulations, an exercise which has not been carried out before.

The analysis intends to exclusively focus on a set of selected[18] African countries from 1980 to 2008. In this regard, the present paper will fill an important research gap that currently exists in the literature in as far as the implications of health and education as components of human capital on growth are concerned. The study contributes to the current existing research gap on an integrated growth framework of the role of human capital on growth within a model that captures all the components of human capital and addresses the problems of omission variable bias. Further, the research gives insight on the dynamic behavior of output emanating from persistent and permanent changes to education and health. The analysis is valuable from a policy perspective since the results will yield valuable information for developing African countries with health problems as well as shed light on human capital policy priorities for the African countries to maximize the growth benefits and potential.

The remainder of this Chapter is structured as follows: The specific issues to be investigated and hypothesis are stated in section 3.1.1. Section 3.2 outlines the model framework developed for an integrated growth framework on the role of human capital on growth and also elaborates on the data and the selected sample. Section 3.3 presents the results of model estimations while section 3.4 explores the dynamic effects of the model in line with the hypothesis to be tested. Section 3.5 gives the conclusions and implications.

[18] Botswana, South Africa, Zimbabwe, Zambia, Uganda, Kenya, Tanzania, Nigeria, Ghana and Ivory Coast. The macroeconomic background indicators, health and education indicators are given in the appendix, tables1-3.

3.1.1 Objectives and Hypothesis

The specific objectives in this Chapter are to:

i. Formulate a macro model framework where health and education determine the effectiveness of labour.
ii. Assess the dynamic response of output to persistent and permanent shocks to education and health.
iii. Measure the relative impacts of the two major components of human capital-health and education on growth.
iv. Measure the impact of permanent shocks to human capital on output.

The hypothesis being tested include:

i. Health and education have a positive impact on output
ii. A 1% increase in health and education leads to a more than 1% increase in output in the long run.
iii. Health has a greater impact on output than education in the long run

3.2 The Model

Recent developments on endogenous economic growth theory by (Romer (1990) Barro (1990) and, Barro and Sala-i-Martin (1990) allow incorporating the effects of human capital in assessing its effects on long term growth. The theoretical framework adopted in this paper modifies the endogenous growth model of Romer (1990) and further extends the model to include health and education as determinants of human capital. Also, a further advancement over the previous models carried out in our paper, is incorporating the dynamic properties of the system of equations to evaluate the stability and convergence properties of the model. The structure of our model and the key equations used for analysis are outlined and explained in the following equations:

$$\tilde{Y}_t = A_t^{1-\alpha}\left[\omega_y \tilde{K}\right]^{\alpha} \quad (1)$$

$$A_t = A_{0t}\ h_t^{\gamma} e_t^{1-\gamma} \quad (2)$$

$$h_t = h_0[\omega_h k_t]^{\beta_h} \quad (3)$$

$$e_t = e_0[\omega_e k_t]^{\beta_e} \quad (4)$$

Equation (1) is the modified constant elasticity of substitution Cobb-Douglas production function following Romer (1990). Our assumptions are that output per capita, $\tilde{Y}_t$ is a function of the proportion ω_y, of the aggregate capital stock per capita $\tilde{K}_t$, used in the production of output.; A_t is the technology or innovations used in the production of output in the form of per capita gross domestic product.

In Equation (2), we extend the model by Romer (1990) to include health and education as components of human capital which drive the effectiveness and productivity of labour. A_t, the productivity or innovation variable, is influenced by the health of the labour force, h_t, and the education, e_t of the labour force. h_t and e_t capture the indicators of health and education in the model which influence labour effectiveness. This innovation is motivated by the findings by Bloom et. al (2004) and Weil (2006) that a healthy work force has positive implications for productivity since the healthy work force is more productive, less absent from work, hence contributing positively to growth of output. In this regard, we also argue for the introduction of health as a factor that influences the effectiveness of labour in the fashion of equation 2. Education is also introduced as positively affecting labour effectiveness and productivity and thus having a positive effect on growth (Barro and Sala-i-Martin, (1995). Romer (1993) formalizes the argument that a more educated populace is better able to integrate new technologies. The index of the effectiveness of labour in the model, taking into account the effects of health and education is thus given by Equation 2.

Equation (3) and (4) describes factors that influence health and education in our model respectively. The changes in health depend on the proportion, ω_h of physical capital in the health sector and other factors, h_0, such as the quality of doctors and nurses. We assume that the physical capital stock in the health sector of a country has a positive role to play on health and its state. Similarly, in Equation 4, education in a particular country depends on ω_e , the proportion of the physical capital stock in the education sector and e_0 are other factors which include the quality of teachers and education systems.

The four equations (1-4) indicate that there is an inter-relationship between health, education, technology or innovation, the physical capital stock and output. The interrelationships and interdependencies amongst these equations are shown through the substitution of the equations into the production function such that we have:

$$\tilde{Y}_t = {A_{0t}}^{1-\propto}[{h_t}^{\gamma}{e_t}^{1-\gamma}]^{1-\alpha}\left[\omega_y\tilde{K}_t\right]^{\alpha} \tag{5}$$

It can be shown that the reduced form of equation 5 following the substitution process can be specified in per capita term in the following form:

$$y_t = {\Omega_0}^{(1-\alpha)}\omega \quad {k_t}^{\theta} \tag{6}$$

Where:

$$\Omega_0 = {h_t}^{\gamma}{e_t}^{1-\gamma},$$

$$\omega = {\omega_y}^{\alpha}{\omega_h}^{\beta_h\gamma(1-\alpha)}{\omega_e}^{\beta_e\gamma(1-\gamma)(1-\alpha)}$$

$$\theta = \alpha + \beta_h\gamma(1-\alpha) + \beta_e(1-\gamma)(1-\alpha)$$

The interrelationships among the system of equation posit the hypothesized relationships for a positive role of the physical capital stock on health, education and growth. An improvement

in health and education would positively affect labour effectiveness. Since the effectiveness of labour is a component of output as indicated by the adopted production function, its improvement through enhanced health and education impacts positively on output.

Our model is closed with assuming a representative household that maximizes a discounted stream of consumption per effective labour, c_t where the utility function takes the form:

$$U(c_t) = \int_0^{\infty} e^{(g(1-\sigma)-\rho)t} \frac{\check{C}^{1-\sigma}}{1-\sigma} dt \tag{7}$$

σ represents the elasticity of marginal utility with respect to consumption and ρ is a constant discount factor calibrated at 0.1 for all the countries. $u(c)$ is the utility function which is strictly increasing in c and concave; $u'(c) > 0$ and $u'' < 0$. The capital accumulation constraint per effective labour faced in the economy evolves according to equation (8).

$$\dot{k_t} = y_t - c_t - (\delta + n + g)k_t \tag{8}$$

Substituting for y_t implies that the reduced form of the capital accumulation constraint takes the form:

$$\dot{k_t} = \Omega_0^{(1-\alpha)}\omega \ \ k_t^{\theta} - c_t - (\delta + n + g)k_t \tag{9}$$

From Equation (9) changes in the per capita capital stock are negatively affected by the depreciation rate δ, the growth rate of labour efficiency, g and the growth rate of the labour force n. The per capita output positively influences the accumulation of capital while per capita consumption, c reduces the rate of capital accumulation.

3.3. Dynamics of the Model

The dynamic behavior of the model allows us to assess the stability properties of our model and employ model simulations to determine the optimal growth path of output in the presence of binding constraints and shocks. We derive the dynamics using the Maximum Principle Approach for optimization according to Greiner, Semmler and Gong (2004). It is assumed that a representative household maximizes a discounted stream of utilities arising from the per capita consumption c_t such that:

$$U(c_t) = \int_0^{\infty} e^{(g(1-\sigma)-\rho)t} \frac{\check{C}^{1-\sigma}}{1-\sigma} dt \tag{10}$$

subject to the capital accumulation constraint:

$$\dot{k_t} = \Omega_0{}^{(1-\alpha)}\omega \;\; k_t{}^{\theta} - c_t - (\delta + n + g)k_t. \tag{11}$$

Following the optimization and derivations of the first order conditions, we can define the key dynamic system of equations[19].

There are two key dynamic processes at the core of the model together with the production function (equation 1), the effectiveness of labour equation (equation 2), and the health (equation 3) and education equation (equation4) that drive the system. The first is the path for the growth of the consumption per capita, the $\dot{c}$ function in equation 11 and the second is the path for the growth of capital accumulation $\dot{k}$ equation (12). The two dynamic equations interact the physical capital stock per capita with consumption, health and education as well as the growth of rates the physical capital stock, depreciation of the physical capital stock and labour. The reduced form of the equations for the dynamics of the model takes the form:

[19] Refer to appendix for derivations following Greiner, Semmler and Gong (2004)

$$\frac{\dot{c}}{c} = \frac{{\Omega_0}^{(1-\alpha)}\omega \;\; \theta {k_t}^{\theta-1} - (\delta+n+g) - \rho}{\sigma} \tag{11}$$

$$\dot{k_t} = {\Omega_0}^{(1-\alpha)}\omega \;\; {k_t}^{\theta} - c_t - (\delta + n + g)k_t \tag{12}$$

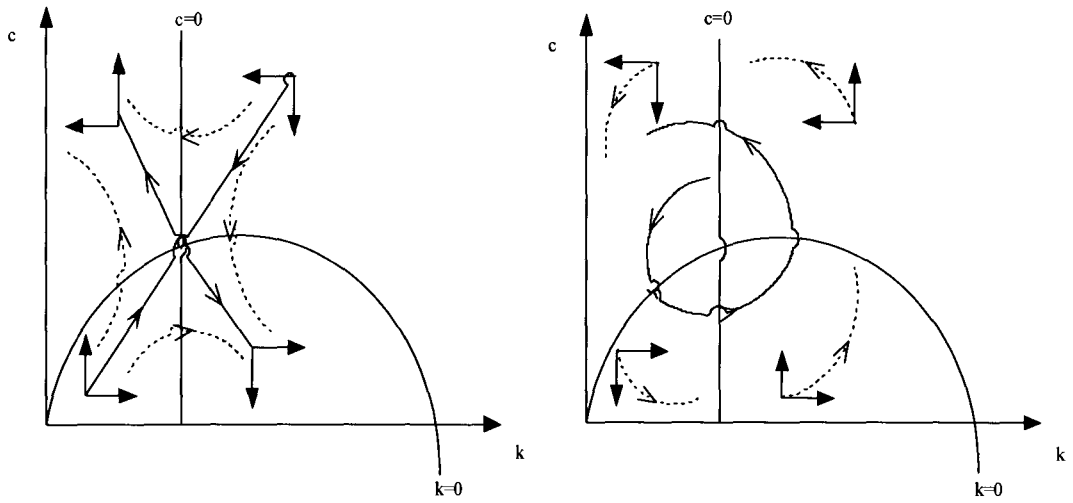
The dynamic system given by *equation (11) - (12)* leads to some dependencies between the rows of the Jacobian (J) of the system. The interdependencies allows us to examine the stability properties of our theoretical model and equilibrium solutions with phase diagrams following Romer (1990) on the basis of the sign structure of the Jacobian.

$$\mathrm{J}=\begin{bmatrix} 0 & c^*{\Omega_0}^{(1-\alpha)}\omega \;\; \theta(\theta-1){k_t}^{\theta-2} \\ -1 & {\Omega_0}^{(1-\alpha)}\omega \;\; \theta {k_t}^{\theta-1} - (\delta + n + g) \end{bmatrix} \tag{13}$$

These two equilibrium outcomes of the model are graphically illustrated with the phase diagram indicated in *Figure 1* and *2*. From the computations, $\dot{k}$ reaches a maximum at $k_{tmax} = \left(\frac{{\Omega_0}^{(1-\alpha)}\omega}{(\delta+n+g)}\right)^{\frac{1}{1-\theta}}$ and the equilibrium $k^* = \left(\frac{\rho+(\delta+n+g)}{{\Omega_0}^{(1-\alpha)}\omega \;\; \theta}\right)^{\frac{1}{\theta-1}}$

Figure 1: Phase Diagrams Analysis of the Theoretical Model

Figure a: Phase Diagram Case 1 with $\theta < 1$ *Figure b: Phase Diagram Case 2 when* $\theta > 1$



Depending on the parameter value for θ, the dynamics yield different stability properties for equilibrium in the model. With $\theta < 1$, the theoretical model yields a stable saddle path solution while a cyclical behavior is observed when $\theta > 1$. Cycles indicate that developing countries may be at a certain phase of development in the circle. Given the short time series we have for developing countries, it may not be possible to completely observe the length of the whole circle and stages as indicated by our theoretical model. For each country in the selected sample, the magnitude of θ is calculated from the estimated parameters to judge where there is a stable saddle path solution or the cyclical behavior observed in figure 2 when $\theta > 1$. In order to assess the dynamics of the model, model simulations are conducted for the system to investigate the impact of both persistent and permanent shocks to health and education on growth. This entails assessing the impact of a shock to health and education on the paths of the system and the reaction of other growth paths to the shock and how the countries adjust to equilibrium through the inter-links.

3.4. Empirical Estimation

3.4.1 Data Description and Measurement

The analysis is conducted for a sample of selected African countries: Botswana, South Africa, Malawi, Zambia, Uganda, Kenya, Tanzania, Cote d'Ivore, Ghana and Nigeria, Ghana. *Table 7* summarizes the data used to estimate the parameters of the model for the countries.

Table 8: Description of the Data and Measurement

Variable	*Measurement*
y_t= Output per capita	Real gross domestic product per capita (2000 US$)
k_t =Physical capital stock	Derived using inventory perpetual method (2000 US$) following Limam and Miller (2004)
A_t = Innovation or technology	Solow residual from estimated production function
ω_y =Proportion of physical capital stock used in the production of output	Proportion of physical stock used for production (1-$\omega_h - \omega_e$)
h_t = Health indicator	Generated from life expectancy at birth. To capture productive age group , alternative indicator is derived from life expectancy as $h_t = \left(\frac{Lifeexpectancy}{65yrs}\right) * 100$
ω_h = proportion of physical capital stock in the health sector	Derived from physical stock series using average share of physical stock in the health sector
e_t= Education indicator	Generated from gross enrolment rates for primary, secondary and tertiary education. To capture the effect of higher education average enrollment rates computed place higher weight on higher education $e_t = 0.1(Primary) + 0.4(Secondary) + 0.5(tertiary)$
ω_e = proportion of physical capital stock in the education sector	Derived from physical stock series using average share of physical stock in the health sector

The data used to estimate the parameters of the model for all the countries has been collected from the 2006 and 2007 World Development Indicators, National Accounts of the respective countries, and the IMF/World Bank Statistics. Data from the United Nations Human Development Reports and Indicators for various years is also used to augment the data from the WDI on the education and health indicators.

We derive the data series for the physical capital stock for each country using the inventory perpetual method following Limam and Miller (2004). A constant rate of depreciation of about 7 percent is adopted in line with Benhabib and Spiegel (1994) and King and Levine (1994). To compute the initial capital stock for each country *i*, the real gross domestic product for 1980 is used as an estimate for the initial output for each country. The initial capital stock, K_{1980}, is derived as $K_{1980} = k_i Y_{1980}$ where k_i is the steady state capital-output ratio and Y_{1980} is the real GDP for 1980. The physical capital stocks for the remaining years are computed according to Limam and Miller's (2004) perpetual inventory formula such that:

$$K_t = \sum_{i=9}^{t=1}(1-\delta)^i I_{t-1} + K_0(1-\delta)^t \qquad (15)$$

Where I_{t-1} is the previous period's gross fixed capital formation for each country.

The index for education and health is derived based on the indicators of education and health adopted in the literature and based on data availability for the selected sample of countries. Bils and Klenow (2000), Bloom, Canning and Sevilla (2004), Barro (1991), Greiner *et. al* (2004), Barro and Sala-i-Martin(1997) use average years of schooling. Other measures of education which have been widely used as an indicator of education are the Barro and Lee (1993) average years of schooling for the population aged over 25 years of age which to some extent captures the role of higher education. The usage of the average years of schooling in this study is however limited by the lack of consistently available data for all the countries in the sample for this study. We therefore adopt school enrollment ratios which are readily and consistently available for the period of our study and countries of focus from the World Development Indicators. The other rationale for taking enrollment rates is that these

have also been frequently used in literature as proxies for the human capital indicator of education and they produce consistent results with those found when using other education indicators for example Barro (1996) Easterly and Rebelo (1993), Barro and Sala-i-Martin (1995, 1999) among others.

This study derives an indicator of education based on enrollment rates but modified to place more weight on higher education given that it plays more role in enhancing the effectiveness and productivity of labour. The weights given are 10% for primary enrollment, 40% for secondary enrollment and 50% to tertiary enrollment rates. This indicator captures higher education as close as possible to the Barro and Lee (1993) average years of schooling of people aged over 25 years in that less weight is given to lower education enrollment and more weight to higher education.

We adopt life expectancy at birth as the indicator for health given that it is widely used as a proxy for health in the literature given its availability from both the World Development Indicators and the Human Development Reports. In this study, the indicator is derived such that more weight is placed on the productive age bracket of the population and it is calculated as life expectancy/retirement age. The indicator is converted into a percentage to attain consistency in the unit of measurement for the education indicator and health indicator.

Weil (2006) explores the role of other health indicators that have been used in the literature on microeconomic studies such as adult survival rates, nutritional status and adult height. Average height of adults is not a perfect indicator of the average health of adults, since height is almost completely determined by the time a person is in his or her mid twenties. Thus it is possible that health environment in which an adult lives will be very different from the one in which he grew up (Strauss and Thomas , 1998). If one is looking at historical data from periods of time in which the environment was changing only slowly, or looking cross-sectionally at countries which differ greatly in their health environments, then this timing effect will not be a serious problem; however, if one looks at countries with rapidly changing health environments, it is a possible concern. According to Weil (2006) adult survival rate has the advantage of measuring survival during working years, and thus seems likely to be a good measure of health during working years, which is what should be most relevant for

determining the level of output per worker, but due to data unavailability for our sample of selected countries, this measure could not be adopted for our study.

With these indicators of health and education derived, we formulate an index of human capital to allow for capturing the possible interactions between health and education. This is important in the assessment where we treat health and education as independent exogenous variables but also for the case where we assume that the interaction may not permit complete isolation an independence. The index for human capital for each country *(country i)* used in the research takes the following form;

$$Human\ capital\ index_i = h^{\gamma} e^{1-\gamma}$$

The specification is simple and does not complicate the equations already specified for the analytical framework. The index allows for cases where the health indicates enter as independent variables in the estimation, but more importantly, the index is formulated in such a way that we can easily convert the two indicators and consolidate them into one index or measure of human capital with all the components of human capital. Also, it makes it easier to use the γ parameter estimate so that the index reflects the role of each indicator based on the parameters estimated for each country which makes the use of the index more consistent, allowing the analysis to be tractable.

3.4.2 Estimated Parameters of the Model

While Greiner, et al (2004) adopt the generalized method of moments (GMM) technique for estimating the parameters of the model, we estimate the parameters of the model here using the non-linear estimation technique which has the advantage of not making any strong assumptions about the data sets and the errors and incorporates the presence of nonlinearities in the parameters of the model. We correct for serial correlation and report corrected standard errors. The estimations include time fixed dummies to capture the effects of other factors and

outlier observations which may be due to structural changes which may bias the results. Table 2 gives a report of the estimated parameters of our model for the 10 countries.

The estimable form of equations based on the base equations (1-4) of the model are specified below in log-linear form:

$$\ln y_t = (1-\propto)a_t + \propto ln\ \omega_y + \propto \ln k_t \quad (16)$$

$$\ln a_t = a_{0t} + \gamma \ln h_t + (1-\gamma) \ln e_t \quad (17)$$

$$\ln h_t = lnh_0 + \beta_h \ln \omega_h + \beta_h \ln k_t \quad (18)$$

$$\ln e_t = lne_0 + \beta_e \ln \omega_e + \beta_e \ln k_t \quad (19)$$

The equations are estimated with time fixed dummies to capture the effects of other factors. The results of the estimations are corrected for serial correlation and the errors are found to be of the AR(1) process. A summary table of diagnostic statistics for the estimations carried out for equations (16-19) are given in Table

We also test for endogeniety between health and education where our findings show that the extent of the endogeniety problem is not serious to affect our estimated parameters. The Hausman test results where we test the null hypothesis of exogeneity against and alternative hypothesis of endogeniety between the education and health indicators shows that we fail to reject the null hypothesis of exogeniety at the 5% level of significance. We also carried out the test with the per capita output and our measure of productivity/labour effectiveness being used as the dependent variable and the results consistently show that the extent of endogeniety is not serious at the 5% level of significance. The approach we adopted entails first estimate the equation with the suspect variables, saving the residuals and running the regression with the residuals and then and testing the joint significance of the first stage residuals.

Table 9: Summary of the Estimated Parameters of the Model

Estimated Parameters (standard errors in parenthesis)

Estimated Parameters	Botswana	South Africa	Zambia	Kenya	Nigeria	Cote d'Ivore	Malawi	Tanzania	Uganda	Ghana
α	0.45 (0.016)	0.35 (0.022)	0.21* (0.013)	0.33 (0.010)	0.36 (0.026)	0.26* (0.015)	0.20* (0.035)	0.25* (0.010)	0.32 (0.010)	0.30 (0.020)
γ	0.52 (0.046	0.47 (0.036)	0.36 (0.038)	0.49 (0.047)	0.40 (0.022)	0.38 (0.019)	0.32 (0.029)	0.35 (0.030)	0.39 (0.027)	0.42 (0.022)
β_h	0.23 (0.043)	0.31 (0.048)	0.24 (0.031)	0.22 (0.016)	0.03** (0.007)	0.06** (0.004)	0.13** (0.010)	0.14** (0.008)	0.02** (0.003)	0.03** (0.001)
β_e	0.33 (0.019)	0.42 (0.027)	0.18*** (0.025)	0.34 (0.027)	0.30 (0.015	0.12*** (0.009)	0.29 (0.056)	0.39 (0.017)	0.49 (0.016)	0.21*** (0.009)
θ	0.603	0.555	0.369	0.522	0.402	0.415	0.391	0.477	0.529	0.394
Calibrated Parameters										
ρ	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
δ	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
σ	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Notes : 1 *stars* indicates countries with where the parameters are less than the average, i.e * where $\propto < 0.30$, ** where $\beta_h < 0.20$ and *** where $\beta_e < 0.30$.

2. Table 14 and 15 in t Appendix 3 show the summary test statistics pertaining to diagnostic statistics including adjusted R-squared, F-test for joint significance and goodness of fit and the Hausman test for the extent of the endogeneity problem among some variables, mainly health, education and per capita output.

The estimated parameters show that output responds positively to changes in the physical capital stock for all countries. The coefficient α, which indicates the percentage change in per capita output resulting from a one percentage change in the per capita physical capital stock is positive and significant for all the countries. On average, a 1 percent change in the physical capital stock leads to about 30% percent change in output. This indicates that an increase in the physical capital stock will have a positive impact on output while deterioration in the physical capital stock will have the effect of reversing growth of output.

Changes in output in the model are also influenced by the effectiveness of labour which is driven by health and education. The variable for technology or innovation, A ,in equation 2 is proxied by the Solow residual from the production function estimated in equation 1 following Romer (1990) .The coefficient for innovation can be positive or negative reflecting the ease with which some countries can discover new technology and innovate through research and development. More developed countries will have higher and positive coefficients for innovation while those that are under developed may have negative coefficient reflecting the difficulty to innovate and advance currently existing technology.

What emerges from the estimated results is that the coefficient on the effect of health on technology varies across countries as shown by the γ parameter estimates ranging between 52% in Botswana to a low of 35% in Tanzania. For those countries where γ is close to 0.5 such as in Botswana (0.52), South Africa (0.47), Kenya (0.49), Ghana (0.42) and Nigeria (0.42) reflects a balanced contribution of health and education on the effectiveness of labour of 50% each. For some countries, a coefficient lower than 0.5 shows a higher contribution of education to the effectiveness of labour and a lower role for health since the contribution for education is given by $(1-\gamma)$. The results show a significant positive role for health as one of the components of human capital for all the countries which averages about 40%. The significant positive role of education and health on labour effectiveness directly impact on output. In this regard, higher education and health would result in higher growth through productivity improvements.

The relationship between health and the physical capital stock shown by the parameter β_h is significant and positive for all countries. South Africa has the highest coefficient at 31% compared to all the countries in the sample which perhaps reflects the highly developed physical capital stock in the country and in the health sector. Other countries such as Botswana, Kenya, Zambia had a coefficient of about 20% indicating the percentage change in health resulting from a 1 percent change in the physical capital stock. The remaining countries, Malawi with elasticities of 13%, Tanzania 14%, Cote d'Ivore 6%, Nigeria and Ghana 3% and Uganda 2% shows that a 1 percent change in the physical capital stock in these countries would lead to about 6% in output.

Perhaps the lower elasticities in these countries reflect the poor and deteriorating physical capital stock and GDP per capita that exits in Malawi, Tanzania, Nigeria, Ghana and Uganda. Since the relationship is positive, a decline in the physical capita stock on health will result in a decline in the health while an improvement in the physical capital stock in health will impact positively on the health of these developing countries. Also, since health influences the effectiveness of labour in the model, its improvement due to developing the physical capital stock will lead to higher output per capita among countries.

Similarly, the result obtained on the relationship between education and the physical capital stock captured by the parameter β_e were found to be positive for all countries ranging from a high elasticities of 42% in South Africa and 12% in Cote d'Ivore. The higher coefficient in South Africa and Botswana could reflect the developed physical capital stock in the education sectors of these countries compared to other countries. Declining physical capital stock will negatively affect education while improvements in the physical stock will impact positively on education. Countries with poor physical capital stock tend to have a lower parameter estimate and this was found to be the case for Zambia, Cote d'Ivore, Malawi, Uganda, Tanzania and Ghana.

The computed θ is less than 1 for all the countries as reported in the table which indicates the presence of stability in the model for all the countries and indicates that the dynamics should give stable path solutions. This parameter shows that the estimated parameters should allow for convergence in the dynamics of the model.

The literature on human capital and growth provides a number of predictions that are worth contrasting with the results of this study. The results obtained for the parameters are consistent with the results of other studies on the role of human capital on growth in that education plays a positive role on growth as found in the work of other studies such as those of Mankiw, Romer and Weil (1992); Caselli, Esquivel and Lefort (1996); Klenow and Rodriguez 1997; Barro, 1991, 1997). Barro (1991), Benhabib and Spiegel (1994), Barro and Sala-i-Martin (1995), Sala-i-Martin (1997), Easterly and Renelt (1997). These authors and many others find schooling to be positively correlated with the growth rate of per capita GDP across countries. Barro (1991) finds that 1960 primary and secondary-school enrollment rates are positively correlated with 1960-1985 growth in real per capita GDP. The estimated

percentage change in GDP growth due to a change in human capital is estimated at 30% percent. Bils and Klenow (2000) in cross country regressions between 1960-1990 use enrollment rates as the indicator of human capital and find that the impact of schooling on growth explains less than one-third of the empirical cross-country relationship (24% percent for all countries). We find elasticities ranging between 42% and 12% for the countries in the sample and the average is about 30% for the role of education on per capita GDP in our model.

A number of studies find a positive role of the physical capital stock on human capital, which is consistent with the findings of our study where the physical capital stock impacts positively on health and education. These include Caballe and Santos (1993) and Job, Saqib, and Philippopoulos (1995) who demonstrate that an increase in the stock of physical capital has a positive effect on the accumulation of human capital, since increased physical capital means human capital will be more productive in the future. In Lucas (1993) and Greiner (1999), any increase in physical capital must be matched by increases in human capital in order to sustain per-capita income growth. The impact parameters of physical capital on growth in Bloom e.t.al average about 45%. The results we find are in line with the literature findings since our average for the parameter is 30% for all the countries though we do find higher parameters for Botswana and South Africa at about 40%. This is explained by the highly developed state of physical capital stock in these countries and high per capita GDP levels compared to the rest of the countries in our sample.

There is a limited number of studies to compare the growth effects of health we find in line with the estimation approach we have adopted. A close study which integrates health on the growth equation is the work of Bloom e.t al (2004) although they adopt a micro perspective in capturing health and education whereas we adopt a more macro growth motivated approach. The findings by Bloom e.t.al reveal that an increase in life expectancy would raise output on average by 4%. Besides this study there are a number of country regressions that have been included health as one of the regressors in the equation without specifically modeling it as a component of human capital. The results of these studies which include life expectancy in the estimations are summarized in the appendix table A4 and the estimations techniques adopted. Our elasticity on the impact of health an growth averages about 20%. There are countries with very low elasticities which are consistent with the findings in the

literature such as the elasticities estimated in Nigeria of 3%, Cote d'Ivore 6%, Uganda 2%, Ghana 3%, Malawi 13%, Tanzania 14% and Zambia 18%. Our average is raised by the Botswana and South Africa with elasticities of 33% and 42% respectively, which portrays the highly developed health and education sectors which play a more pronounced role on the effectiveness of labour and growth.

3.4.3 Testing for Endogeneity and Model Stability

In order to deal with the possibility of endogeniety in the model particularly between education and health, we used other indicators of education besides the computed education indicator based on the enrollment ratios where the data was available. This is mainly in the case of Botswana and South Africa where we had good data on both the literacy rate and enrollment ratios. In this case, we find that the literacy rate is positively related to output percapita and the physical capital stock. This shows that even though we suspected possible endogeneity between health and education, when using other variables, to instrument for suspect variables, we still find a stable consistent relationship between education and health which shows significant exogeneity and that the endogeneity problem in between the variables is not serious enough to affect our estimations. We also used the mortality rate to proxy for health in the estimations for these countries, and similarly, the results show a positive relationship. The analysis was limited to countries where data was available.

We also lagged the suspect variables by one period, (in line with Wooldridge 2002) where the argument is that although current values of a variable might be endogenous, it is unlikely that past values will suffer from the same problem. Although we find significance for the role of past health and education in the estimated equations, testing for the joint significance of the errors using the F-test leads to a rejection of the hypothesis that they are significant with possibilities of an endogeniety problem. Here we run the first stage regression and save the residuals, then include the first stage residuals as additional regressors in the main equation, testing joint significance of the first residuals. Here we mainly tested whether or not there is correlation between the dependent variable and that part of the suspect variables variation that is not explained genuinely by exogenous factors.

Since the tests for endogeniety through instruments is limited by the availability of data and weak instruments, we also directly tested the possible extent of the endogeniety problem in the estimations, mainly between health and education and output where the null hypothesis of exogeneity was tested versus an alternative hypothesis of endogeniety using the Hausmann test. We found lower values of the test statistic when performing the Hausmann test where the null is accepted at the 5% level of significance. In this case, we conclude that the although there might be a case for endogeniety between some variables, the problem is not a serious one to affect the estimations and give biased results and interpretations in the analysis since we reject the alternative hypothesis at a very high level of significance. This entails first estimating the equation with the suspect variables, saving the residuals, running the regression with the residuals and then and testing the joint significance of the first stage residuals.

From the parameters of the estimated model, their magnitudes are integral to the θ, which determines whether given the estimated parameters for each country, the dynamics will be stable or not. In this case, we computed the values of θ and we find that the computed θ is less than 1 for all the countries as reported in the *Table 9,* which indicates the presence of stability in the model for all the countries and indicates that the dynamics should give stable path solutions. This parameter shows that the estimated parameters should allow for convergence in the dynamics of the model.

Also, in the conditions for testing for the dynamic stability of model, for each country there are interdependencies form the equations of the dynamic system *(equations 11-12)* which serve to determine the stability properties of the model. The dynamic system given by *equation (11) - (12)* leads to some dependencies between the rows of the Jacobian (J) of the system (Greiner *e.t al* 2004). These interdependencies allows us to examine the stability properties of our theoretical model and equilibrium solutions with phase diagrams following Romer (1990) as shown in *Figure 1* on the basis of the sign structure of the Jacobian. Also, for each country, the sign structure of the Jacobian which is derived from the equation below following from equation 11-12, allows us to determine the stable paths we report in *Figure 2* and *3* following the simulations.

$$J=\begin{bmatrix} 0 & c^{*}\Omega_0^{(1-\alpha)}\omega \;\; \theta(\theta-1)k_t^{\theta-2} \\ -1 & \Omega_0^{(1-\alpha)}\omega \;\; \theta k_t^{\theta-1}-(\delta+n+g) \end{bmatrix}$$

For each country, the sign structure of the Jacobian based on the parameters estimated are computed and the stable simulations following shocks to some of the variables of the model show evidence to the stability of the model as seen from the some of the dynamic simulations carried out with shocks to health and education and the reaction of output are stable for all the countries. (Figures 1 and 2 where the reaction of output to permanent and temporary shocks to health and education are reported). If the model and estimated parameters lead to instability, then the sign structure would lead to explosive paths and non-convergence in the simulations where we assess the role of temporary and persistent shocks to some variables and the reaction of other variables in the dynamic setting to such shocks.

3.4.4 Dynamic Estimations and Simulations

3.4.4.1 The Impact of Human Capital on Growth

In this section we analyze the effect of both persistent and permanent shocks to health and education on the dynamic behavior of output using the dynamic system of equations and the core equations of the model developed. Two scenarios are considered. The first case considers the dynamic effects of persistent shocks to health and education on per capita output. In the second case, we consider the dynamic implications on output with a permanent shock to the human capital variables considered. *Figure 2* indicates the dynamic response of output to a persistent shock on education and health with the estimated country parameters. *Figure 3* shows the reaction of output when there is a one percent permanent shock to education and health, also with the estimated country parameters. The impact of shocks on a temporary and permanent base is repeated where we assess the reaction of output to shocks on the human capital index to take account of the interactions between health and education. These response functions are reported in *Figure 4* and *5*.

In order to test the hypothesis that health and education have a positive impact on output, we conduct dynamic simulations where there is a positive transitory shock to education and health and assess the response of output over time. The results for some countries in the sample are presented in *figure 2*. The main finding is that health and education impact positively on per capita output. In the case of Botswana, the impact of health on output is greater compared to the impact of education.

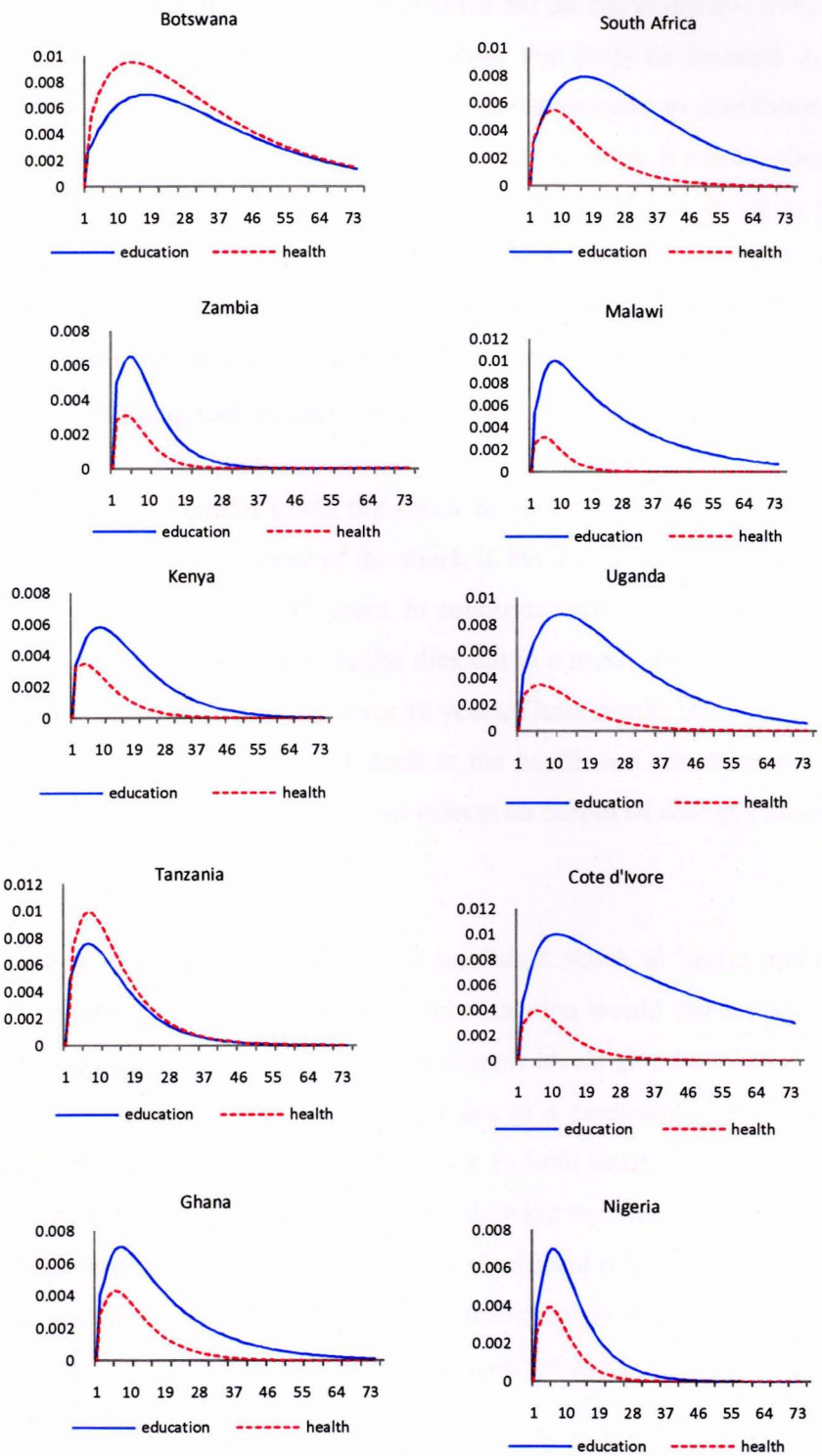
The second hypothesis we test is that a 1% increase in health and education leads to a more than 1% increase in output in the long run. To test this hypothesis, we conduct simulations on the reaction of output to a 1 percent permanent shock to health and education. The results for some countries are presented in figure (3).

The dynamic simulations for the countries reveal that a 1% permanent shock to both education and health leads to a 1.2% average increase on per capita output respectively in the case of Botswana, South Africa and Kenya. In the case of Nigeria, the increase in education leads to a more than 1% permanent increase in output in the long-run while the shock to health leads to a less than proportionate increase in output (0.8%). We observe that for all countries a one percent permanent shock to education and health raises output for all countries.

The third hypothesis tested is whether health has a greater impact on output than education in the long run. The results from the simulations in *Figure (2)* and *(3)* are used to test this hypothesis by observing whether the impact on output is larger when there is a positive transitory/permanent shock to education or health. From figure (2) and (3), health has a greater impact on output in Botswana while the shock to education produces a greater impact on output in the other countries.

Figure 2: Dynamic Response of Output to Temporary Shocks on Health and Education

(Simulation with estimated country parameters of the model)



The simulation of a positive persistent shock to education reveals that although countries react differently in terms of the magnitudes of the percentage deviations from equilibrium following the shock to health, the impact is positive for all the countries. Similarly, output reacts positively to a shock to education indicating that both an increase in health and education impacts positively on per capita output. The adjustment to equilibrium for output and time taken for the shock to decay differs across the countries. It can be observed that in Botswana and Tanzania, compared to other countries, the persistent shock to health has a larger impact on output rather than education. Also, it can be noted that the time of decay for the impact on output from the shocks in Botswana and South Africa takes a longer time horizon which shows that increasing health and education would have a long run positive impact on output, with long term benefits for the growth of these economies.

The reaction of output is greater given the shock to education all the countries except for Botswana, although the time of decay of the shock is longest in Botswana and South Africa, dying out in a period of more than 75 years. In countries such as Zambia, Kenya, Tanzania, Cote d'Ivore and Malawi, the shock to health dies out in a much shorter period taking about 28 years while that for education decays over 50 years. These results score the importance for the need to enhance the physical capital stock in the health and education sectors of these countries if they are to realize the longer term effects on output of changes brought about by higher education and health status.

The major finding from the simulation of the persistent shock to health and education in these African countries is that raising health and education would impact positively on the output. The average increase in output from its current levels given a shock to education is higher at about 1% while the impact on output due to a persistent shock to health would average about 0.8%. In some countries, the shock to both health and education results in output increasing by more than 1% in both cases, showing the presence of increasing returns to human capital on growth. The results suggest a significant role for education on health on output and its growth. Developing health and education thus stands as a core priority for development policy agenda for African countries given the significant output growth benefits that can be realized in such an endeavor.

Figure 3: Dynamic Response of Output to a 1% permanent Shock on Health and Education

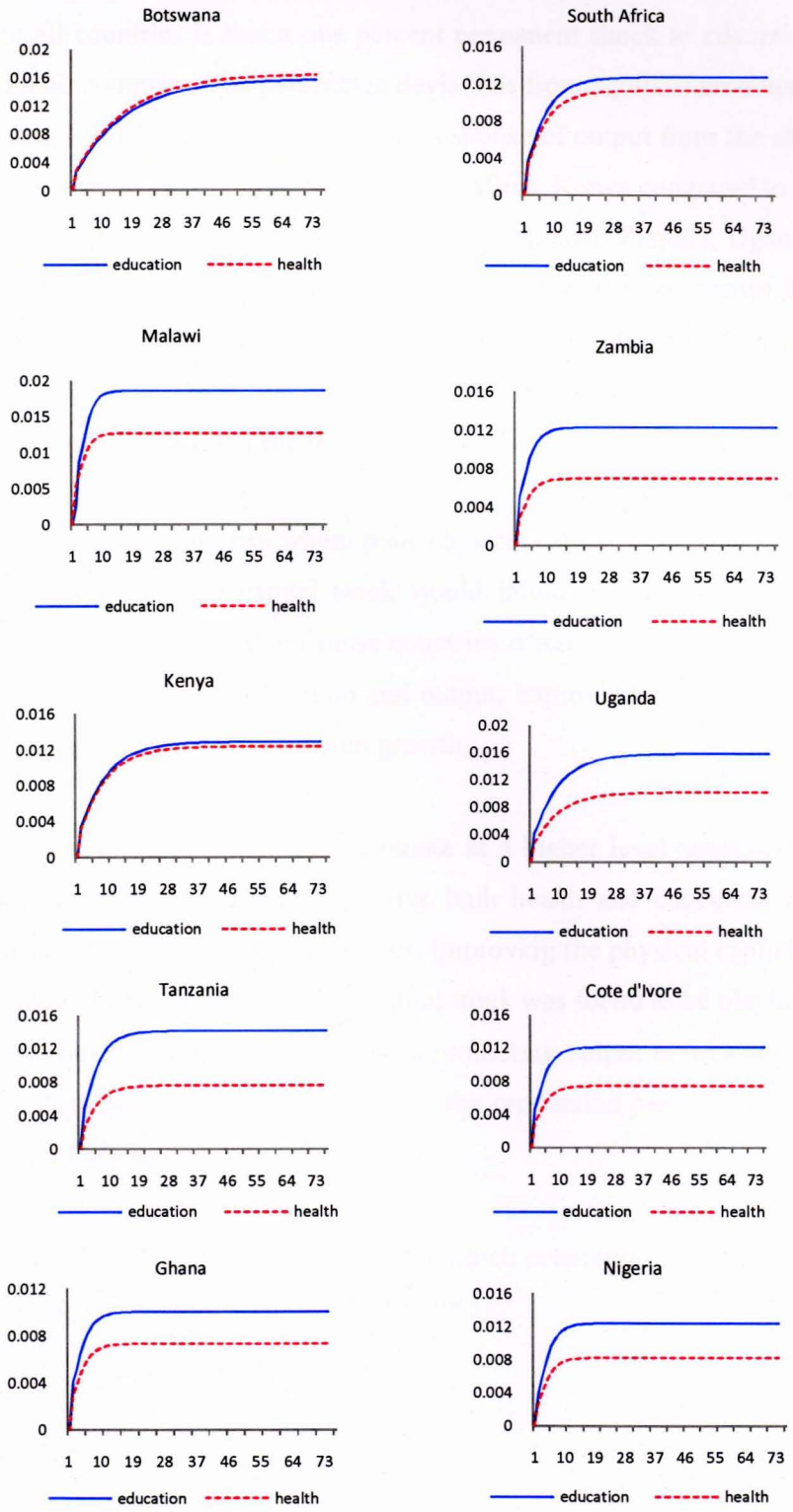


Figure 3 presents the response of output to a 1 percent permanent shock to health and education in the dynamic system with estimated country parameters. What emerges from both figures in all countries is that a one percent permanent shock to education and health raises output for all countries. The percentage deviations from equilibrium output vary across countries but it is interesting to note the similar response of output from the shock to health and education of more than 1% in Botswana, South Africa, Kenya compared to the gap in the output reaction functions observed in other countries (Malawi, Zambia, Uganda, Tanzania, Cote d'Ivore, Ghana and Nigeria). For other countries, the analysis shows that education would produce a higher impact on output of about 1% while health impact varies more across countries averaging about 0.8%. On average, the 1% permanent shock to education and health would raise output by 1.2% and 0.8% respectively.

This shows that for those countries where poor physical capital stock leads to poor state of health, improving the physical capital stock would improve health and hence achieve a higher impact on output. Similarly, for those countries where the role of the physical capital stock was found to be lower on education and output, improving the physical capital stock would serve to raise the role of education on growth.

The permanent shock causes output to equilibrate at a higher level across countries which shows that policies and measures that improve both health and education would lead to longer term sustainable growth across countries. Improving the physical capital stock among the countries where the role of the physical capital stock was found to be playing a lower role on education and health would go a long way in promoting output in such countries through enhancing education and health which feeds into the production process through promoting the effectiveness of labour and productivity.

The impact of shocks to the human capital index which constitutes the health and education indicators are shown in the following *figures (4 and 5).*

Figure 4: Dynamic Response of Output to a Temporary Shock to the Human Capital Index

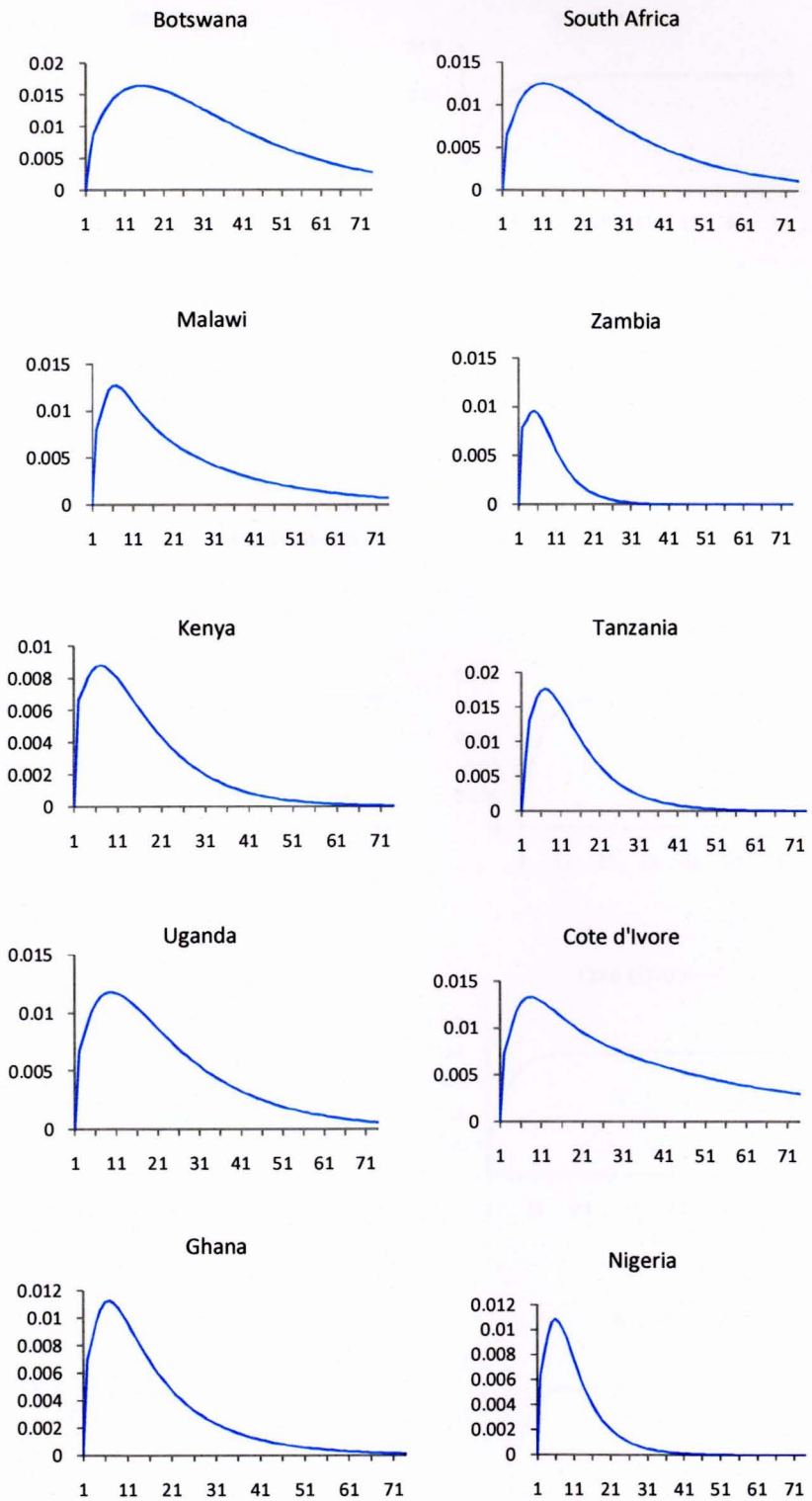
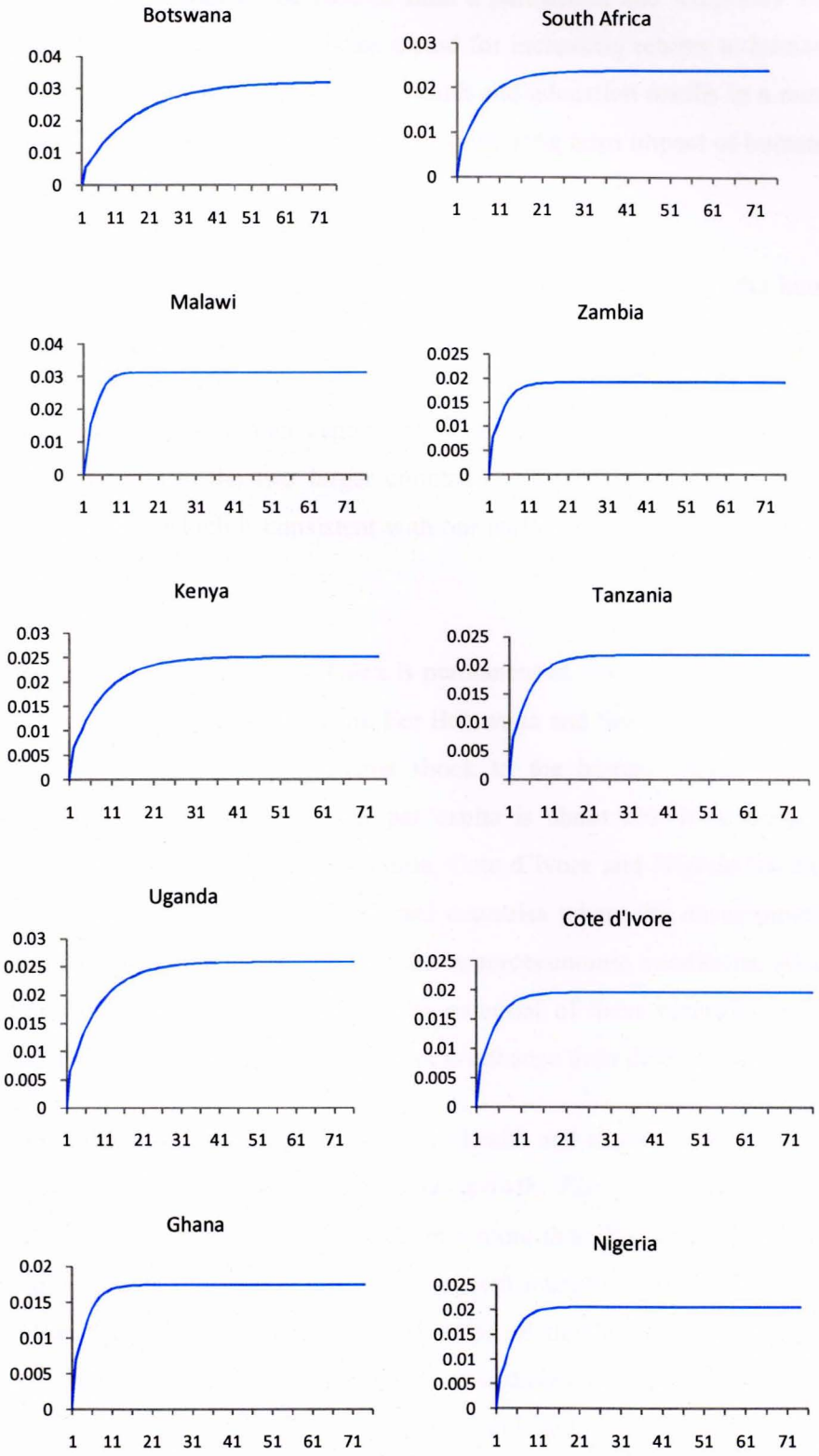


Figure 5:Dynamic Response of Output to a 1% Permanent Shock to the Human Capital Index



The results show that an increase in the human capital index leads to a more than 1% increase in output per capita in the case of both a permanent and temporary shock to the human capital index. These results indicate a case for increasing returns to human capital in the sense that a one percent increase in both health and education results in a more than 1% increase in output. The results underscore the positive long term impact of human capital on growth in general.

It is clear that in Figure 4, the reaction of output to temporary shocks to the human capital index is less in Zambia, Uganda, Cote d'Ivore averaging just about 1% in these countries while Botswana, South Africa experience on average, an increase of 1.5% in output following the shock to the human capital index. That is increasing health and education confers greater benefits in the two larger countries compared to the other less developed countries in the sample which is consistent with our earlier findings where the shocks are on either health or education.

When the shock to the human capital index is permanent at 1%, it is interesting to note that the reaction of output is highly significant. For Botswana and South Africa, output increases by about 3% following a 1% permanents shock to the human capital index. In other countries, the average increase in output per capita is about 2%. It is worth noting the reaction of output in countries such as Zambia, Cote d'Ivore and Nigeria which is slightly less than 2% compared to other less developed countries where the development of health and education has been affected by the unstable macroeconomic conditions. Also, resource constraints in these countries have limited the potential of these countries to provide the infrastructure in the health and education sectors to enhance their development and growth.

These findings show a positive significant role for health and education on growth. Sustained increases in education would result in long run growth. Also, increasing both health and education by 1% permanently would resulting in a more than 2% increase in output as seen from the results obtained following the 1% permanent increase in the human capital index. The implication for policy is that policies directed at developing human capital should therefore target both health and education to realize sustained positive growth effects through productivity enhancements emanating from better health and education. These efforts should

be coupled with the development of the physical capital stock of a country which directly impacts on health, education and growth.

Table 10:Summary Table for the Impact Effects of Temporary and Permanent Shocks to Health and Education

Measuring the Impact Effect of the Reaction of Per Capita Output to Temporary and Permanent Shocks (Percentage Deviation from Equilibrium/steady state[20])

		Botswana	South Africa	Malawi	Zambia	Kenya	Uganda	Tanzania	Cote d'Ivore	Ghana	Nigeria
Reaction of Output Per capita to Temporary Shocks (maximum figure reported)	% change in output due to a positive shock on Health	1%	0.6%	0.4%	0.3%	0.4%	0.5%	0.5%	0.4%	0.4%	0.4%
	% change in output due to a positive shock on education	0.6%	0.8%	1%	0.7%	0.6%	0.9%	0.8%	0.8%	0.9%	0.9%
	% change in output due to a positive shock on human capital index	1.6%	1.4%	1.4%	1%	1%	1.4%	1.3%	1.2%	1.3%	1.3%
Reaction of Output Per capita to 1% permanent shocks.	% change in output due to a 1% permanent shock to health	1.6%	1.1%	0.8%	0.8%	1.1%	0.9%	0.8%	0.7%	0.8%	0.8%
	% change in output due to a 1% permanent shock to education	1.5%	1.4%	1.2%	1.2%	1.2%	1.3%	1.3%	1.2%	1.1%	1.2%
	% change in Output due to a 1% permanent shock to the human capital index	3.1%	2.8%	2%	2%	2.2%	2.2%	2.1%	1.9%	1.9%	2%

[20] here the equilibrium for the indicator is given by the average indicator/GDP for the period 1980-2008. this represents steady state over this period

3.5 Summary

This Chapter sought to assess the possible implications of health and education as components of human capital on growth for selected African countries. The results obtained from the estimated parameters of the model show that human capital in the form of health and education play a positive role on growth through enhancing the effectiveness of labour. The findings indicate the importance of health and education on productivity of the labour force. The implication of this finding is that it is imperative for policies that aim to promote human capital to encompass both aspects of health and education to realize further economic growth through enhanced productivity. The positive relationship suggests that countries where the health of the population is deteriorating will experience a decline in labour effectiveness which would translate into low growth. It is therefore essential to address the state of health given that the declining health would adversely affect human capital, labour productivity and growth.

The model allows for the assessment of the interactions between the physical capital stock and output as well as the role of the physical capital stock on education and health. The parameters show that the physical capital stock has a positive role to play in the development of health, education and growth. In this regard, a deteriorating physical capital stock will negatively affect health, education and growth. The implication of this finding reinforces the importance of promoting policies geared at improving and accumulating physical capital in the health and education sectors for developing countries given its positive role for promoting health, education and growth.

The dynamic reaction of output which links all the components of the model with the estimated parameters and dynamic interactions reveal that a persistent shock to education and health would raise output for all the countries. A permanent shock to education and health raise output and cause the economy to realize higher sustained output levels and growth. The percentage increases on per capita output following the shocks the permanent shock to education and health average 1.2% and 0.8% respectively while in some countries the increase in output is more than 1% for both health and education. When the shock is on the human capital index, constituting health and education, we find that a 1% shock to the

index leads to an increase in per capita output by about 2.5% on average. For other countries, this impact is higher at 3%, showing significant increasing returns to human capital on growth. We conclude that if all countries could realize an increase to education and improvement in health which is sustained, this would cause output to increase and the growth would be sustainable.

These findings indicate that it is imperative for policies geared at improving human capital to be cross cutting and should be two-thronged in approach targeting health and education to realize sustained positive growth effects through productivity enhancements emanating from better health and education. That is, policies directed at developing human capital should target all the components of human capital in the form of health and education for the developing countries so that the benefits of investing in human capital can be fully exploited and play a more significant and meaningful role in the economy. If the approach to human capital does is not balanced, growth may be thwarted given the roles played by both health and education. These efforts should be coupled with the development of the physical capital stock of a country which directly impacts on health, education and growth.

Chapter 4: Macro-Model for Human Capital and Growth with the Government Budget Constraint, Government Spending and Fiscal Policy Rules

4.1 Introduction

In Chapter 4 we introduce the government budget constraint in the model developed in Chapter 3. The aim in this Chapter is to assess the extent to which expenditure on human capital delivers long run fiscal sustainability. Developing countries are encouraged to prioritize human capital improvements as part of meeting the Millennium Development Goals. However, the fiscal sustainability of such policy proposals remains an issue that requires further research. The upshot of the analysis from this Chapter may be that because of major gaps in human capital levels, some developing countries may be unable to close these gaps within reasonable time on the strength of their domestic resources. Surprisingly, few studies integrate endogenous growth with the government budget constraint. For example, Romer (1990) features government spending but does not explore the implications of the government budget constraint. The study that comes close to ours is the one by Greiner et.al. (2004). This study features the government budget constraint, but human capital is modeled as education.

While the growth implications of human capital have been analysed to a considerable extent in the past empirical research[21], the role of human capital on growth within a framework that captures both components of human capital, health and education as well as the GBC still remain under explored, and surprisingly few studies focus on the developing countries with high debt problems and poor fiscal positions. Accordingly, there remains little by way of understanding the process by which fiscal dynamics shape the growth prospects of human capital for developing countries. The existing empirical research on human capital generally identifies human capital with education leaving out the role of health as a component of human capital. Also, the literature does not provide a clear picture of how human capital affects growth within an analytical framework that captures the GBC and assessing the

[21] Mankiw, Weil and Romer (1992), Levine and Renelt (1992), Romer (1990), Barro (1990), Barro and Sala-I-Martin (1990), Greiner, Semmler and Gong (2004), Greiner, (2004) and Casselli e.*t.al.* (1997),

growth dynamics (for example, Romer 1990, Barro (1990), Barro and Sala -i-Martin (1995), Levine and Renelt (1992), Makiw, Weil and Romer (1992)[22].

A major aspect of this paper is to capture the fiscal constraints faced by developing countries within the integrated model of human capital and growth by incorporating the government budget constraint in the growth model developed. A particular weakness of the studies cited above on human capital and growth is the wide spread tendency among studies to ignore the implications of the government budget constraint for their regressions. The studies do not recognize the constraints faced by some countries by incorporating the government budget constraint in the model frameworks adopted.

The importance of introducing the government budget constraint in growth models has been highlighted by Turnovsky (1975) and Kneller *et al.* (1999). They posit that it is important to capture the variables that enter the government budget constraint for a meaningful analysis of the long run growth effects of fiscal policy. Christ (1979) and Aizenman *et. al.* (2004) also state that econometric models used for policy analysis should be careful to keep track of the implications of the government budget constraint in order to avoid being subject to potential biases arising from omitting variables that enter the government budget constraint. The possibility of omission bias arises due to the fact that these studies only focus on the expenditure side of the budget constraint and ignore the revenue side (Aizeman et.al (2004) which is eliminated by including the GBC variables and studying the dynamics they introduce in the estimations

Also, a general conclusion and recommendation arising from the research on human capital is for government to increase government expenditure education to realize further growth (World Bank, 2007). Cashin (1995) and Bose *et.al*, (2003) emphasizes that while the provision of public goods is growth-enhancing, the distortionary taxes that need to be raised to fund the provision of the same public goods may have growth-diminishing effects. For developing countries, which are resource constrained with high debt and poor revenue prospects, rising expenditures have the potential to sup away the positive growth realized. It is against this background that there is recent interest in growth theory in gaining further insight on the growth implications of fiscal policies particularly for developing countries.

[22] Caselli et. al (1996), Greiner, Semmler and Gong (2004)

Raising expenditure for enhancing health and education is limited by rising debt which negatively affects growth. These views may serve to support empirical evidence by other studies which have found an insignificant role of human capital on growth for developing low income countries.

Developing countries therefore, have to restrain their spending patterns to obtain sustainable fiscal positions and reduce high debt burdens and this directly affects the education and health development policy priorities, in the event suppressing their growth potential. Sachs (1989) outlines in great detail the nature of the debt crisis facing many small open economies with serious difficulties in repaying debt, or in many cases even the interest on the debt. Economists argue that high debt makes it more difficult for countries to achieve the Millennium Development Goals (MDGs) since the high debt and debt service absorbs resources that could be used for essential spending on poverty reduction, and diverts resources away from public investment on sectors such as education and health. (Patillo *e.t al.* 2002). Consequently, many developing countries face unsustainable fiscal options which negatively affect their growth potential.

Thus, there are trade-offs between growth, financing the public debt and allocating expenditure on human capital while maintaining a healthy state on the fiscal side with implications for the long run growth. It is therefore, important that an integrated assessment of the role of human capital on growth includes the government budget constraint for a meaningful evaluation of the effects of human capital on growth. Against this background, this study intends to incorporate the GBC in the growth model that captures health and education as components of human capital. This approach avoids the omission variable bias that may result from leaving out the full implications of the GBC given the challenges faced by developing countries in raising revenue for expenditure as well as the prevalent deficits and high debt to GDP ratios. The GBC serves to capture the sources and the uses of funds simultaneously for a meaningful evaluation of the effects of human capital on growth in the model

As in the preceding Chapter, the analysis will focus on the same set of selected African countries[23]. The focus on developing countries is important, because the fiscal constraints

[23] Botswana, South Africa, Zimbabwe, Zambia, Uganda, Kenya, Tanzania, Nigeria, Ghana and Cote d'Ivore.

facing developing and developed countries differ profoundly and the literature that exists is highly based on developed country experiences. In this regard, the present paper will fill an important research gap that currently exists in the literature in as far as the implications of human capital on growth given the GBC are concerned. Further, the study contributes to the existing research gap on an integrated growth framework of the role of human capital on growth within a model that captures all the components of human capital, health and education but also featuring fiscal variables on the revenue and expenditure side by including the GBC. This analysis is pertinent from a policy perspective for developing countries prone to fiscal imbalances and high debt ratios. This study is thus justified to provide an understanding of the role of human capital on growth given fiscal constraints for developing countries.

The remainder of this paper is structured as follows: Section 4.1.1 outlines the specific issues being investigated and hypothesis being tested. Section 4.2 details the model framework adopted for analysis and elaborates on the data and the selected sample. Section 4.3 focuses on the dynamics of the model while Section 4.4 focuses on the empirical estimation. Section 4.5 draws the study conclusions and implications.

4.1.1 Objectives and Hypothesis

The specific objectives in this Chapter are:

- Chapter 3:
  i. Extend the model framework in Chapter 2 to integrate the government budget constraint and government spending in the model
  ii. Assess the dynamic behavior of output to shocks on health and education in this framework
  iii. Assess the impacts of increased government spending on health and education on public deficit and debt.

The hypothesis being tested:

i. A 1% increase in government spending on health and education leads to a budget surplus in the long run.
ii. A 1% increase in government spending on health, holding spending on education constant, leads to a better budget balance compared to spending on education.
iii. A 1% increase in public debt leads to a more than 1% decrease in human capital.

4.2 The Model

The recent literature on endogenous economic growth allows for incorporating the effects of human capital and fiscal policy and assessing their effects on long term growth (Barro 1990, Barro and Sala-i-Martin, 1990). The theoretical framework adopted follows the endogenous growth model of Romer (1990) but modified to include health and education and the government budget constraint. The model considered in the present analysis assumes that the economy is composed of three sectors: the household sector, the productive sector and the government sector. The model assumes one decision variable, consumption and two state variables, public capital stock and public debt.

In this Chapter, we therefore modify the endogenous growth model of Romer (1990). The analytical approach is extended to include health and education as the main components of human capital which determine the effectiveness of labour and productivity. In line with Barro (1990), we integrate the role of government expenditure within the endogenous growth model developed to assess the effects of government expenditure on human capital and output per capita. Further, we introduce the GBC to assess the growth implications of human capital within a framework that captures the fiscal dynamics. According to Slow and Blinder (1967) and Christ (1968), the GBC introduces a dynamic system to an otherwise static system which allows an assessment of the long run growth dynamics. The core equations and the structural relationships of the model framework we adopt for analysis which features the productive sector, the household sector and the government sectors is outlined and explained in the following equations in each of these sectors.

4.2.1 The Productive Sector

In Equation (20), the production function is modified following Romer (1990). We assume that output per capita, $\tilde{Y}_t$ is a function of the proportion ω_y, of the aggregate capital stock per capita $\tilde{K}_t$, used in the production of output.; A_t is the technology or innovations used in the production of output. The role of government expenditure G on production is introduced according to Barro (1990) and in our model, $1 - \upsilon_e - \upsilon_h$ is the proportion of government spending on other sectors besides the health and education sectors. Government expenditure on health and education enters the production function through equations (22) and (23) which show the dependency between health, education, the physical capital stock and government expenditure.

$$\hat{Y} = A_t^{1-\propto}\left(\omega_y \hat{K}_t\right)^{\propto}\left((1 - \upsilon_e - \upsilon_h)G\right)^{\mu} \tag{20}$$

$$A_t = A_{0t}\, h_t^{\gamma}\, e_t^{1-\gamma} \tag{21}$$

$$h_t = h_0\, (\omega_h k_t)^{\beta_h}\, (\upsilon_h\, g)^{\chi_h} \tag{22}$$

$$e_t = e_0\, (\omega_e k_t)^{\beta_e}\, (\upsilon_e\, g)^{\chi_e} \tag{23}$$

In Equation (21), we extend the Romer (1990) approach to include health, h_t, and education, e_t as determinants of human capital which directly influence the effectiveness of labour A_t . h_t and e_t capture the indicators of health and education in the model. According to Bloom *et. al* (2004) and Weil (2006), a healthy work force has positive implications for productivity since the healthy work force is more productive, less absent from work and therefore contributing positively to growth of output. In this regard, we also argue for the introduction of health as a factor that influences the effectiveness of labour in the manner presented in equation (21). Education is also introduced as positively affecting labour effectiveness and productivity and thus having a positive effect on growth (Barro and Sala-i-Martin, (1995). Romer (1993) formalizes the argument that a more educated populace is better able to integrate new technologies. The index of the effectiveness of labour in our approach, taking into account the effects of health and education is thus given by Equation (21).

Equation (22) and (23) describes factors that influence health and education in our model respectively. The changes in health depend on the proportion ,ω_h of physical capital in the health sector and other factors,h_0, such as the quality of doctors and nurses. We assume that the physical capital stock in the health sector of a country has a positive role to play on health and its state. Similarly, in Equation (23), education in a particular country depends on ω_e , the proportion of the physical capital stock in the education sector and e_0 are other factors which include the quality of teachers and education systems. In these equations, both education and health are also influenced by the proportion of government expenditure; υ_h and υ_e in the health and education sectors respectively. The introduction of government expenditure is assumed to positively affect health and education through availing resources for the continual operations of these sectors such that declining shares of government expenditure in these sectors may inhibit education and health development and therefore reduce growth prospects (Bose *e.t al* 2004).

The four equations (20-23) describing the productive sector indicate the inter-relationships between health, education, technology or innovation, the physical capital stock, government expenditure and output. The interrelationships and interdependencies amongst these equations are shown through the substitution of the equations into the production function such that we have:

$$\hat{Y} = A_0^{1-\propto}\left(h_t^{\gamma}\, e_t^{1-\gamma}\right)^{1-\alpha}\left(\omega_y \hat{K}_t\right)^{\propto}\left((1-\upsilon_e-\upsilon_h)G\right)^{\mu} \qquad (24)$$

It can be shown that the reduced form of equation (24) following the substitution process can be specified in per capita term in the following form

$$y_t = \Omega_0^{1-\alpha}\ \omega\ k_t^{\theta}\upsilon\ \phi^{\mu} g \qquad (25)$$

where:

$$\Omega = {h_0}^{\gamma}{e_0}^{1-\gamma},$$

$$\omega = {\omega_h}^{\beta_h\gamma(1-\alpha)}{\omega_e}^{\beta_e(1-\gamma)(1-\alpha)}{\omega_y}^{\alpha}$$

$$\theta = \alpha + \beta_h\gamma(1-\alpha) + \beta_e(1-\gamma)(1-\alpha)$$

$$g = g^{\chi_h\gamma(1-\alpha)}g^{\chi_e(1-\gamma)(1-\alpha)}g^{\mu} \quad [24]$$

$$\phi = (1 - \upsilon_e - \upsilon_h) \text{ and}$$

$$v = {\upsilon_h}^{\chi_h\gamma(1-\alpha)}{\upsilon_e}^{\chi_e(1-\gamma)(1-\alpha)}$$

The interrelationships among the system of equation posit a positive role of the physical capital stock and government spending on health, education and growth. An improvement in health and education positively effects labour effectiveness. Since the effectiveness of labour is a component of output as indicated by the adopted production function, its improvement through enhanced health and education impacts positively on output.

4.2.2 The Household Sector

We assume that a representative household maximizes a discounted stream of utilities arising from consumption c_t such that:

$$U(c_t) = \int_0^{\infty} e^{(\varphi(1-\sigma)-\rho)t}\frac{\check{C}^{1-\sigma}}{1-\sigma}dt \qquad (26)$$

σ is the elasticity of marginal utility with respect to consumption and ρ is a constant discount factor calibrated at 0.1 for all the countries. $u(c)$ is the utility function which is strictly increasing in c and concave; $u'(c) > 0$ and $u'' < 0$ (Greiner e.t al, 2004).

[24] The g's on the right hand side are the sub components from the optimization. Refer to appendix section to follow the differentiation stages.

Changes in the capital stock, K are influenced by the previous capital which depreciates over time at the rate δ. Output changes, Y have a positive effect on physical capital, while consumption, c reduces the rate of capital accumulation. Increasing government expenditure, g reduces the rate of capital accumulation while a rising growth rate of debt service negatively effects capital accumulation. Increasing government spending will raise the debt and debt weighs on the accumulation of capital which reduces growth. A rising expenditure on health and education implies that the government has to raise taxes to reverse the negative growth effect that arises from increased spending. The specification adopted for the rate of growth of capital accumulation takes the form:

$$\dot{k}_t = y_t - c_t - g_t - r_t b_t - (\delta + n + \psi)k_t \qquad (27)$$

Substitution for y_t and the marginal productivity of capital, r_t implies that the reduced form of the capital accumulation constraint per unit of effective labour takes the form:

$$\dot{k}_t = \Omega_0^{1-\alpha}\ \omega\ k_t^{\theta}\ \phi^{\mu} g\ - c_t - g_t - \Omega_0^{1-\alpha}\ \omega\ \theta\ k_t^{\theta-1}\ \phi^{\mu} g b_t - (\delta + n + \psi)k_t \qquad (28)$$

Where $b(t)$ is the public debt and $r_{t-1}b_{t-1}$ is the debt service. From Equation (28) changes in the per capita capital stock are negatively affected by the depreciation rate δ the growth rate of labour efficiency, ψ and the growth rate of the labour force n. The per capita output positively influences the accumulation of capital while consumption per capita, c reduces the rate of capital accumulation.

4.2.3 The Government Sector

Christ (1967, 1968), Silber (1970), Blinder and Solow (1973) and others have shown how the GBC imposes a dynamic structure on an otherwise static system. The reason for this is that the financing of any budget deficit or surplus must involve changes in the net claims of

the private sector against the government, and these in turn lead to changes in the other endogenous variables. Hence the system can be in equilibrium only when the government's budget is balanced. The Blinder and Solow (1973) paper in particular, has shown how the method used by the government to finance its budget deficit has a crucial effect on both the stability of fiscal policy and the long-run impact of government expenditure on activity. Obstacles including the highly concentrated tax systems and expenditure rigidities complicate developing countries efforts to consolidate their fiscal positions (Burgess and Stern, 1993). Some countries face considerable increases in government debt and hence, they are undergoing reforms to reduce the deficits through tax reform and reduced expenditure.

Given the importance of the GBC for the growth dynamics of human capital, we assume a government that faces a government budget constraint such that the growth in government debt, $\dot{b}$. b_t depends on the debt service $r_t b_t$ of the existing debt with interest on debt, $r_t$government expenditure, g less tax revenues, t

$$\dot{b} = g - t + (r - n - \varphi)b \tag{29}$$

Since taxes are a proportion of income, equation (29) is re-written as:

$$\dot{b} = g - \tau y + (r - n - \varphi)b \tag{30}$$

and τ is the proportion of taxes in total income. Substituting for y and the marginal productivity of capital, we obtain the following government budget constraint in our framework:

$$\dot{b} = g - \tau\left(\Omega_0^{1-\alpha}\ \omega\ k_t^{\theta}\ \ \phi^{\mu} g\right) + \left(\Omega_0^{1-\alpha}\ \omega\, \theta\, k^{\theta-1}\ \phi^{\mu} g - (n + \varphi)b\right) \tag{31}$$

According to Clements et al (2003) the debt stock and debt service, at least when they are at very high levels may hinder growth through distortions of private and public investment incentives. A high current debt may severely hamper future debt-servicing capacity because it might introduce the economy all kinds of disincentive effects to invest and adjust, resulting in a severe negative effect on future economic growth[25]. This is the so called debt overhang hypothesis (Pattillo *et al.* (2002) and Chowdhury (2004). This effect is usually linked to a high stock of debt. Sachs (1986) argue that in this situation the high stock of debt acts like a high marginal tax on investment. They suggest that the incentives for domestic firms or the debtor government to invest at home are distorted since any positive returns from investment projects are used for debt payments. Hence, the net present value of repayments increases.

When there is a debt overhang, a country's debt exceeds its expected ability to repay, and expected debt service is likely to be an increasing function of the country's output level. Thus, some of the returns from investing in the domestic economy are effectively "taxed away" by foreign creditors. As a result, investment by both domestic and foreign investors, and thus economic growth is discouraged. Clements *e.t al* , (200) argues that the debt overhang can also depress growth by increasing uncertainty about the actions and policies that the government will resort to in order to meet its debt service obligations.

Second, a high current debt-service burden also may act as an important constraint that is difficult to deal with from a political or moral point of view. The issue is that the resources allocated to debt service may crowd out social or other poverty-related spending as defined, for instance, through the measures needed to reach the MDGs or other targets specified in a country's Poverty Reduction Strategy Paper (PRSP). As such, a wedge can be inserted between the capacity to pay debt service and what would be considered "affordable" debt service (Patillo, 2002) in order not to crowd out priority sector spending. The so-called human development approach to debt sustainability refers specifically to the spending

[25] In an empirical study, Pattillo *et al.* (2002) find evidence of debt overhang. Using a panel data set comprised of 93 developing countries for the period 1969-1998, they suggest that at a debt stock of 35-40 percent of GDP, the average effect of debt on per capita growth becomes negative. Clements *et al.* (2003) confirm their results of a debt overhang. Furthermore, they find that debt service has a "crowding out" effect on public investment, thereby lowering the overall growth rate of a developing country. They argue that if resources freed up by debt service relief can be directed towards public investment, growth rates in some HIPC countries would increase by half a percentage point annually. Similarly, Chowdhury (2001) finds evidence for debt overhang in his sample.

necessary to reach social and poverty reduction goals, and the political pressure to take on more debt to finance needed additional expenditures.

The theoretical literature thus suggests that foreign borrowing has a positive impact on investment and growth up to a certain threshold level; beyond this level, however, its impact is adverse, giving rise to a laffer curve[26] type relationship between external debt, on the one hand, and investment and per capita income growth on the other. External debt service (in contrast to the total debt stock) can also potentially affect growth by crowding out private investment or altering the composition of public spending. Other things being equal, higher debt service can raise the government's interest bill and the budget deficit, reducing public savings; this, in turn, may either raise interest rates or crowd out credit available for private investment. Higher debt service payments can also squeeze the amount of resources available for infrastructure and human capital formation, with further negative effects on growth.

However, there is disagreement about the existence or importance of debt overhang and the debt Laffer curve. For example, Bird and Milne (2003) question the presence of a debt overhang problem in low-income countries. Official resource transfers to highly indebted countries often exceed their debt service payments. Hence, incentives for domestic investment may not be distorted for after all. Furthermore, they caution that providing (unconditional) debt relief to highly indebted countries may simply redistribute resources to countries with a history of unsound macroeconomic policies. Hence, "bad policies" in the past would be rewarded ex-post by providing debt relief. In the theoretical literature, there are several papers questioning the conventionally held view that an excessive level of sovereign debt has distortionary incentive effects on the behavior of economic agents in the indebted country (Cohen , 2000, Baldacci and Fletcher, 2004, Fedellino and Kudina, 2003).

The model is closed with 3 simple budgetary rules to assess how the model behaves under different fiscal policy rules. These are

1. Government expenditure rule where the government expenditure as a proportion of GDP depends on the proportions of expenditure on education, health, and debt such that:

[26] the *debt Laffer curve*, which is represented by an "inverted U" relationship between the level of debt stock and expected net present value (NPV) of debt service payments. Debt overhang in this context means that a country is to the right of the peak of this curve. In this scenario, a decrease in debt stock (through debt relief) increases the expected NPV of repayments

$$\dot{g} = v_b(b - b^*) + v_g(g - g^*) \quad (32)$$

v_g, v_b are the proportions of government expenditure for the respective components.

2. Primary balanced budget rule where the deficit is zero such that:

$$g - \tau y = 0 \quad (33)$$

3. Zero growth rate in debt such that:

$$\dot{b} = 0 \quad (34)$$

This is contrary to the budgetary regime followed by the government where instruments (expenditure and taxes)[27] are used to derive the government budgetary rule. (Greiner e.t al (2004). The budgetary rules adopted in this chapter are essential in order to impose a constraint on the budgetary policy of government. The rules are also essential for macroeconomic stability[28].

4.2 Dynamics of the Model[29]

The dynamic behavior of our model which allows us to employ the simulations to determine the optimal growth path in the presence of binding constraints is derived using the Maximum Principle Approach for optimization according to Greiner, Semmler and Gong

[27] See Greiner , Semmler and Gong (2004) for a discussion of the budgetary regimes introduced by Blinder and Solow (1973)

[28] See Greiner , Semmler and Gong (2004) for a discussion of other budgetary regimes introduced by Blinder and Solow (1973)

[29] In case equations do not display due to memory capacity for equations, *refer to Appendix 2* for a repeat of these equations (36-38)

(2004). In our model we assume that a representative household maximizes a discounted stream of utilities arising from consumption c_t such that:

——— (36)

subject to the capital accumulation and the debt constraint of the model:

(37)

(38)

The derivations of the first order conditions and dynamic system are detailed in *Appendix 2*. There are three key dynamic processes that drive the system of the model together with the production function (equation 1), the effectiveness of labour equation (equation 2), and the health (equation 3) and education equation (equation4). The first is the path for the growth of the consumption per capita, the function in equation 11 and the second is the path for the growth of capital accumulation equation (12) and thirdly, the debt equation which constitutes the GBC. The dynamic equations interact the physical capital stock per capita with consumption, government expenditure, health and education as well as the growth of rates the physical capital stock, depreciation of the physical capital stock and labour. The reduced form of the equations for the dynamics of the model takes the form:

$$\frac{\dot{c}}{c} = \frac{(1-\tau)\ \Omega_0{}^{(1-\alpha)}\ \omega\ \ \theta\ k\ \ ^{\theta-1}\ v\ \phi^{\mu}\ g-(\delta+n+\varphi)-\rho}{\sigma} \qquad (39)$$

$$\dot{k} = \Omega_0^{1-\alpha}\ \omega\ k^{\theta}\ v\ \phi^{\mu} g - c\ \ - g\ \ - \Omega_0^{1-\alpha}\ \omega\ \theta\ k^{\theta-1}\ v\ \phi^{\mu} g\ b\ \ -$$

$$(\delta + n + \psi)\ k \qquad (40)$$

$$\dot{b} = g - \tau\left(\Omega_0^{1-\alpha}\ \omega\ k_t^{\theta}\ v\ \phi^{\mu} g\right) + \left(\Omega_0^{1-\alpha}\ \omega\ \theta\ k_t^{\theta-1}\ v\ \phi^{\mu} g - (n +\right.$$

$$\varphi)\ b \qquad (41)$$

The dynamic system given by *equation (17 - (20)* leads to some dependencies between the rows of the Jacobian of the system, which allows us to examine the stability properties of the model and equilibrium solutions with phase diagrams following Romer (1990) on the basis of the sign structure of the Jacobian.

$$\begin{vmatrix} 0 & c^*(1-\tau)\left(\Omega_0{}^{(1-\alpha)}\omega\ \ \theta(\theta-1)k^{\ \theta-2}v\,\phi^{\mu}g\right)-(\delta+n+\varphi) & 0 \\ -1 & \Omega_0{}^{(1-\alpha)}\omega\ \ \theta k^{\ \theta-1}v\,\phi^{\mu}g-\left(\Omega_0{}^{(1-\alpha)}\omega\ \ \theta(\theta-1)k^{\ \theta-2}v\,\phi^{\mu}g\right)b-(\delta+n+\varphi) & -\Omega_0{}^{(1-\alpha)}\omega\ \ \theta(\theta-1)k_t{}^{\theta-2}v\,\phi^{\mu}g \\ 0 & \tau\left(\Omega_0{}^{(1-\alpha)}\omega\ \ \theta k^{\ \theta-1}v\,\phi^{\mu}g\right)+\left(\left(\Omega_0{}^{(1-\alpha)}\omega\ \ \theta(\theta-1)k^{\ \theta-2}v\,\phi^{\mu}g\right)-n-\varphi\right)b & \Omega_0{}^{(1-\alpha)}\omega\ \ \theta k^{\ \theta-1}v\phi^{\mu}g-n-\varphi \end{vmatrix}$$

The system is tested for stability using the Routh–Hurwitz stability criterion which is a necessary (and frequently sufficient) method to establish the stability of a dynamic system of equations (Turnovsky, 1968). The criterion establishes a systematic way to show that the linearized equations of motion of a system have only stable solutions. It can be performed using either polynomial divisions or determinant calculus. For the 3 by 3 system and following the determinant calculus, the conditions for stability:

For the a 3×3 matrix indicated above, and assuming that the matrix is given by J as below, the procedure followed too test the stability of the system for each country is given below:

is given by $$J = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

For matrix J, the principal minors *Ji* are given by:

$$J_1 = \begin{vmatrix} a_{22} & a_{22} \\ a_{22} & a_{33} \end{vmatrix}, \qquad J_2 = \begin{vmatrix} a_{11} & a_{13} \\ a_{31} & a_{33} \end{vmatrix} \text{ and }, \qquad J_3 = \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix}$$

The Routh-Hurwitz necessary and sufficient condition for the stability of the system is expressed as:

- Trace (J)<0, where trace (J)= $a_{11} + a_{22} + a_{33}$
- $J_1 + J_2 + J_3 > 0$
- Det J<0
- -trace (J)($J_1 + J_2 + J_3$)+|J|>0
- Det |J| = $a_{11}|a_{22}a_{33} - a_{32}a_{33}| - a_{21}|a_{12}a_{33} - a_{32}a_{13}| + a_{31}|a_{12}a_{23} - a_{22}a_{13}|$

When these conditions are met for each of the dynamic system of equations, the simulations converge following the shocks. In the case where the stability criteria is not met, then the paths to converge will either explode or be unstably and not return to stability. This is one test for the stability of the theoretical model.

4.4 Empirical Estimation

4.4.1 Data Description and Measurement

The analysis is conducted for a sample of selected African countries: Botswana, South Africa, Malawi, Zambia, Uganda, Kenya, Tanzania, Cote d'Ivore, Ghana and Nigeria, Ghana. The table below summarizes the data used to estimate the parameters of the model for the countries in the selected sample for ease of reference. Most variables and indicators are the same as in the preceding chapter and new variables relate to the public debt, government expenditure and shares in the health and education sectors.

Description of the Data and Measurement

Variable	*Measurement*
y_t= Output per capita	Real gross domestic product per capita (2000 US$)
k_t =Physical capital stock	Derived using inventory perpetual method (2000 US$)
A_t = Innovation or technology	Solow residual from estimated production function
g_t	Government expenditure per capita (2000 US$)
b_t	Public debt per capita
ω_y =Proportion of physical capital stock used in the production of output	Proportion of physical stock used for production (1-$\omega_h - \omega_e$)
h_t = Health indicator	Generated from life expectancy at birth. To capture productive age group , alternative indicator is derived from life expectancy as $h_t = \left(\frac{Lifeexpectancy}{65yrs}\right) * 100$
ω_h, ω_e= proportion of physical capital stock in the health sector and educatotion sector respectively	Derived from physical stock series using average share of physical stock in the health sector and education sector
e_t= Education indicator	Generated from gross enrolment rates for primary, secondary and tertiary education. To capture the effect of higher education average enrollment rates computed place higher weight on higher education $e_t = 0.1(Primary) + 0.4(Secondary) + 0.5(tertiary)$
υ_h, υ_e	Share of government expenditure in the health and education sector.

The data used for estimation is collected from the IMF/World Bank Statistics, the World Development Indicators and the National Accounts of the respective countries. Data from

the Human Development Indicators for various years is also used to augment the data from the WDI on the education and health indicators. The physical capital stock series is the same as the one in the previous Chapter and it is derived for each country using the inventory perpetual method following Liman and Miller (2004)[30]. We use a constant rate of depreciation of about 7 percent in line with Benhabib and Spiegel (1994) and King and Levine (1994).

For the education indicator, the same approach is followed as in the previous Chapter. We derive as index for education and health based on the indicators of education and health adopted in the literature, mainly the enrollment ratios. The indicator we derive while based on enrollment rates is modified so that it places more weight on higher education given that it plays more role in enhancing the effectiveness and productivity of labour. The weights given are 10% for primary enrollment, 40% for secondary enrollment and 50% to tertiary enrollment rates. This indicator captures higher education as possible to the Barro and Lee (1993) average years of schooling of people aged over 25 years in that less weight is given to lower education enrollment.

Other studies use other indicators but these are not readily available in the set of countries chosen here for analysis[31]. School enrollment ratios are readily on a consistent basis for the period of our study from the World Development Indicators for most developing countries. Also, enrollment rates have also been frequently used in literature as proxies for the human capital indicator of education and they produce results that are consistent with those found when using other education indicators for example Barro (1996) Easterly and Rebelo (1993), Barro and Sala-i-Martin (1995, 1999) among others.

We adopt life expectancy at birth given that given its wide usage as a health indicator, but more important because it is readily available in many data sources for our set of countries.

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[30] The initial capital stock, K_{1980}, is derived as $K_{1980} = k_i Y_{1980}$ where k_i is the steady state capital-output ratio and Y_{1980} is the real GDP for 1980. The physical capital stocks for the remaining years are computed according to Limam and Miller's perpetual inventory formula such that: $K_t = \sum_{i=9}^{t=1}(1-\delta)^i I_{t-1} + K_0(1-\delta)^t$ where I_{t-1} is the previous period's gross fixed capital formation for each country. To compute the initial capital stock for each country i, the real gross domestic product for 1980 is used as an estimate for the initial output for each country

[31] Bils and Klenow (2000), Bloom, Canning and Sevilla (2004) , Barro (1991), Greiner *at. e.l* (2004), Barro and Sala-i-Martin(1997) use average years of schooling. Other measures of educations which have been widely used as an indicator of education are the Barro and Lee (1993) average years of schooling for the population aged over 25 years of age which to some extent captures the role of higher education.

The indicator is derived such that more weight is placed on the productive age bracket of the population and it is calculated as life expectancy/retirement age. The indicator is converted into a percentage to attain consistency in the unit of measurement for the education indicator and health indicator. Research by Weil (2006) Strauss and Thomas (1978), explores the role of other health indicators that have been used in the literature but unfortunately, these indicators are not available in most African countries. The index of human capital is derived in the same way as in the preceding chapter and its is used to address the interactions between health and education.

4.4.2 Estimated and Calibrated Parameters of the Model

In this Chapter, we follow the same approach as in the previous Chapter to estimate the parameters of the model. We adopt the non-linear estimation technique which does not make any strong assumptions about the data set and the errors. This procedure allows for possibilities of nonlinearities in the parameters of the model. Similarly, we correct for serial correlation and report and the estimations include time fixed dummies to capture the effects of other factors and outlier observations which may be due to structural changes which may bias the results. The diagnostic statistics and endogeneity tests are summarized in table 14 and 15 of the appendix. Other parameters are calibrated. This is mainly where the availability of disaggregated data on government expenditure did not permit for the direct estimation of those parameters, for example in the cases of μ, based on Barro (1990), Bose et. Al (2004) while v_h v_e calibrated for each country based on the proportions of expenditure in the health and education sectors respectively.

The calibration of χ_h χ_e is informed by the literature on the possible role of government spending and infrastructure specifically on the health and education sectors, that is the impact of government spending/infrastructure on the education and health sectors (Bose e.t al ,2004). The other parameters which have been calibrated relate to the rate of depreciation as 7% following Benhabib and Spiegel (1994) and King and Levine (1992). The time rate of preference and discount factor are calibrated at 0.1% and 0.9% in line with Romer (1990). In this case, we have similar parameters as those obtained in the previous chapter for α γ β_h β_e $and\ \theta$ since we directly estimate them based on each country data

Calibrated and Estimated Parameters (standard errors in parenthesis)

Estimated Parameters	Botswana	South Africa	Zambia	Kenya	Nigeria	Cote d'Ivore	Malawi	Tanzania	Uganda	Ghana
α	0.45 (0.016)	0.35 (0.022)	0.21* (0.013)	0.33 (0.010)	0.36 (0.026)	0.26* (0.015)	0.20* (0.035)	0.25* (0.010)	0.32 (0.010)	0.30 (0.020)
γ	0.52 (0.046	0.47 (0.036)	0.36 (0.038)	0.49 (0.047)	0.40 (0.022)	0.38 (0.019)	0.32 (0.029)	0.35 (0.030)	0.39 (0.027)	0.42 (0.022)
β_h	0.23 (0.043)	0.31 (0.048)	0.24 (0.031)	0.22 (0.016)	0.03** (0.007)	0.06** (0.004)	0.13** (0.010)	0.14** (0.008)	0.02** (0.003)	0.03** (0.001)
β_e	0.33 (0.019)	0.42 (0.027)	0.18*** (0.025)	0.34 (0.027)	0.30 (0.015	0.12*** (0.009)	0.29 (0.056)	0.39 (0.017)	0.49 (0.016)	0.21*** (0.009)
θ	0.603	0.555	0.369	0.522	0.402	0.415	0.391	0.477	0.529	0.394
Calibrated Parameters										
ρ	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
δ	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
σ	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
μ	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
υ_h	0.10	0.16	0.04	0.09	0.12	0.05	0.08	0.04	0.07	0.05
υ_e	0.16	0.20	0.06	0.12	0.16	0.15	0.18	0.15	0.18	0.18
χ_h	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
χ_e	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Note: * indicates countries with $\propto < 0.30$, ** where $\beta_h < 0.20$ and *** where $\beta_e < 0.30$. which are averages for these parameters. Diagnostic tests are provided in the summary table in the appendix and the test for endogeneity between health and education.

4.4.3 Dynamic Estimations and Simulations

4.4.3.1 Impact of Public Debt Human Capital and Growth.

The main hypothesis being tested is that a 1% increase in public debt leads to a more than 1% decrease in human capital. This hypothesis is tested under different fiscal policy rules. The three main rules being explored is where the government maintains zero growth in debt. We test the hypothesis under the primary balanced budget rule, zero growth rate in the public debt and a flexible rule where the government reacts to spending on the public debt and public spending. This is mainly to evaluate which fiscal rule offers more optimal results on the impact of the public debt on growth and the development of human capital.

A high public debt can act as a deterrent to the development of human capital. This is because public debt takes away resources that can be allocated for development projects and social spending such as on health and education. A number of studies including Patillo, Poirson and Ricci (2002, 2004) Ebaldawi, Ndulu and Ndungu (1997), Sachs (1986) and Easterly (1999) underscore the adverse implications of a high public debt on the growth and the development of developing countries. The analysis in this section aims to investigate the role of the public debt in health and education. This is carried out by conducting simulations were I assess the impact effect of temporary and permanent shocks to the public debt on health, education, output and government spending in the extended model framework where there is the government budget constraint.

In order to capture the possible links and interactions between health and education, the impact of the shock on the public debt is carried out with the human capital index. The impulse response functions for the impact of temporary and permanent shocks to the public debt under the different fiscal policy rules on output, government spending and the human capital index is given in *Figures 4-9* whereby the different figures present the following results:

Figures 4-9

Figure 4: Impact of Temporary Shock to the Public debt under Flexible Fiscal Policy Rule
Figure 5: Impact of a Permanent shock to the public debt under Flexible fiscal policy rule
Figure 6: Impact of a Temporary shock to the public debt under a Balanced budget fiscal policy rule
Figure 7: Impact of a Permanent shock to the public debt under a Balanced budget fiscal policy rule
Figure 8: Impact of Temporary shock to the public debt under a Zero growth in debt fiscal policy rule
Figure 9: Impact of Permanent shock to the public debt under a Zero growth in debt fiscal policy rule

The magnitude of the impact of the public debt on human capital, output, government spending and the deficit is summarized in *Table 10.*

Figure 4 presents the reaction of output, human capital as in health and education as well as government expenditure to a temporary shock to the public debt where the government follows a flexible fiscal policy rule. In *Figure 5*, the reaction functions relate to the case where the shock to the public debt is permanent. In this case, (*figure 5*), the shock is a 1% permanent on the public debt for the respective countries in the sample. Under the flexible rule, the government restrains spending when government expenditure exceeds a certain percentage of GDP or when the debt GDP ratio rises beyond an acceptable sustainable proportion. For example, in the case of Botswana, when government spending to GDP ratio exceeds, 40% of GDP, the government restrains its spending to maintain fiscal sustainability. For other countries, mainly those following the IMF structural adjustment programmes aimed at restoring macroeconomic stability and fiscal prudence, such countries restrain spending when debt/GDP ratio exceeds 60% since higher proportions beyond this percentage are seen as detrimental to growth (World Bank, 2001). This is the same principle for the HIPC countries and other highly indebted countries in the sample of selected African countries.

In *Figure 6* and *7*, the impact of temporary and permanent shocks to the public debt is conducted under a balanced budget rule. In this case the economy ensures that the choice

between spending and revenues generated from tax income always maintain a balance in the budget. This is mainly intended to eliminate the persistence of deficits in the budget. *Figures 8* and *9* present the results for the impact analysis of temporary and permanent shocks to the public debt in the case where a zero growth rate in the public debt is maintained as a fiscal policy rule. In this case, an attempt is control the growth in the exting public debt of an economy by ensuring that it does not increase from its current level. That is the debt/GDP ratio is maintained at certain percentage which is deemed not detrimental to growth (Clements *e.t al*, 2003, Patillo *e,t al* 2002). For example some countries would ensure that the debt to GDP ratio is maintained at less than 40-60% of GDP since beyond this percentage, higher proportions have been found to have detrimental effects on growth. In this case, the ratio is maintained at the rate and it is not allowed to grow by maintaining a zero growth rate in the public debt.

Figure 6: Impact of a Temporary Shock to the Public Debt under a Flexible Fiscal Policy Rule

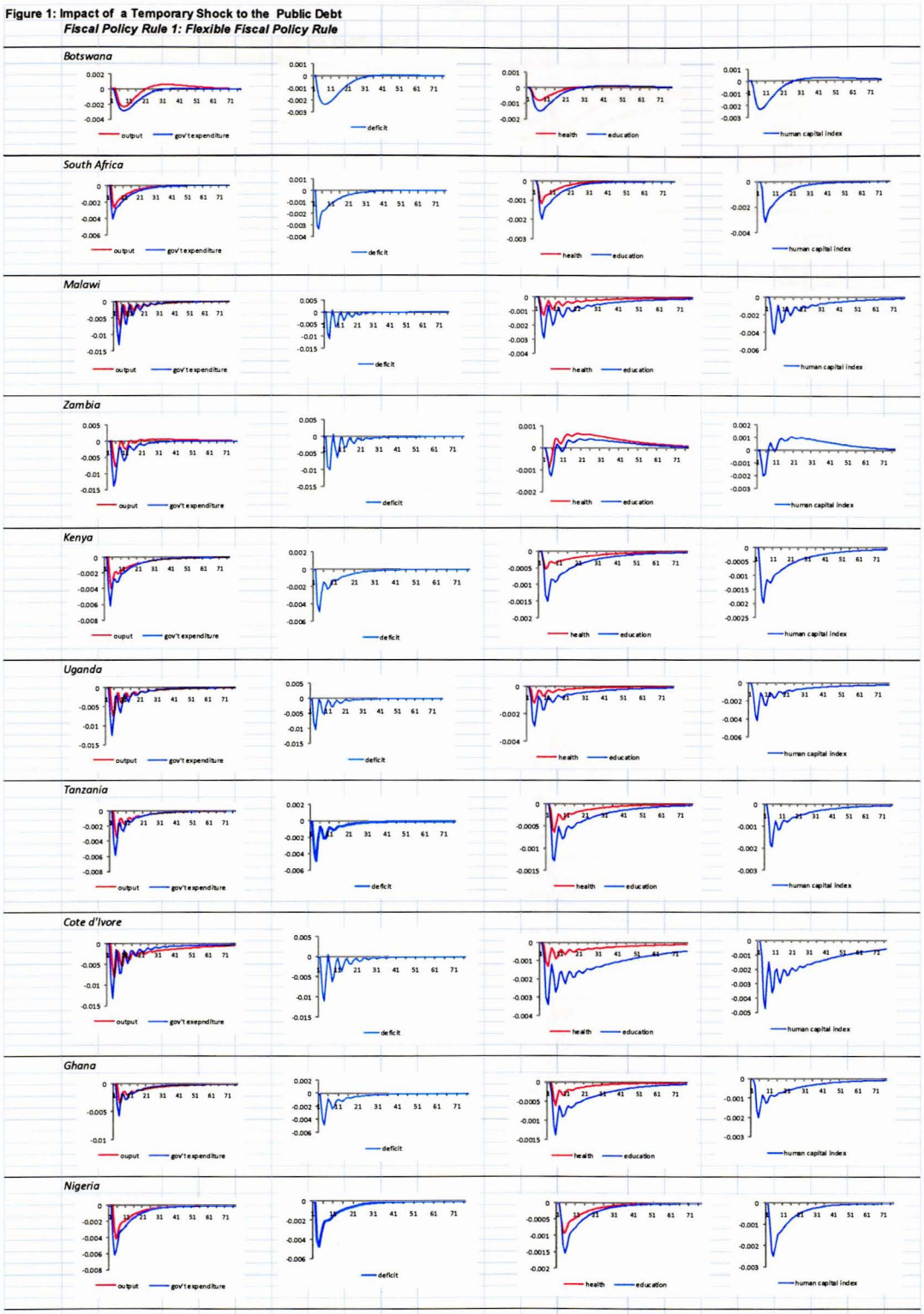


Figure 7: Impact of a 1% Permanent Shock to the Public Debt Under a Flexible Fiscal Policy Rule

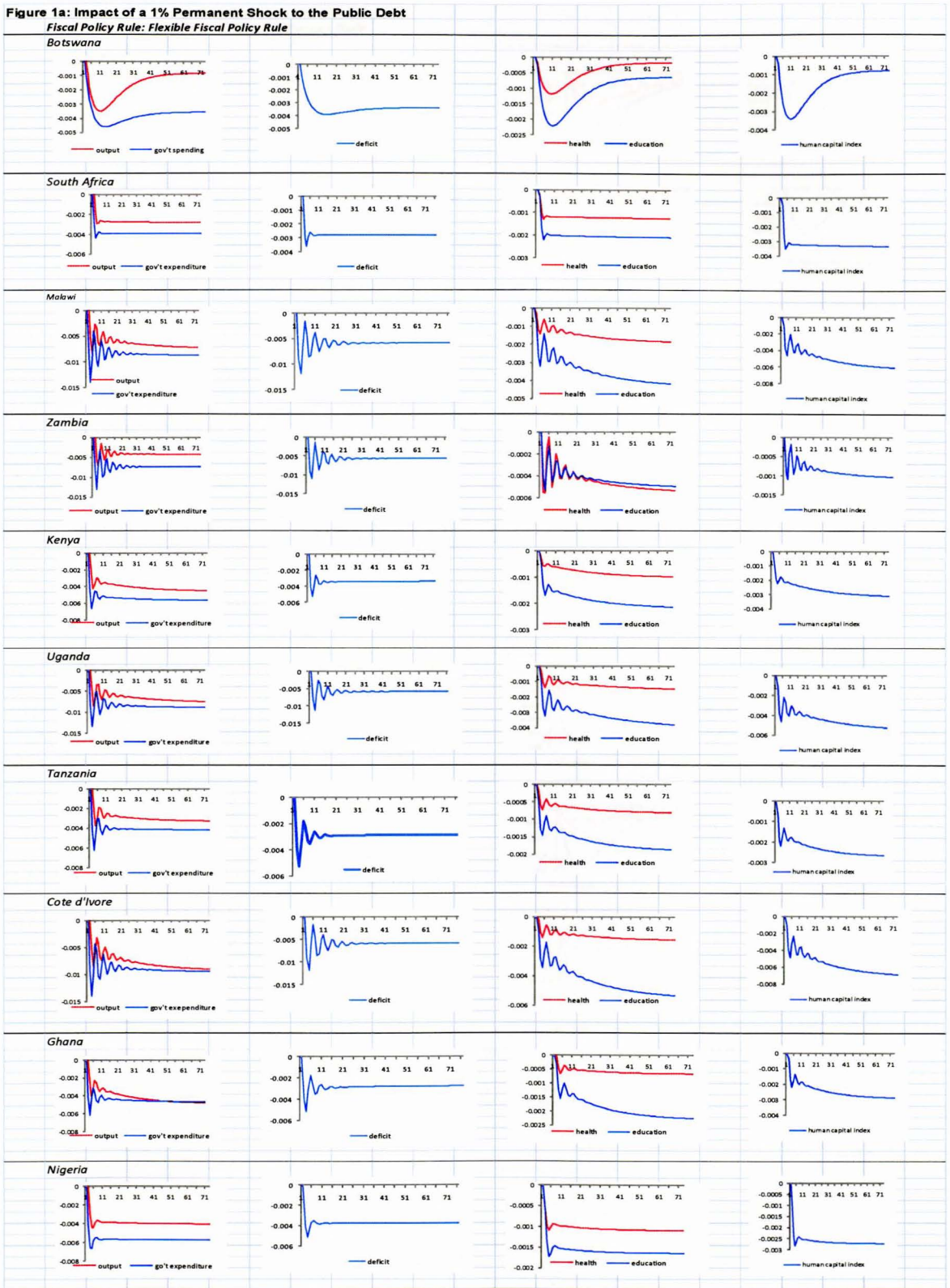


Figure 8: Impact of a Temporary Shock to the Public Debt under a Balanced Budget Fiscal Policy Rule

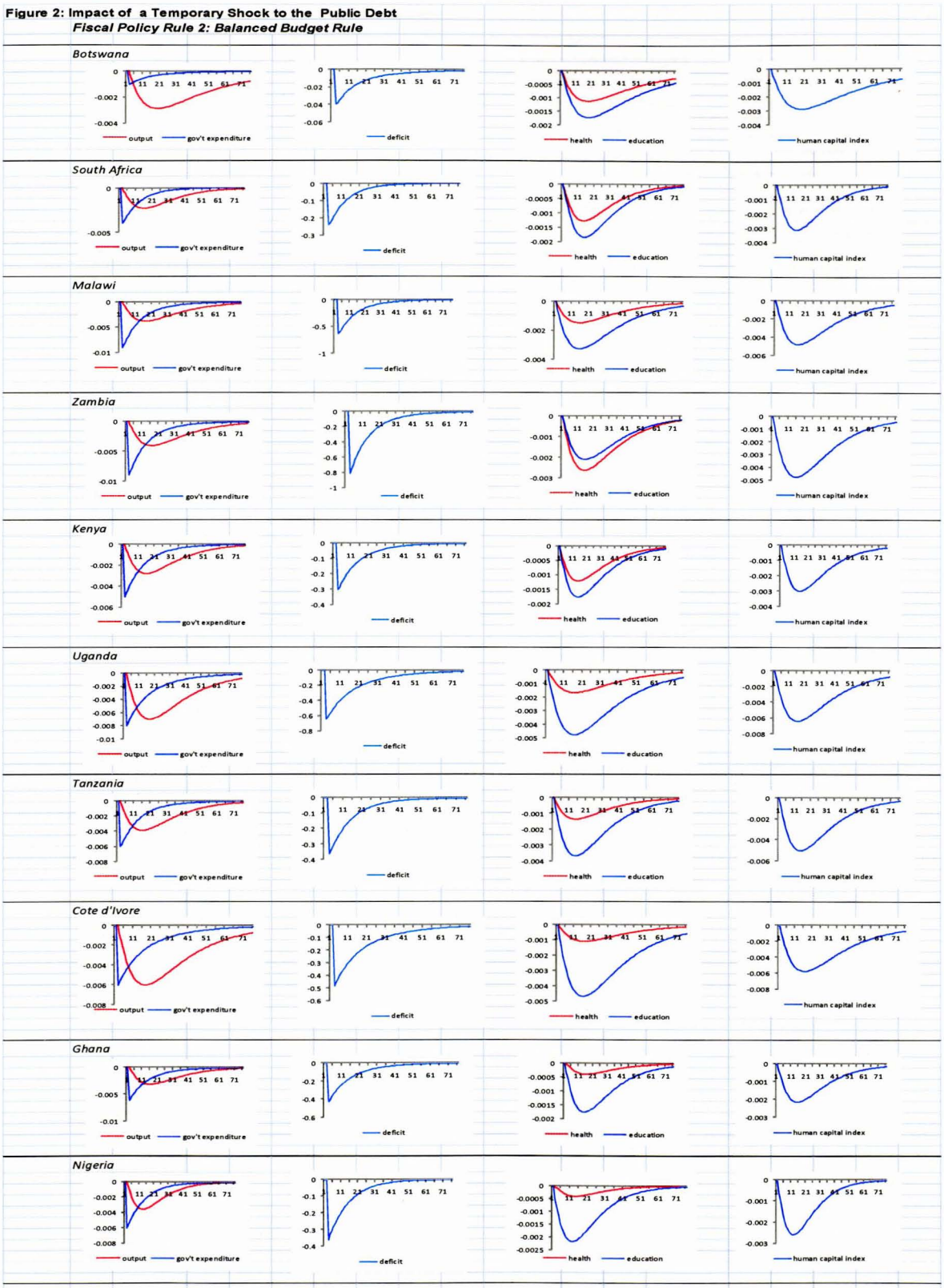


Figure 9: Impact of a 1% Permanent Shock to the Public Debt under a Balanced Budget Fiscal Policy Rule

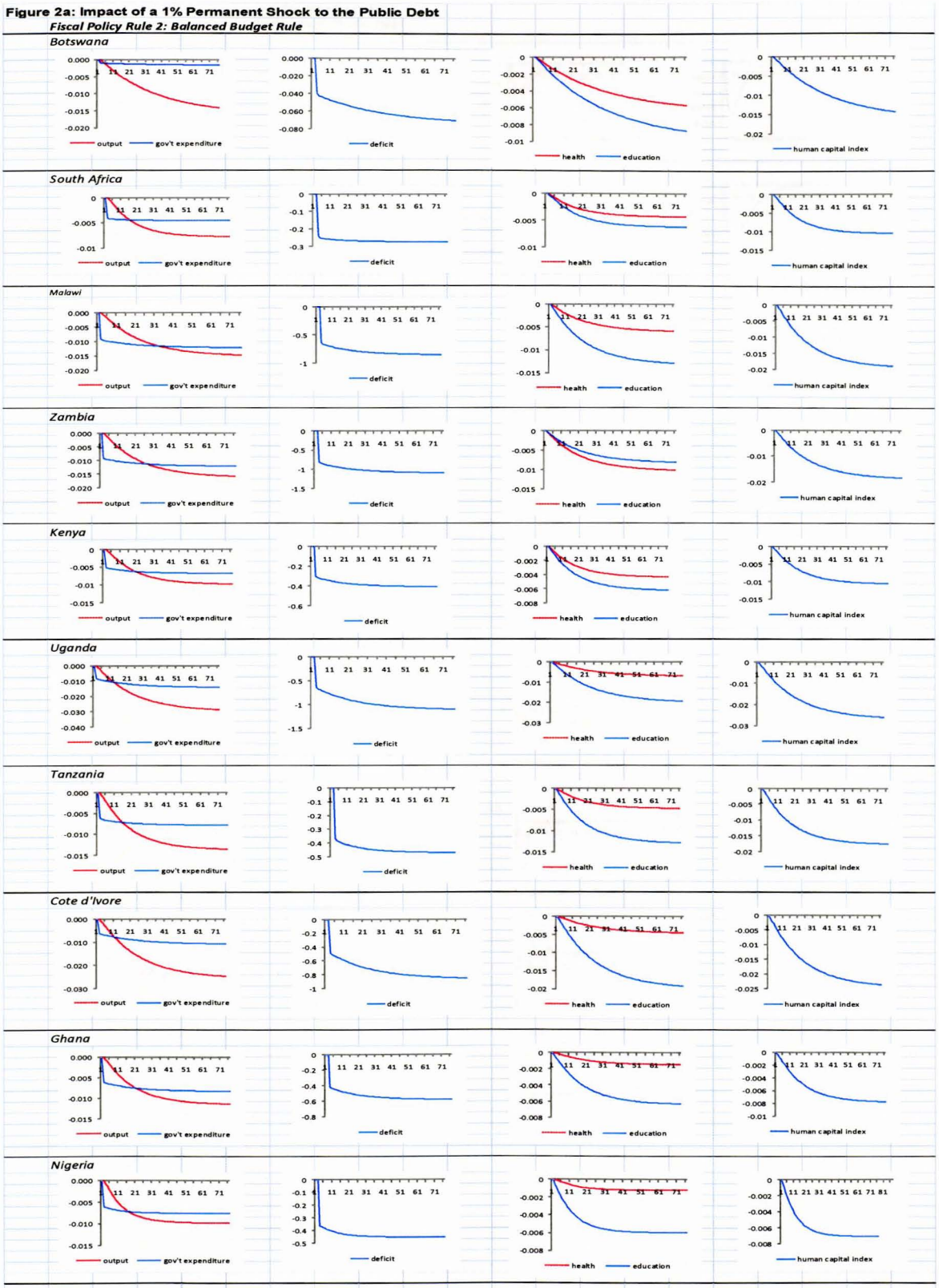


Figure 10: Impact of a Temporary Shock to the Public Debt under a Zero Growth in Debt Fiscal Policy Rule

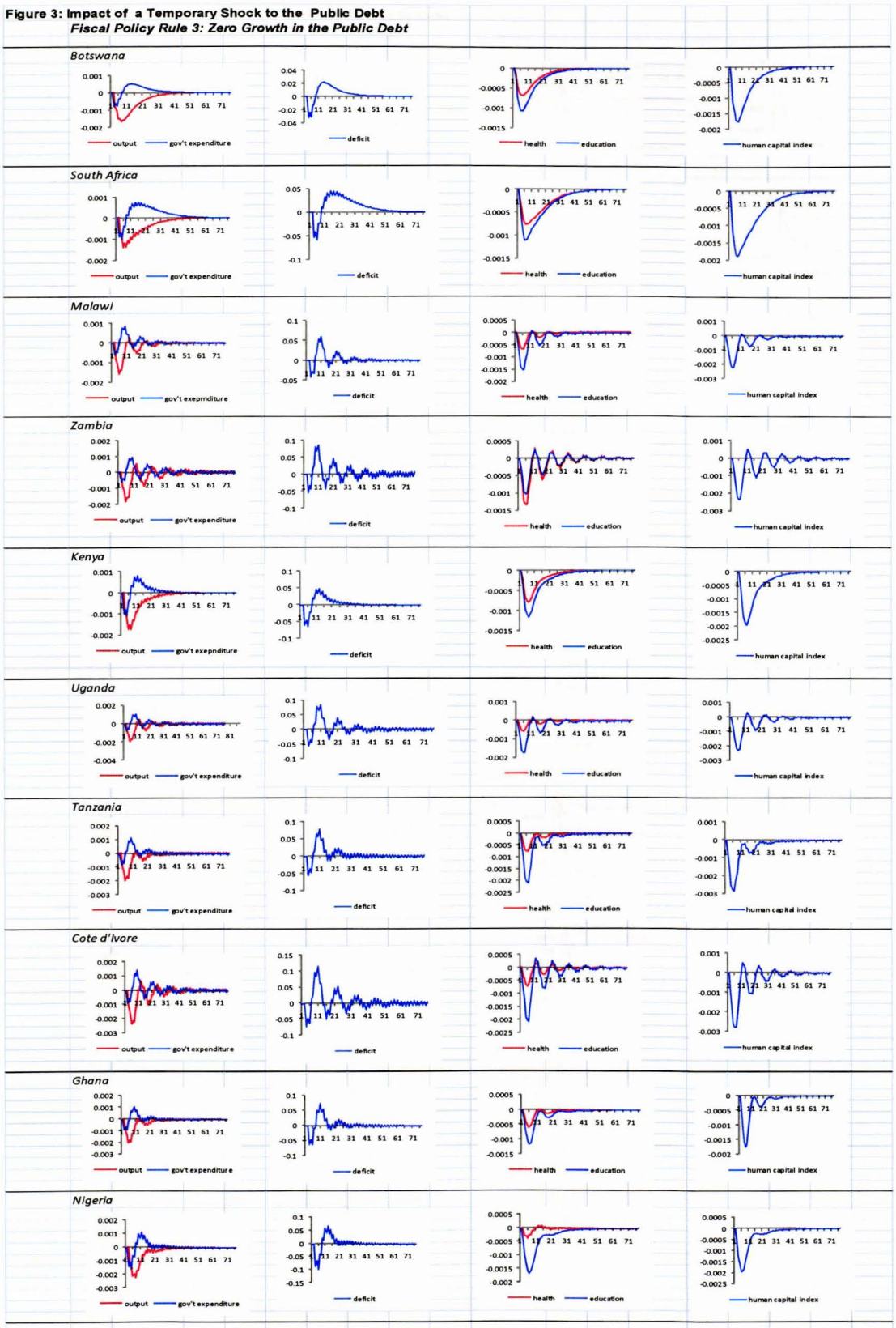
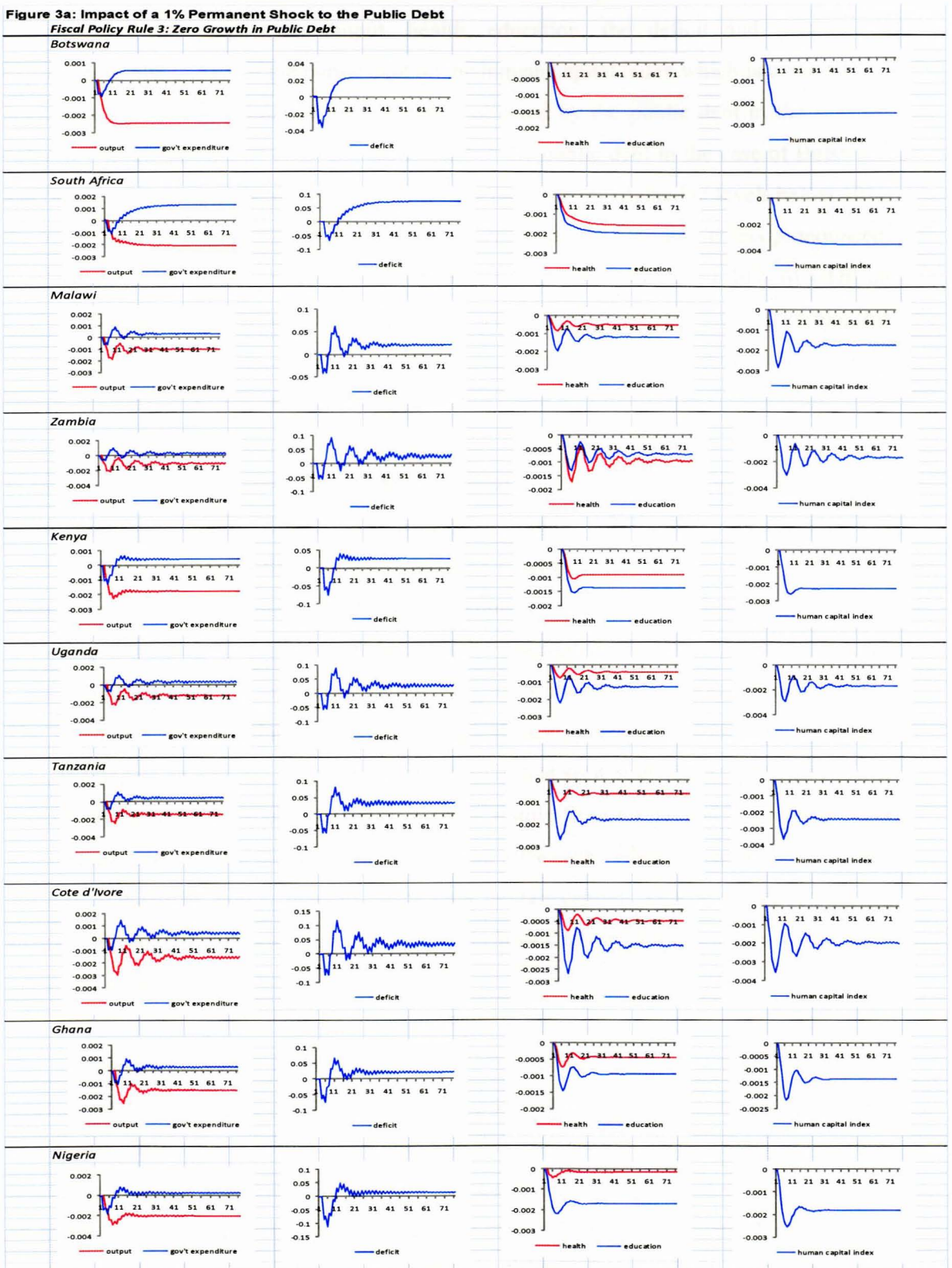


Figure 11: Impact of a1% Permanent Shock to the Public Debt under a Zero Growth in Debt Fiscal Policy Rule



Our findings show that, in general under the three fiscal policy rules, an increase in the public debt leads to a decrease in human capital. There is, however, a variation on the magnitude of the impact on output, health, education, the deficit and government expenditure. The impact of the public debt on the human capital index which is composed of health and education is found to be negatively affected by the public debt in the selected countries. In all cases, it is clear that the impact of the public debt in the case of Botswana and South Africa where the public debt/GDP ratio has been maintained at levels below 40%, the impact effect on human capital, the deficit and government spending is less pronounced. In other countries, however, where the debt to GDP ratio has exceeded 40% of GDP on average in the sample period of 1980-2008 (for example in countries such as Zambia, this has gone as high as 180%), the impact of the debt is found to lead to significant declines in output, human capital and government expenditure while the deficit rises substantially.

In these countries, where the public debt has exceeded 40% on average (with the exception of Botswana and South Africa) the impact of the public debt both on a temporary and permanent basis under the flexible, balanced budget and zero debt growth fiscal policy rules leads to significant volatility in output, government expenditure and in human capital following the shock to the public debt. This is observed in Zambia, Malawi, Tanzania, Uganda and Cote d'Ivore which fall in the category of the highly indebted poor countries. The results for Kenya, Ghana and Nigeria, though also adversely affected by the public debt, the impact causes less volatility as compared to that seen in the casers of Zambia, Cote d'Ivore, Malawi, Uganda and Tanzania. What is visible from the results of the analysis is that countries with a debt to GDP ratio of less than 40% such as Botswana and South Africa are less affected by public debt in developing human capital. This is evidenced by the smooth adjustment following the shock and the lesser adverse effect of the public debt compared to other countries.

Our analysis is indicative of the fact that there is a certain level of the public debt that affects growth and the development of human capital. This is clear from the results obtained in the case of Botswana where the public debt has consistently been maintained at lower levels of averaging less than 20% of GDP. Similar results on the impact of the public debt on human capital and growth are observed in the case of South Africa where the public debt averages about 30% and in Kenya where the public debt GDP ratio stands at just about 40%. For other countries where the public debt has exceeded 40%, going over 60-70% of GDP in

some years in the cases of Zambia, Malawi, and Cote d'Ivore, there is evidence that the high public debt has a significant impact on human capital and growth. Our results show that beyond a certain debt/GDP ratio, which in this case is 40% and above, public debt adversely affects human capital and growth. These findings are consistent with the literature results which show that beyond a certain threshold, debt is bad for growth and development (see for example findings by Bennedict, Bhattacharrya and Nguyen, 2003, Bigsteten, Levin and Persson, 2003, Ebaldawi, Ndulu and Ndung'u, 1997, and Denis, Moreno Dodson and Quenton, 2008). A number of studies estimate this threshold at about 60%, i.e. when the debt to GD ratio exceeds 60% while Patilli *e.t al* 2002 estimate it at 35-40% of GDP. In our study, we find that countries such as Botswana and South Africa, where the debt to GDP ratio has been consistently maintained at less than 40%, debt does not significantly affect output. Following a shock to the public debt, the economy is able to recover its fundamentals with less volatility and smoothly in these countries where the debt/GDP ratio is lower. For countries where debt exceeds more than 40% threshold, there is volatility in the adjustment towards steady state following the shock. Also, the impact on output, health and education is negative and remains low and declining for a long time.

These findings are pronounced for countries that are in the highly indebted poor countries (HIPC) category, which have remained trapped in debt for many years. South Africa and Botswana which have succeeded at maintaining a lower debt/GDP ratio do not experience worse effects of shocks to the public debt over time. Even with the IMF support to reduce the debt to lower sustainable levels, the debt in these countries has tended to go back to higher levels following debt relief (Fedelino and Kudina, 2003). Our results show that high debt over the 40% threshold adversely affects human capital development and growth. These findings are consistent with those of other findings which show that beyond a certain level, debt is bad for growth. Research by Clements *e.t al* (2003) Pattillo (1997) and Chowhoudry (2001) also find evidence of the adverse effects of the public debt on growth and development especially in excess of 35-40%. In this regard, our analysis finds consistency with the existing literature on the impact of the debt on growth beyond a certain threshold.

These finding is also similar to research by for example Easterly (1999) Milbourne (1995) Ebaldawi *e.t al* (1997) and Denis *e.t al* (2008) who find that heavily indebted are more significantly affected by the high public debt and these are mostly the HIPC countries. Even

after debt cancelation, these countries have often slipped back into high debt (Chowdhury, 2001). This shows that such countries will not be able to pursue human capital development on the strength of their own domestic resources. Even with initiatives such as those by the IMF/World Bank on addressing the public debt, it remains critical to have a fund that specifically focuses on human capital development, mainly health and education.

Overall, for all the countries, it is clear that the shock to the public debt results in declining health, education and output. Following the shock to the public debt, there is a pronounced fall in government spending and this shows that as government restrains its spending to maintain fiscal sustainability induced by the high public debt, this move takes away resources for the development of human capital. This results in declines in health and education which translates in to the fall in output. This shows that as the public debt takes away the resources and results in restrained public spending in the health and education, this leads to a fall in health and education and fall in output. The adverse impact of the public debt on growth through a reduction in the resources available for developing human capital are somewhat consistent with the crowding out effects of the public debt and resources in line with Patillo, Poirson and Ricci (2004) who also argue that a high public debt takes away and diverts resources for growth and development.

There is evidence of delayed lag effects on the effect of the public debt on the other variables of the model. This mainly on the length of time it takes for the effects of the public debt to take effect on government spending, health, education and output. There is a time lag on the impact of human capital on growth and on the feed through mechanism of the public debt and its impact on human capital and growth. When we used the human capital index, constituting of health and education to take care of the possible interaction between health and education, we find that the response of the human capital index to the shock to the public debt shows similar results in that the public debt negatively affects the index, similar to the impact effects found when health and education indicators are treated separately in the simulation.

4.4.3.2 Impact of Public Debt under Different Fiscal Policy Rules.

Investigating the impact of the public debt under different fiscal policy rules shows that more flexible rules tend not to have severe effects on human capital and growth compared to other fixed fiscal policy rules such as the balanced budget rule and the zero growth rate of debt. With the flexible rule, the government expenditure maintains flexibility in adjusting government expenditure in view of the accumulation of the public debt. In Botswana, this has led to the strong fiscal position of the country in that when there is limited revenue resources and the public debt rises, government reduces its government expenditure rule on spending, which is mostly drawn at 40% of GDP..

Comparing the impact effects under the different fiscal policy rules, there is more volatility induced by the impact of the public debt on output, health, education, public deficit and government expenditure when a zero growth rate in the public debt is maintained as a fiscal policy rule. It is however puzzling that the zero growth rate in debt rule leads to some significant volatility in some countries although this may point to that fact that the public debt GDP ratio has been high in some years such that the average for the 1980-2008 is quite high at above 60-70% which shows that the adjustment before the country is able to have the balanced budget will go through some volatility as it adjusts. The volatility is more severe in Zambia, Malawi, Tanzania, Uganda and Cote d'Ivore. For all countries, in the case, this fiscal policy rule tends to give worse results in terms of swings that arise as seen from the reactions functions for these components following the shock to the public debt on a temporary and permanent basis.

The balanced budget rule, though there is less volatility compared to the zero debt growth rule, we note the adverse effects on health, output, education and government expenditure which are on the higher side compared to when more flexible rules to fiscal policy are adopted. These observations from the results of the impulse response functions are confirmed by the magnitude of impact as summarized in *Table 11* for all the countries.

Table 10 provides the average impact of the shocks to the public debt for all countries. In the case of the temporary and permanent shocks, the impact on output, health, education, public deficit and government expenditure is significantly negative and higher than under the flexible rule. On average, a 1% permanent shock to the public under the balanced budget

rule leads to a more than 1% decline in output and the human capital index. Under this rule , the deficit would rise by more than 40% from its average percentage level while in the case of the flexible fiscal policy, the deficit following the shock would rise by less that 12% if the public debt increases by 1% permanently. The impact on health and education is more pronounced in the case where the balanced budget rule is adopted compared to the case of flexible rules where there is a reaction to the public debt and government budget to maintain fiscal prudence. The zero growth in debt fiscal rule tends to cause volatility is lesser developed countries and oscillations in countries such as Botswana, South Africa, Kenya and this may not be good if macroeconomic stability is to be achieved.

Table 11: Average % Change Due to a Public Debt Shock Under Different Fiscal Policy Rules

	Flexible Fiscal Policy Rule	**Zero Growth in Debt Fiscal Policy Rule (1)**	**Balanced Budget Fiscal Policy Rule**
Temporary Shock Impact on:			
Output	-0.30	-0.18 (5), volatility (5)	-0.40
Government Expenditure	-0.50	-/+ (5) , volatility (5)	-0.70
Deficit Increase	0.70	+/- (5), volatility (5)	40
Health	-0.12	-0.07(5), volatility (5)	-0.10
Education	-0.20	-0.11 (5), volatility (5)	-0.25
Human capital Index	-0.30	-0.20 95), volatility (5)	-0.40
Permanent Shock Impact on:			
Output	-0.40	-0.25 (5), volatility (5)	-2.0
Government Expenditure	-0.60	-/+ (5), volatility (5)	-1.0
Deficit Increase	0.65	+/- (5) , volatility (5)	25
Health	-0.15	-0.10 (5), volatility (5)	-0.40
Education	-0.30	-0.14 (5), volatility (5)	-0.60
Human capital Index	-0.50	-0.25 (5), volatility (5)	-1.2

Note: 1. Here the average impact for those countries where the rule does not cause volatility is reported while volatility shows that it causes volatility in other countries In the parenthesis we note the number of countries.

3. Signs +/- shows the oscillations occurring following the shock, whether there is an increase (+) and decline (-) immediately. Number of countries where this occurs on average are in parenthesis.

Table 10 gives a summary of the magnitudes on the impact analysis of the shock to the public dent under the different fiscal policy rules. What is important is the impact on the output, health, education and the human capital index. From the table, it is clear that different countries are affected differently by the public debt. This also emphasizes the importance of avoiding recommending blanket fiscal policy rule for all countries especially through adjustment and stabilization programmes as it is often done by the IMF/World Bank structural adjustment programmes. It is important that the background of some countries is taken into account and that programmes adjusted must reflect the macroeconomic conditions prevailing in a country, particularly to avoid adverse effects on development priority areas such as human capital development, which are often not considered when the programmes for structural adjustment are put in place on the onset. There is clear evidence of lag effects on the impact effects and transmission of health, education and impacts on output with the number of years varying across countries in the sample.

Table 12: Summary of Measurement Impact of Shocks to the Public Debt under different Fiscal Policy Rule

		Botswana	South Africa	Malawi	Zambia	Kenya	Uganda	Tanzania	Cote d'ivore	Ghana	Nigeria
Impact of a Temporary Shock to the Public Debt											
1. Fiscal Policy Rule: Flexible Rules	*Impact on:*										
	Output	-0.2	-0.3	-0.08	-0.09	-0.4	-0.08	-0.4	-0.8	-0.03	-0.4
	Government Expenditure	-0.3	-0.4	-1.14	-0.15	-0.6	-0.12	-0.6	-1.2	-0.05	-0.6
	Deficit	0.25	0.3	1.0	1.0	0.5	1.0	0.5	1.0	0.5	0.5
	Health	-0.08	-0.1	-0.015	-0.1	-0.05	-0.1	-0.06	-0.15	--0.5	-0.08
	Education	-0.1	-0.2	-0.2	-0.15	-0.15	-0.3	-0.12	-0.35	-0.15	-0.15
	Human capital Index	-0.2	-0.3	-0.4	-0.2	-0.2	-0.4	-0.2	-0.45	-0.2	-0.28
2. Fiscal Policy Rule: Zero growth in debt	*Impact on:*										
	Output	-0.15	-0.15	volatile	volatile	-0.18	volatile	volatile	volatile	-0.2	-0.2
	Gov't Expenditure	-/+	-/+	volatile	volatile	-/+	volatile	volatile	volatile	-/+	-/+
	Deficit	+/-	+/-	volatile	volatile	+/-	volatile	volatile	volatile	+/-	-/+
	Health	-0.08	-0.07	volatile	volatile	-0.08	volatile	volatile	volatile	-0.05	-0.05
	Education	-0.1	-0.15	volatile	volatile	-0.12	volatile	volatile	volatile	-0.12	-0.15
	Human capital Index	-0.2	-0.2	volatile	volatile	-0.2	volatile	volatile	volatile	-0.2	-0.2
3. Fiscal Policy Rule: Balanced Budget Rule	*Impact on:*										
	Output	-0.3	-0.4	-0.4	-0.5	-0.3	-0.7	-0.4	-0.6	-0.3	-0.4
	Gov't Expenditure	-0.1	-0.8	-0.9	-0.9	-0.8	-0.8	-0.6	-0.6	-0.6	-0.6
	Deficit	4.0	25	60	80	30	60	40	50	40	35
	Health	-0.1	-0.13	-0.1	-0.2	-0.15	-0.2	-0.15	-0.1	-0.05	-0.05
	Education	-.015	-0.15	-0.4	-0.3	-0.2	-0.5	-0.4	-0.5	-0.2	-0.2
	Human capital Index	-0.3	-0.3	-0.5	-0.5	-0.3	-0.6	-0.5	-0.6	-0.2	-0.25
Impact of a 1% Permanent Shock to the Public Debt											
1. Fiscal Policy Rule: Flexible Rules	*Impact on:*										
	Output	-0.35	-0.03	-0.55	-0.5	-0.4	-0.5	-0.3	-0.8	-0.4	-0.4
	Government Expenditure	-0.45	-0.04	-0.8	-0.8	-0.6	-0.9	-0.5	-0.9	-0.6	-0.6
	Deficit	0.3	0.4	0.8	1.0	0.5	0.8	0.7	1.0	0.5	0.5
	Health	-0.12	-0.15	-0.15	-0.5	-0.1	-0.2	-0.05	-0.2	-0.05	-.01
	Education	-0.25	-0.20	-0.5	-0.4	-0.2	-0.3	-0.15	-0.5	-0.2	-0.15
	Human capital Index	-0.35	-0.35	-0.6	-1.0	-0.3	-0.5	-0.3	-0.8	-0.3	-0.25
2. Fiscal Policy Rule: Zero growth in debt	*Impact on:*		-								
	Output	-0.3	-0.2	volatile	volatile	-0.2	volatile	volatile	volatile	-0.2	-0.3
	Gov't Expenditure	-/+	-/+	volatile	volatile	-/+	volatile	volatile	volatile	-/+	-/+
	Deficit	+/-	+/-	volatile	volatile	+/-	volatile	volatile	volatile	+/-	+/-
	Health	-0.1	-0.15	volatile	volatile	-0.1	volatile	volatile	volatile	-0.05	-0.05
	Education	-0.15	-0.18	volatile	volatile	-0.15	volatile	volatile	volatile	-0.15	-0.2
	Human capital Index	-0.3	-0.4	volatile	volatile	-0.3	volatile	volatile	volatile	-0.2	-0.3
3. Fiscal Policy Rule: Balanced Budget Rule	*Impact on:*										
	Output	-1.5	-1.0	-1.8	-1.8	-1.0	-3.0	-1.5	-3.0	-1.15	-1.2
	Gov't Expenditure	-0.1	-0.4	-1.0	-1.0	-0.6	-1.5	-0.9	-1.0	-1.0	-1.0
	Deficit	4.5	25	9	12	40.0	12	45	10.0	40	40
	Health	-0.5	-0.4	-0.6	-0.6	-0.4	-1.0	-0.5	-0.5	-.02	-0.2
	Education	1.0	-0.6	-1.0	-0.8	-0.6	-2.0	-1.5	-2.0	-0.8	-0.6
	Human capital Index	-1.5	-0.2	-0.2	-0.2	-1.0	-3.0	-2.0	-2.5	-1.0	-0.9-

4.4.3.3 Impact of Government Spending on Human Capital and Growth

In this section, we investigate the role of government spending on output and human capital development within the model framework that captures the government budget constraint. In the first hypothesis, we disaggregate government spending according to spending on the health and education sectors. This allows us to assess the impact of a shock to government spending on health (education) while holding spending on education (health) constant. There are two specific hypothesis being tested on the role of government spending on human capital in this section.

The first specific hypothesis being tested is that *a 1% increase in government spending on health, holding spending on education constant, leads to a better budget balance compared to spending on education.* This hypothesis is mainly motivated by the fact that it is not always possible for countries where resources are a constraint to raise development spending on all social sectors for example simultaneously on education on health. The competing priority sectors often put government under pressure to not to raise spending on many sectors at the same time but to prioritize sectors and commit resources where they are most needed in any budget period. Most countries, particularly lesser developed countries, are not always in a position to raise government spending for a number of sectors at the same time. This is because of the resource constraints and also the competing priority sectors for government resources (Cashin, 1995). Against this backdrop, it is sensible to test the hypothesis on the impact effect of government spending on one of the sectors holding spending on the other sector constant. In this case, the simulations are first carried out with a shock to government expenditure on health being increased while spending on education is held constant. Similarly, I also conduct the simulations of shocks on government spending on education holding government spending on health constant.

Due to the interactions between health and education, the results of what happens to education and health when there is a shock to either government spending on education or health are reported. This is because, the interactions between health and education make it possible for health to change as a result of increasing spending on education as education makes people more aware of their health, leading to an improvement in health. Also, with more health resources, education improves since healthy people live long to take up education opportunities (Staruss and Thomas,1998). The human capital index is used to evaluate the impact of increasing government spending either on education or health where we assume we cannot explicitly separate health and education. As in the preceding sections, the impact analysis is carried out using the temporary

shock and a permanent shock. The results of the implications of shocks to government spending on either health or education holding one constant are reported in *Figures 10 (temporary shock) and Figure 11 (permanent shock).*

The second hypothesis being tested in this section is the impact of government spending on human capital. Specifically the hypothesis tests that a *1% increase in government spending on health and education leads to a budget surplus in the long run.* In this case, the main issue is assuming that government pursues a policy of developing human capital and commits resources to both health and education as human capital, what is the possible impact on the two components of human capital, the public debt and output. In this case, the shock to government spending is on education and health compared to the previous case where the shock is on government spending on one component of human capital holding spending on the other component constant. The results showing the impulse response functions following the temporary and 1% permanent shock are presented in *Figure 12* (temporary shock) and *Figure 13* (permanent shock). The magnitude of impact is given in the summary table for ease of reference and comparison.

This hypothesis is premised on the idea that if human capital is to be developed and pursued with more rigor as a priority to growth of developing countries, then policy should target both health and education. As such, government spending which provides resources should be on both health and education. We therefore, test the impact of increasing government spending on health and education as human capital and assess the possible implications for the public debt, health, education and growth. One can then infer the effect on the budget surplus in the long from what happens to the public debt. For the same technicalities we ran into in testing the hypothesis under all the three fiscal rules, we encountered the same data limitations here. This hypothesis is therefore explored under the flexible rule. Although we would have liked to conduct the analysis for the impact of government spending under the different fiscal rules, we were limited by the lack of disaggregated data for all the countries in the selected sample. Disaggregating the government expenditure data so that it is in line with the balanced budget rule and the zero growth in debt rule was not possible in the framework, which limited the analysis to assess the impact of government spending on human capital, growth and the public debt in this section. We therefore focus on the flexible rule which has offered optimal results on the public debt impacts on health, education and output for all the countries so far.

Figure 12: Impact of a Temporary Shock to Government Spending on Health/ Education (holding one constant)

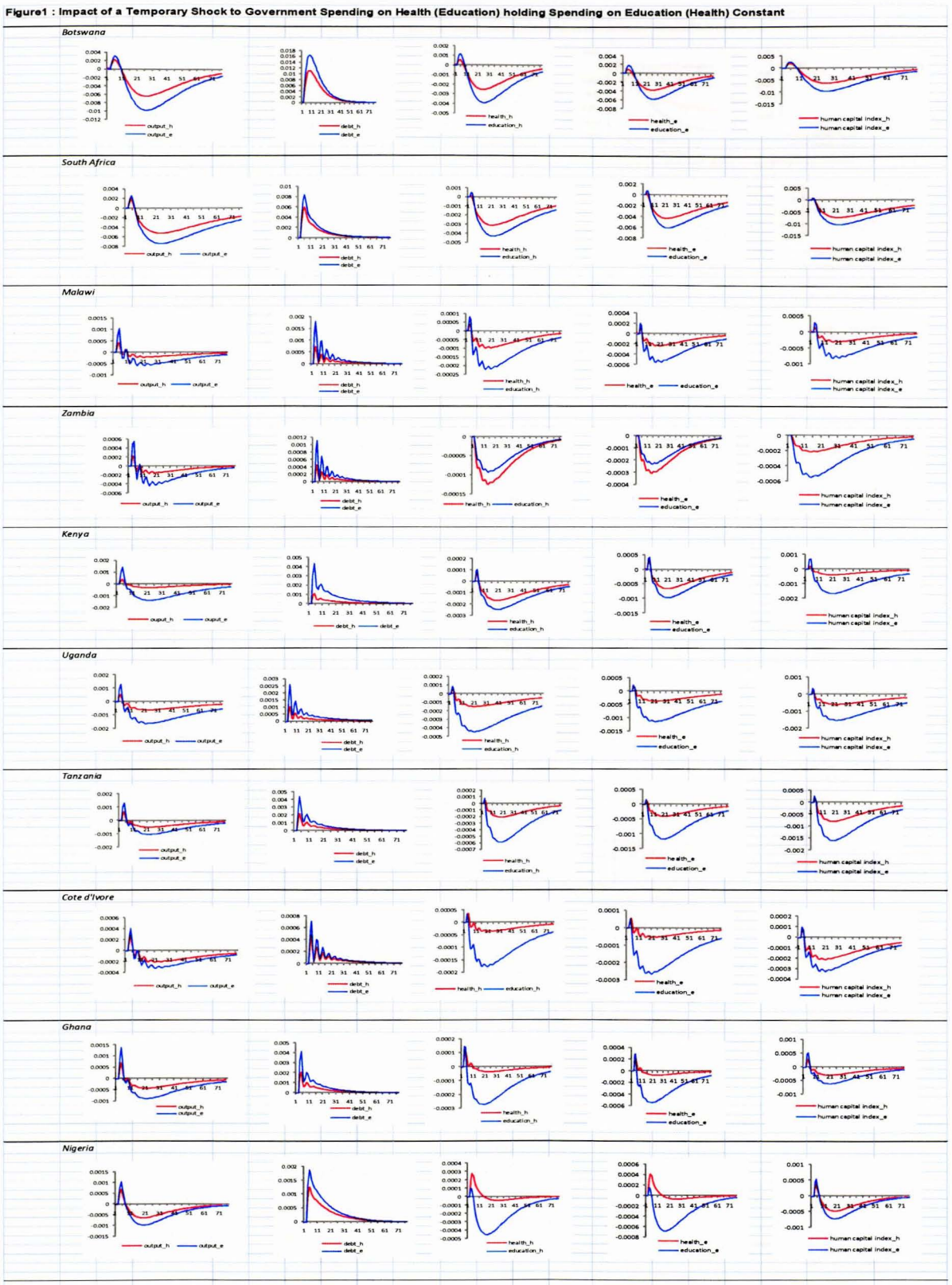


Figure 13: Impact of a 1% permanent Shock to Government Spending on Health/Education (holding one constant)

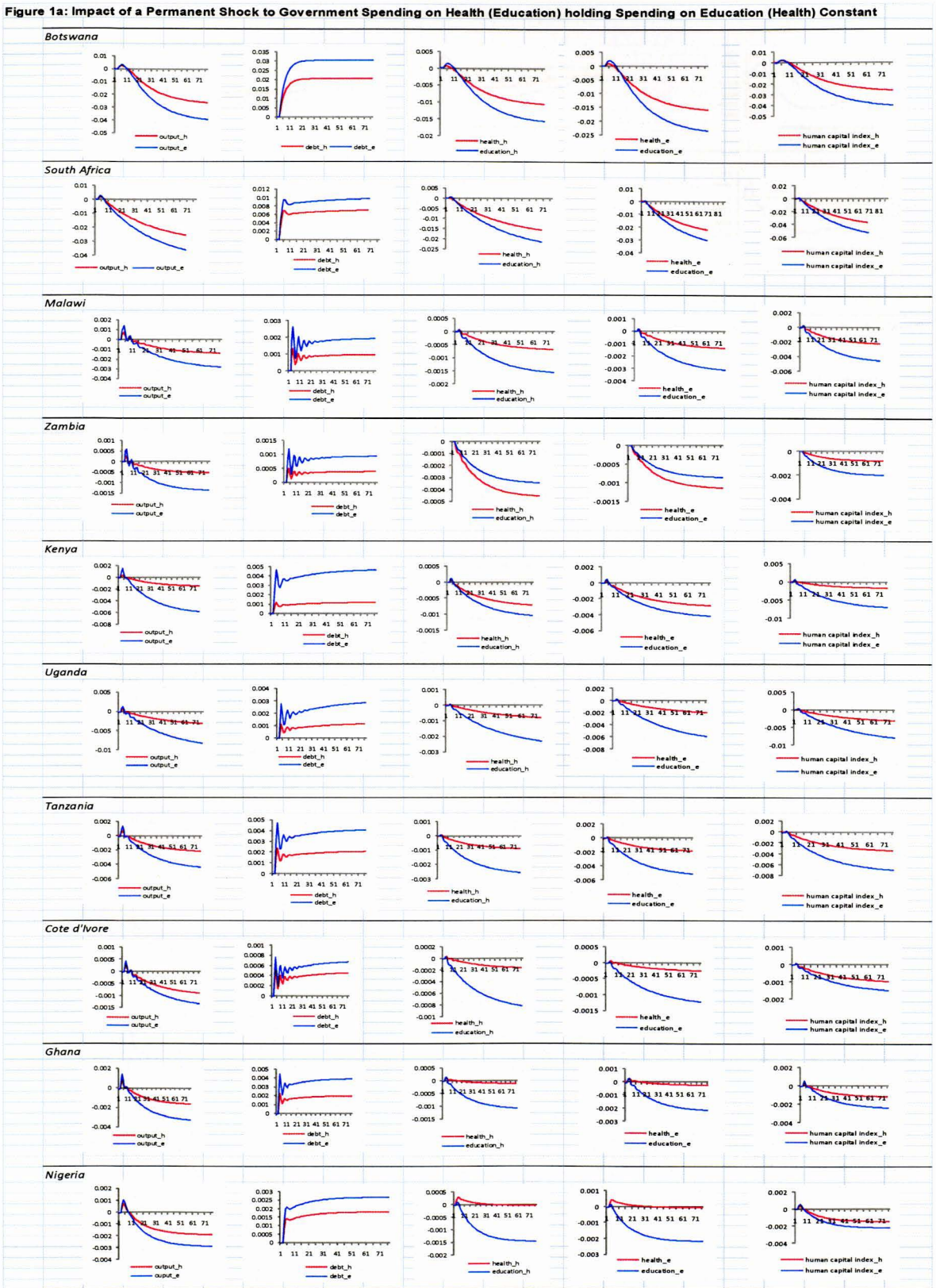


Figure 14: Impact of a Temporary Shock to Government Spending on Health and Education (total effect)

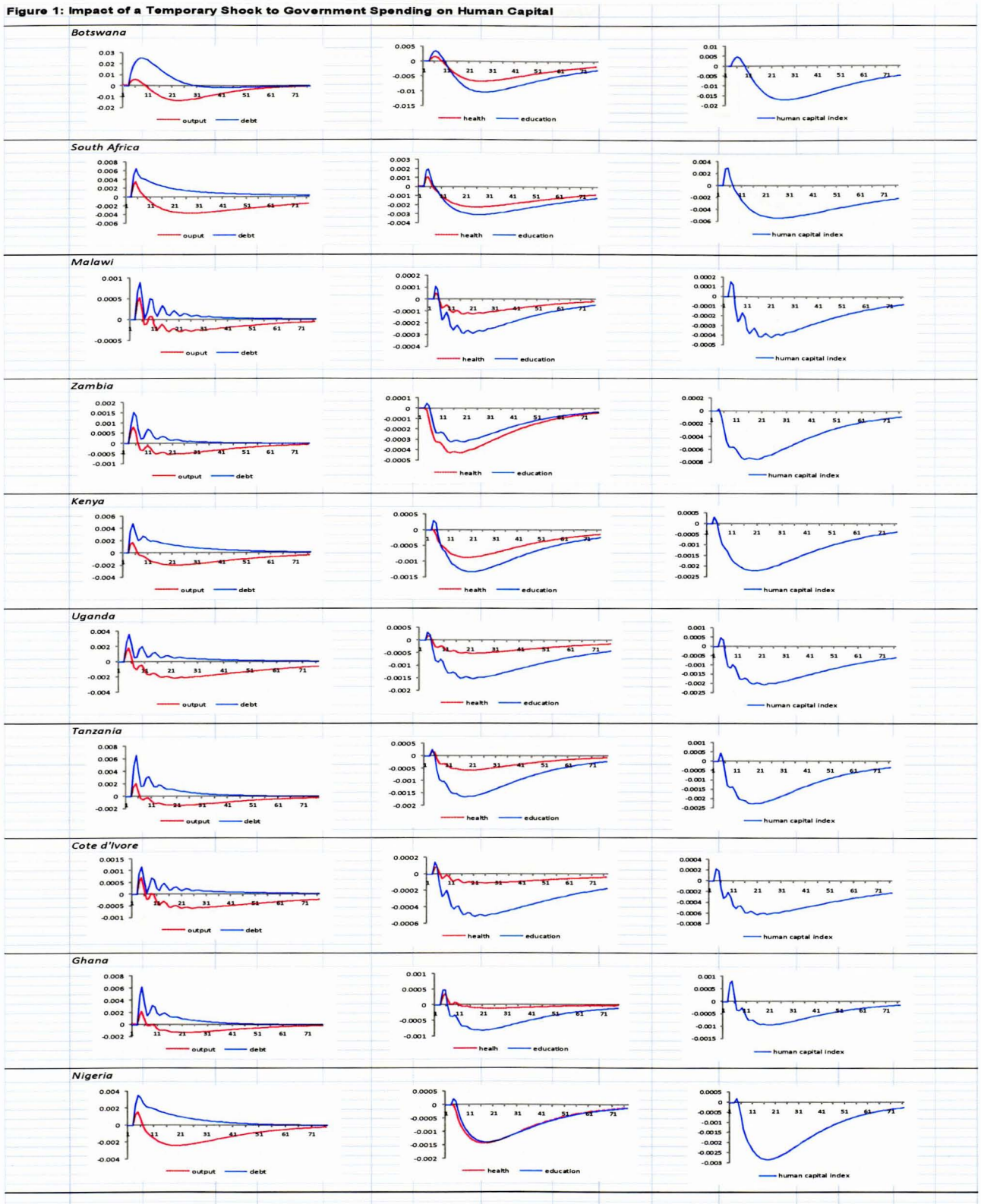
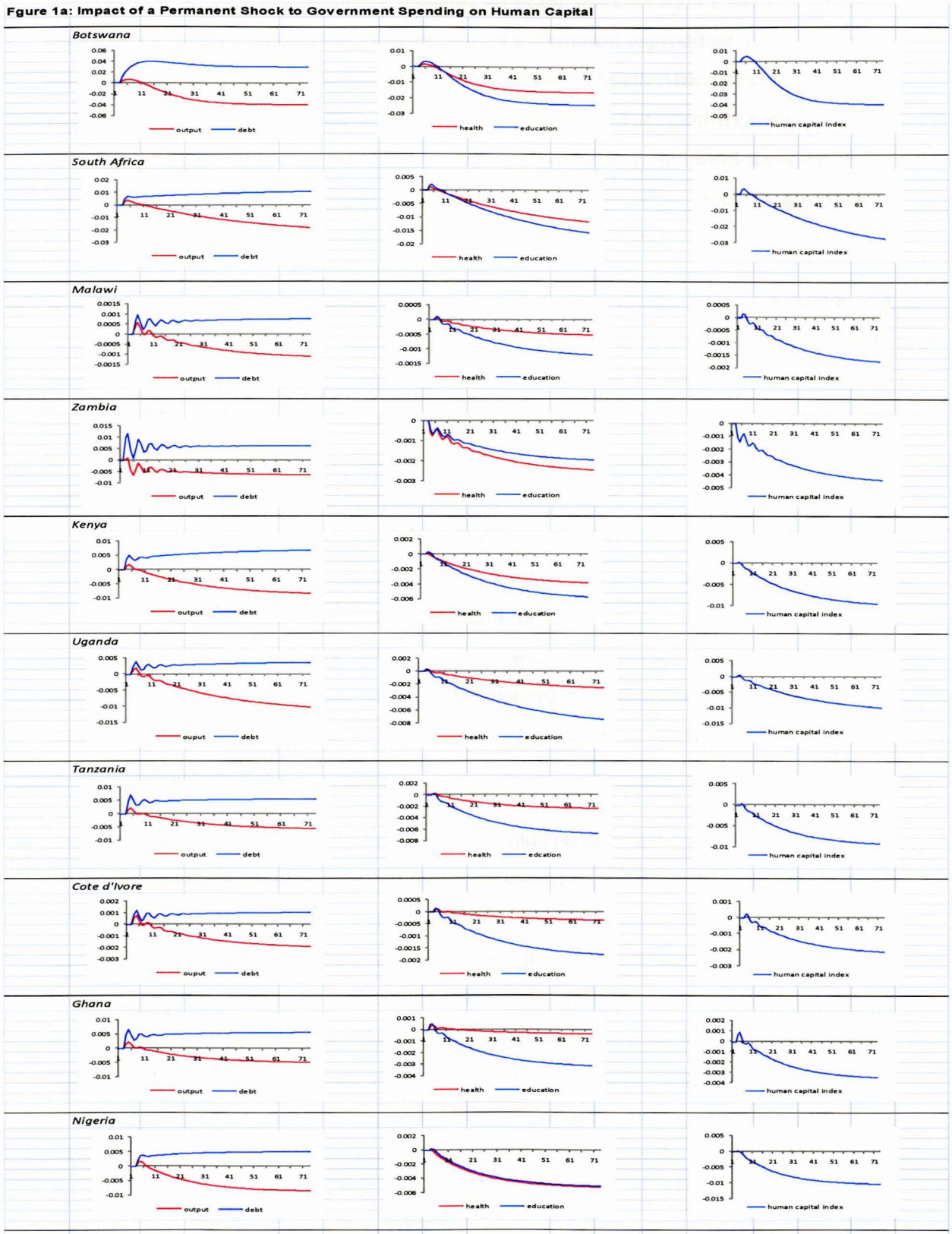


Figure 15: Impact of a 1% Permanent Shock to Government Spending on Health and Education (total effect)



The impact of a shock to government spending on health and education is more pronounced for countries which allocate a higher proportion of government expenditure to the health and education sectors. This is evident in the case of Botswana . South Africa where expenditure on education sectors averages 20% of the sectoral allocations. For countries such as Zambia and Nigeria, only about 5% and 10% on average is allocated to government spending on the health and education sector respectively. The impact effect of a shock to government spending in these two countries is found to be of a lesser magnitude.

It is clear that in these countries (Botswana and South Africa) debt from health and education rises more since they devote a significant proportion of government spending to health and education in their budget allocations. Compared to other countries such as Zambia, Malawi, Uganda and Tanzania, the proportions of government spending allocated to health and education in the national budget averages less than 10% while in the case of Botswana and South Africa, the allocation averages about 20%. As such, a permanent shock to government spending on health and education has a significant and pronounced impact on public debt in Botswana and South Africa. This is consistent in the case of Botswana where the country commits high resources due to health problems that affected the country since the 1990,s particularly the HIV/AIDS pandemic with government provide free education and HIV/AIDS treatment. South Africa has developed education and health infrastructure which has been enabled by the high proportion of government resources committed over years to their development.

This is an interesting finding and result since the indication is that the higher the resources committed to health and education, the grater the impact on output growth and development of human capital. This also shows that countries with lower human capital and those that are committing less resources in the form of government spending would have to channel more resources in the health and education sectors to realize significant human capital development and further growth. These findings show that countries without the fiscal space and flexibility to raise government revenue and expenditure would be constrained in developing human capital and achieving more sustainable growth. In this regard, such countries would not be able to develop human capital solely on the strength of their own domestic resources. Studies by Cashin (1995), Bose et. Al (Ladau (1983, 1985, 1986) and Aizeman e.t al (2007) find support for the positive role of government spending on growth

but also underscore the importance of constraints such as on revenues and sources which limit resource allocation to important priority sectors in developing countries to ensure sustained growth.

The impact of government spending on human capital has a more significant effect on health, education, output and the human capital index. Following the shock to government spending, human capital as it relates to health and education increases, and so does output. This shows the positive benefits of government expenditure on human capital development where both health and education are targeted as human capital. However, for those countries that commit higher resources to health and education such as in Botswana, the deficit rises more and the debt also increases which takes away the positive impact on output. It is evident that there is a notable positive impact for a number of countries as seen by the increase in the human capital index following the shock to government spending on human capital.

4.5 Summary

A high public debt can act as deterrent to the development of human capital. This is because public debt takes away resources that can be allocated for development projects and social spending such as that on health and education. A number of studies including Patillo (, Poirson and Ricci (2002, 2004) Ebaldawi, Ndulu and Ndungu (1997), Sachs (1986) and Easterly (1999) underscore the adverse implications of a high public debt on the growth and development of developing countries. Our findings show that, in general under the three fiscal policy rules, an increase in the public debt leads to a decrease in human capital although there is variation on the magnitude of the impact on output, health, education, the deficit and government expenditure.

The impact of the public debt on the human capital index which is composed of health and education is found to be negatively affected by the public debt in the selected countries. In all cases, it is clear that the impact of the public debt in the case of Botswana and South Africa where the public debt/GDP ratio has been maintained at levels below 40%, the impact effect on human capita, the deficit and government spending is less pronounced. In other countries, however, where the debt to GDP ratio has exceeded 40% of GDP on average in the sample period of 1980-2008 (for example in countries such as Zambia, Malawi, Cote d'Ivore, Tanzania, Uganda), the impact of the debt is found to lead to significant declines in output, human capital and government expenditure while the deficit rises substantially. There is also some notable volatility following both a temporary and permanent shock to the public debt under the flexible, balanced budget and zero debt growth fiscal policy rules on output, government expenditure and in human capital. This is observed in Zambia, Malawi, Tanzania, Uganda and Cote d'Ivore which fall in the category of the highly indebted poor countries. The results for Kenya, Ghana and Nigeria, though also adversely affected by the public debt, the impact causes less volatility as compared to that seen in the casers of Zambia, Cote d'Ivore, Malawi, Uganda and Tanzania.

Our analysis is indicative of the fact that there is a certain level of the public debt that affects growth and the development of human capital. This is clear from the results obtained in the

case of Botswana where the public debt has consistently been maintained at lower levels of averaging less than 20% of GDP. Similar results on the impact of the public debt on human capital and growth are observed in the case of South Africa where the public debt averages about 30% and in Kenya where the public debt GDP ratio stands at 40%. For other countries where the public debt has exceeded 40% in the cases of Zambia, Malawi, there is evidence that the high public debt has a significant impact on human capital and growth. Out results show that beyond a certain debt/GDP ratio, which in this case is above 40%, public debt adversely affects human capital and growth. These findings are consistent with the literature results which show that beyond a certain threshold, debt is bad for growth and development (see for example findings by Bennedict, Bhattacharrya and Nguyen, 2003, Bigsteten, Levin and Persson, 2003, Ebaldawi, Ndulu and Ndung'u, 1997, and Denis, Moreno Dodson and Quenton, 2008). A number of studies estimate this threshold at about 60%, i.e. when the debt to GDP ratio exceeds 60% while others estimate it at 30-40% of GDP.

Investigating the impact of the public debt under different fiscal policy rules shows that more flexible rules and the balanced budget rule tend not to have severe effects on human capital and growth compared to other fixed fiscal policy rules such as maintaining a zero growth rate in debt. With the flexible rule, the government expenditure maintains flexibility in adjusting government expenditure in view of the accumulation of the public debt, but pursues a rigorous policy of ensuring that the debt is maintained at a sustainable ratio and government expenditure is restrained to ensure sustainability. In Botswana for example, this policy approach where government expenditure is restrained at less than 40% of GDP has led to the strong fiscal position of the country in that when there is limited revenue resources and the public debt rises, government reduces its government expenditure rule on spending, which is mostly drawn at 40% of GDP. In general for countries where the debt.GDP ratio is less than 40%, the balanced budget rule, maintaining a zero growth rate in the public dent and maintaining flexibility in the reaction to government spending and the public debt yields better results when compared to the case where debt/GDP rations have exceeded 40% of GDP.

With regards to the impact of a shock to government spending on health and education, we find that this effect is generally positive and more pronounced for countries which allocate a higher proportion of government expenditure to the health and education sectors. This is evident in the case of Botswana and South Africa where expenditure on education sectors averages 20% of the sectoral allocations. For countries such as Zambia, Cote d'Ivore and Malawi, Uganda and Tanzania, only an average of 10% and less is allocated to government spending on the health and education sector respectively. The impact effect of a shock to government spending in these countries is found to be of a lesser magnitude, though still positive.

It is clear that in these countries (Botswana and South Africa) debt from health and education rises more since they devote a significant proportion of government spending to health and education in their budget allocations. Compared to other countries such as Zambia, Malawi, Uganda and Tanzania, the proportions of government spending allocated to health and education in the national budget averages less than 10% while in the case of Botswana and South Africa, the allocation averages about 20%. As such, a permanent shock to government spending on health and education has a significant and pronounced impact on public debt in Botswana and South Africa. This is consistent in the case of Botswana where the country commits high resources due to health problems that affected the country since the 1990,s particularly the HIV/AIDS pandemic with government provide free education and HIV/AIDS treatment. South Africa has developed education and health infrastructure which has been enabled by the high proportion of government resources committed over years to their development.

This is an interesting finding and result since the indications is that the higher the resources committed to health and education, the grater the impact on output growth and development of human capital. This also shows that countries with lower human capital and those that are committing less resources in the form of government spending would have to channel more resources in the health and education sectors to realize significant human capital development and further growth. These findings show that countries that without the fiscal space and flexibility to raise government revenue and expenditure would be constrained in developing human capital and achieving more sustainable growth. In this case, these countries would not be able to develop human capital solely on the strength of their own domestic resources and

strength. Studies by Cashin (1995), Bose *et. al. (2004),* Ladau (1983, 1985, 1986) and Aizeman *e.t al* (2007) find support for the positive role of government spending on growth but also underscore the importance of constraints such as on revenues and sources which limit resource allocation to important priority sectors in developing countries to ensure sustained growth.

The impact of government spending on human capital indicates a more significant effect on the health, education, output and the human capital index. Following the shock to government spending, human capital as it relates to health and education increases, and so does output. This shows the positive benefits of government expenditure on human capital development. However, for those countries that commit higher resources to health and education such as in Botswana, the deficit rises more and the debt also increases which takes away the positive impact on output. It is evident that there is a notable positive impact for a number of countries as seen by the increase in the human capital index following the shock to government spending on human capital

The conclusions drawn from the analysis are that there is a positive role for government expenditure in growth and development of human capital. In order to realize the higher benefits of human capital on growth, it is important to ensure that human capital resource allocations in the form of government expenditures are directed to the health and education sectors. Beyond a certain proportion, the public debt impacts negatively on human capital development. It is therefore important to ensure that countries maintain debt/GDP rations at proportions that are not detrimental to the growth and human capital development initiatives. It is clear that countries that already face high debt and fiscal constraints may not be in a position to develop human capital solely based on the strength of their domestic resources. Besides, the efforts to deal with the public debt, such as the HIPC and multilateral debt relief initiatives, it is important to have a fund that targets human capital development specifically, focusing on health and education in developing countries. This would go a long way in ensuring that some of the objectives and targets of the MGDs are realized. More importantly, the development of human capital will result in the long term sustained growth that is required by developing countries.

Chapter 5: Conclusions and Implications

5.1 Introduction

The main thrust of my thesis is to develop an integrated framework of human capital and growth to investigate the role of the two major components of human capital (health and education) on growth for a set of selected African countries[32] from 1980-2008. The main elements of the research work focused on examining the growth effects of the two components of human capital with particular focus on health and education. This entailed disaggregating human capital into two components, health and education, where health and education determines labour effectiveness and assessing their relative impact on growth. The second focus centered on assessing the fiscal policy implications of the government budget constraint, government expenditure and the public debt on health, education, public deficit and growth. Mainly, the analysis introduced a government budget constraint into the model framework to capture the fiscal dynamics and their implications for fiscal policy sustainability, human capital development and growth were the role of fiscal policy rules is also captured. Besides the empirical analysis, another important aspect aimed at conducting a descriptive analysis on the macroeconomic, health and education profiles and patterns in the selected set of countries.

The main proposition in this thesis is that, it is essential to include health as part of human capital, especially for developing countries where poor health adversely affects the productivity of labour. Also, fiscal policy constraints such as high public debt in developing countries affects both the education and health developmental goals as well as aspirations for higher growth that can be realized from human capital through productivity enhancements and labour effectiveness. The main findings, conclusions, implications and issues outlined for further research are summarized in the subsections that follow.

[32] *Botswana, South Africa, Zambia, Malawi, Tanzania, Uganda, Kenya, Cote d'Ivore, Ghana, Nigeria*

5.2 Role of Health and Education on Growth

The results obtained from the estimated parameters of the model show that human capital in the form of health and education play a positive role on growth through enhancing the effectiveness of labour. The findings indicate the importance of health and education on productivity of the labour force. The implication of this finding is that it is imperative for policies that aim to promote human capital to encompass both aspects of health and education to realize further economic growth through enhanced productivity. The positive relationships suggest that countries where the health of the population is deteriorating will experience a decline in labour effectiveness which would translate into low growth. Our analysis also show a positive role for the physical capital stock on output as well as on education and health. In this regard, a deteriorating physical capital stock will negatively affect health, education and growth. The implication of this finding reinforces the importance of promoting policies aimed at improving and accumulating physical capital in the health and education sectors for developing countries given its positive role for promoting health, education and growth.

The dynamics of the model reveal that, in the long run, temporary and permanent positive shocks to health and education impact positively on labour effectiveness and growth. A persistent shock to education and health would raise output for all the countries. Increasing education and health on a permanent basis by 1% leads to on average, a permanent sustained increase in output of 1.2% and 0.8%, respectively. For some countries, the permanent shock to health and education raises output by 1.2% in both cases, indicating presence of increasing returns to scale from health and education on output growth A permanent shock to education and health raises output and causes the economy to realize higher sustained output levels and growth. The percentage increases on per capita output following the shocks the permanent shock to education and health average 1.2% and 0.8% respectively while in some countries the increase in output is more than 1.2% for both health and education. With the human capital index, the analysis shows significant positive growth from rising both health and education. Our findings show that on average, a 1% permanent increase in health and education as shown by the changes in the human capital index would lead to a 2.5% increase in per capita output on average. In Botswana and South Africa, the 1% permanent shock to the human capital index results in about 3% increase in per capita output. These findings show

that a concerted effort on human capital development would result in long-run sustained growth for developing countries. We conclude that if all countries could realize an increase to education and improvement in health which is sustained, this would cause output to increase and the growth would be sustainable.

These findings indicate that it is imperative for policies directed at improving human capital to be cross cutting and should be a balanced two-thronged approach targeting health and education to realize sustained positive growth effects through productivity enhancements emanating from better health and education. That is, policies directed at developing human capital should target all the components of human capital in the form of health and education for the developing countries so that the benefits of investing in human capital can be fully exploited and play a more significant and meaningful role in the economy. If the approach to human capital does is not balanced, growth may be thwarted given the roles played by both health and education. These efforts should be coupled with the development of the physical capital stock of a country which directly impacts on health, education and growth.

5.3 Role of Fiscal Dynamics on Human Capital and Growth

With the government budget constraint in the model, the dynamics reveal that high stocks of the public debt depresses the effect of human capital on output growth through limiting government expenditure resources available for developing human capital. A high public debt can act as deterrent to the development of human capital. This is because public debt takes away resources that can be allocated for development projects and social spending such as that on health and education. Our findings show that, in general under the three fiscal policy rules, an increase in the public debt leads to a decrease in human capital.

Our analysis is indicative of the fact that there is a certain level of the public debt that affects growth and the development of human capital, in this case beyond 40% of GDP. These findings are consistent with the literature results which show that beyond a certain threshold, debt is bad for growth and development (see for example findings by Bennedict,

Bhattacharrya and Nguyen, 2003, Bigsteten, Levin and Persson, 2003, Ebaldawi, Ndulu and Ndung'u, 1997, and Denis, Moreno Dodson and Quenton, 2008).

The impact of the public debt on human capital and growth is found to vary in the selected countries depending on the public debt/GDP ratio and on whether the fiscal policy rule is more flexible in reacting to debt and government expenditure; maintains a balanced budget or maintains a zero growth rate in the public debt. Although for all the three fiscal policy rules, we find consistency that an increase in the public debt adversely affects human capital and growth and that the impact is much more pronounced when the public debt/GDP ratio goes beyond 40%, our findings show that maintaining a flexible fiscal policy rule and the balanced budget rule gives better results compared to the other fiscal rules. The other option is the balanced budget rule while maintaining a zero growth rate in the public debt is found to give worst results. For countries where the debt/GDP ratio exceeds 40% of GDP, the effect of the public debt under the different fiscal rules is comparatively worse than for countries where the debt/GDP ratio is less than 40%. The results show that the balanced budget rule tend to yield volatility in countries with a high debt ahich perhaps just indicates that the period following the shock and the adjustment would cause some instabilities initially. The impact of the public debt under the different rules and the varying effects also point to a very important policy implication. This is that, it is important that fiscal policy rules adopted in a country are those that give the best optimal growth dynamics. It is therefore, essential that fiscal policy rules also implemented under structural adjustment programmes particularly in addressing the fiscal imbalances in the lesser developed and HIPC countries take into account the possible impact of the rules suggested on the development of human capital.

We find evidence that the impact of a shock to government spending on health and education is more pronounced for countries which allocate a higher proportion of government expenditure to the health and education sectors. These results show that the higher the resources committed to health and education, the greater the impact on output growth and development of human capital. This also shows that countries with lower human capital and those that are committing less resources in the form of government spending would have to channel more resources in the health and education sectors to realize significant human capital development and further growth.

Based on these findings we conclude that countries that without the fiscal space and flexibility to raise government revenue and expenditure would be constrained in developing human capital and achieving more sustainable growth. We conclude that the implications of the public debt on human capital and growth indicate that some developing countries, especially those where the public debt remains high and face fiscal challenges such as poor unsustainable revenue prospects to back government expenditure on health and education cannot solely develop human capital based on the strength of their domestic resources. Also, while we find a significant positive role for education and health on growth in the model without the government budget constraint, incorporating fiscal dynamics reveals that the impact of health and education on growth becomes less pronounced. This underscores the importance of taking into account fiscal dynamics in assessing the impact of health and education on growth to avoid possibly over estimating their growth potential in countries where there are fiscal constraints such as those where the public debt remains high and recurs. In this case, these countries would not be able to develop human capital solely on the strength of their own domestic resources and strength. Studies by Cashin (1995), Bose *et. al* (2002) Ladau (1983, 1985, 1986) and Aizeman *e.t al* (2007) find support for the positive role of government spending on growth but also underscore the importance of constraints such as on revenues and sources which limit resource allocation to important priority sectors in developing countries to ensure sustained growth.

The implications for policy is that besides the efforts on addressing the public debt in a number of developing countries through initiatives such as the HIPC and multilateral debt relief initiatives, it is important to have a global fund aimed at developing human capital for developing countries. Human capital development will have to focus on both the health and education. This would play a major role in the realization of the Millennium Development Goals but also lead to long term sustainable growth required in developing countries.

5.5 Questions for Further Research

The role of human capital on growth is still an ongoing debate in the growth literature particularly in developing countries. A number of issues still remain to be understood in the context of developing countries. While our analysis and research contributes to this debate through including one component of human capital and the recognizes the role of fiscal challenges that some developing countries face, a number of issues still remain to be explored in this subject.

- Our research attempts to include one of the components of human capital in analytical framework. This is because human capital theory emphasizes a number of factors that constitute human capital. It therefore remains a question for further research to assess the implications of the other aspects and components of human capital on growth particularly amongst developing countries.

- A wide number of fiscal challenges exist in developing countries, some are poverty related issues and there are also those that are due to poor institutions and governance. Therefore, there is a need for further research on human capital and growth which should integrate these issues in the analysis to investigate how they affect human capital development

- Further research on human capital and growth in developing countries should also include surveys to broaden the understanding of the role of human capital on specific sectors of the economy and also serve to identify the constraints to human capital development in developing countries.

- There are possible links between the human capital components which remain under explored in developing countries. Further research is required to unlock these links and channels in the case of developing countries. This would serve to inform and enrich analytical techniques with the benefit of more accuracy in maintaining the theoretical and analytical tractability but also provide useful results and conclusions for policy purposes.

- Further research should also focus on the improving data compilation and data standards in developing countries. This important to ensure that there is adequate and consistently available data on human capital indicators such as health and education to allow for more rigorous analysis. Our analysis was limited in conducting the variable instrumentation technique due to lack of data on alternative instruments for the health and education indicators. Further research should thus focus on initiatives to develop and compile data on these indicators on a consistent and timely basis across developing countries. This would allow for more rigorous analysis on these relationships and more understanding of the role of human capital on growth and potential links and channels between education and growth in developing countries.

- It still remains a question for further research to establish the possible links and interactions between health and education especially from the macroeconomic perspective. The existing literature is mainly dominated by the micro literature[33] on biological and social sciences. While in this thesis, a human capital index was developed as an attempt to take into account the possible links and interactions, it is important that indices are informed by clear channels and mechanisms of the links between these two variables for a more informed approach to modeling the links from a more macroeconomic perspective in the case of developing countries..

[33] Refer to a review by Weil (2006)

References

Acemoglu J. and J. Robinson (2003). "Economic backwardness in political perspective" *National Bureau of Economic Research Working Paper, NO 8831* 1050 Massachusetts Avenue Cambridge, MA 02138.

Annicchiarico B., and N. Giammarioli (2004). "Fiscal Rules and Sustainability of Public Finances in an Endogenous Growth Model" *Working Paper Series*, No. 381. European Central Bank.

Aghion, P. and P. Howitt (1998). Endogenous Growth Theory, MIT Press. Massachussets, Canbridge, London, England.

Alexander, W. R. (1990). "Growth: Some Combined Cross-Sectional and Time-Series Evidence from OECD Countries", *Applied Economics*, 22, pp. 1197-1204.

Aizenman, J., K. Kletzer and B. Pinto (2007). "Economic Growth with Constraints on Tax Revenues and Public Debt: Implications for Fiscal Policy and Cross-Country Differences" *National Bureau of Economic Research Working Paper* 12750 1050 Massachusetts Avenue Cambridge, MA 02138

Aschauer, D. (1989). "Is Government Spending Productive?" *Journal of Monetary Economics*, 23, pp. 177-200.

Azariadis, C. and D. Drazen (1990). "Threshold Externalities in Economic Development", *Quarterly Journal of Economics,* Vol 105, Issue 2, pp. 501 – 526.

Baldacci, E. and K. Fletcher (2004). "A Framework for Fiscal Debt Sustainability Analysis in Low-Income Countries." In *Helping Countries Develop: The Role of Fiscal Policy,* ed. S. Gupta, B. Clements, and B. Inchauste, 130–61. International Monetary Fund, Washington. DC.

Bleaney M., Gemmell N., Kneller R., (2001). "Testing the Endogenous Growth Model: Public Expenditure, Taxation ,and Growth over the Long Run" *The Canadian Journal of Economics* Vol. 34, No. 1, pp. 36-57.

Barro, R.J. (1990). "Government Spending in a Simple Model of Endogenous Growth", *Journal of Political Economy*, 98, 5 (October), Part II, S103-S125.

Barro, R.J. (1991). "Economic Growth in a Cross Section of Countries", *Quarterly Journal of Economics*, CVI, May 1991, pp. 407-444.

Barro, R.J. and J-W. Lee (1994). "Sources of Economic Growth", *Carnegie-Rochester Conference Series on Public Policy*.

Barro, R.J. and X. Sala-i-Martin (1995). Economic Growth, McGraw-Hill, Boston, Mass.

Barro, R.J. and X. Sala-i-Martin (1999). Economic Growth, First MIT Press Edition

Barro, Robert, and Xavier Sala-i-Martin, X.(1992). 'Public finance in models of economic growth,' Review of Economic Studies 59, pp. 645-61

Barro, Robert J. and Lee (1993), Jong-Wha. "International Comparisons of Educational Attainment." *Journal of Monetary Economics* 32(3), pp. 363-94. .

Barro, R.J. and X. Sala-i-Martin (2004). Economic Growth, (Second edition) MIT Press.

Barro R.J. (2001). "Human Capital and Growth" *The American Economic Review*, Vol. 91, No. 2, Papers and Proceedings of the Hundred Thirteenth Annual Meeting of the American Economic Association, May 2001, pp. 12-17

Bassanini, A. & S. Scarpetta (2001). Does human capital matter for growth in OECD countries? Evidence from pooled mean-group estimates. *Economic Development Working Papers*, No. 28, Organization for Economic Co-operation and Development.

Benedict C., R. Bhattacharya, and T. Q. Nguyen (2003). External Debt, Public Investment, and Growth in Low-Income Countries. *IMF Working Paper* WP/03/249, Washington, DC.

Bigsten, A., J. Levin, and H. Persson (2001). "Debt Relief and Growth: A Study of Zambia and Tanzania". Prepared for the WIDER Development Conference on Debt Relief, Helsinki, 17-18 August 2001.

Boote, A. R., and K. Thugge (1997). "Debt Relief for Low-Income Countries and the HIPC Initiative", IMF Working Paper 97/24, Washington, DC.

Bose N., Haque E.M., D.R. Osborn (2003). "Public Expenditure and Economic Growth: A Disaggregated Analysis for Developing Countries"

Bulow, J., and K. Rogoff (1988) Brookings Papers on Economic Activity.

Bils M. and P.J. Klenow (2000). "Does Schooling Cause Growth?" *The American Economic Review*, Vol. 90, No. 5. (Dec., 2000), pp. 1160-1183.

Benhabib, J and M. Spiegel (1997). Growth and Investment Across Countries: Are Primitives All that Matter? *Working paper*. New York University.

Benhabib, J., and Spiegel, M. (1994). "The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data." *Journal of Monetary Economics*,34(2), pp. 143-74.

Benhabib, Jess & Spiegel, M., (2004). "Human Capital and Technology Diffusion," Handbook of Economic Growth, in: Philippe Aghion & Steven Durlauf (ed.), *Handbook of Economic Growth*, edition 1, volume 1, chapter 13, pp. 935-966 Elsevier

Bhargava A., D. Jamison, T. Lau and C. Murray (2001). "Modeling the Effects of Health on Economic Growth" *Journal of Health Economics* 20, pp. 423–440

Bloom D.E., D. Canning and J. Sevilla (2004). "The Effect of Health on Economic Growth:A Production Function Approach" *World Development* Vol. 32, No. 1, pp. 1–13.

Blinder, A.S. and R.M. Solow (1973). "Does fiscal policy matter?" *Journal of Public Economics* 2, pp. 319-338.

Christ, C.F., (1967). "A short-run aggregate-demand model of the interdependence and effects of monetary and fiscal policies with Keynesian and classical interest elasticities". *American Economic Review* 57,pp. 434-443.

Christ, C.F., (1968). "A simple macroeconomic model with a government budget restraint". *Journal of Political Economy* 76, pp. 63-67.

Caselli, F., G. Esquivel, and F. Lefort (1996). "Reopening the convergence debate: a new look at cross country growth empirics". *Journal of Economic Growth*, 1, pp. 363–389.

Cashin, P. (1995). "Government Spending, Taxes, and Economic Growth", *IMF Staff Papers*, Vol. 42, No. 2 (June), pp. 237 - 269.

Caballe, J. and M. S. Santos (1993). "On Endogenous Growth with Physical and Human Capital". *Journal of Political Economy*. 101, pp. 1042–1067.

Christopher A. S. (1995). "Econometric Implications of the Government Budget Constraint" April, 1995, revised October 1995.

Claessens, S. (1990). "The Debt Laffer Curve: Some Estimates."*World Development* 18 (12), pp. 1671–77.

Clemments, B., R. Bhattacharya, and T. Q. Nguyen (2003). "External Debt, Public Investment, and Growth in Low-Income Countries". *IMF Working Paper* WP/03/249, Washington, DC.

Crespo C. J. and G.A. Vincelette, (2008). Debt Relief and Human Capital Accumulation of Young Cohorts, Mimeo, *World Bank* and University of Innsbruck.

Fedelino, A., and A. Kudina. (2003). "Fiscal Sustainability in African HIPC Countries: A Policy Dilemma?" Working Paper WP/03/187, *International Monetary Fund*,Washington, DC.

Christ, C. (1979). "On Fiscal and Monetary Policies and the Government Budget Constraint," *American Economic Review* 69, pp. 526-38.

Chowdhury, A.R., (2001). External Debt and Growth in Developing Countries: A Sensitivity and Causal Analysis. WIDER Discussion Paper No. 2001/95, United Nations University.

Cohen, D. (2000). "The HIPC Initiative: True and False Promises", OECD Development Centre Technical Paper No.166, September.

Cutler and Lieras-Murray (2007). "Education and Health: Evaluating theories and evidence" NBER Working paper 12352.

Cass D. (1956). "Optimum Growth in an Aggregative Model of Capital Accumulation." *Review of Economic. Studies 32: pp. 233-40.*

Denis C., B. Moreno-Dodson and W. Quentin (2008). "Debt Sustainability for Low-income Countries: A Review of Standard and Alternative Concepts, *MPRA Paper No. 11077* World Bank.

Easterly, W. and S. Rebelo (1993). "Fiscal Policy and Economic Growth: An Empirical Investigation", *Journal of Monetary Economics*, 32 , pp. 417-458.

Easterly, W. R. and R. Levine (1997). "Africa's Growth Tragedy: Policies and Ethnic Divisions" *Quarterly Journal of Economics*, 112:, pp. 1203–1250.

Easterly, W. (1999). "How Did Highly Indebted Poor Countries Become Highly Indebted-Reviewing Two Decades of Debt Relief". *Policy Research WP 2225*. Washington, DC: World Bank, Development Research Group.

Easterly W., R. Levine, and D. Roodman (2003). "New Data, New Doubts: Revisiting Aid, Policies, and Growth". Washington: *Center for Global Development*, Working Paper No. 26.

Elbadawi, I.A., B. J. Ndulu, and N. Ndung'u (1997). "Debt Overhang and Economic Growth in Sub-Saharan Africa," Chapter 5 in External Finance for Low-Income Countries, ed. by Z. Iqbal and R. Kanbur (Washington: International Monetary Fund).

Fayissa, B. (1996). "Human capital, research and development, trade, and economic growth". *Economia Internationale*, 49 (3), pp. 373-384.

Frankel, J.A. and D. Romer (1999). "Does Trade Cause Growth." American Economic Review. 89, pp. 379-399.

Fernández-Huertas M. J. and Vidal J.P (2004). "Fiscal Sustainability and Public Debt in an Endogenous Growth Model" European Central Bank *Working paper Series*, No. 395.

Frankel, J., D. Romer and T. Cyrus. (2000). "Trade and Growth in East Asian Countries: Cause and Effect." in Hans Singer, Neelambar Hatti, and Rameshwar Tandon (eds), NICs After Asian Miracle, New World Order Series Vol. 23. India: BR Publishing Corporation Ltd.

Fischer, S. (1993). "The Role of Macroeconomic Factors in Growth", *Journal of Monetary Economics*, 32, pp. 485 – 512.

Fuente, de la A. (1997). "Fiscal Policy and Growth in OECD", *CEPR Discussion Paper*, 1755.

Greiner, A. (1999). Endogenous Growth Through Externalities of Investment: A Different Approach, *Atlantic Economic Journal*. 27:, pp. 86–90.

Greiner, A. (2008). Human capital formation, public debt and economic growth. *Journal of Macroeconomics, 30*, pp. 415-427

Greiner A. and Semmeler W. (2000). "Endogenous Growth, Government debt and budgetary regimes". Journal of Macroeconomics, Vol. 22, pp. 363-84.

Greiner A., W. Semmler W., and G. Gong (2004). Economic Growth: A Time Series Perspective. Princeton University Press.

Grossman, G. M. & E. Helpman (1991). Innovation and growth in the global economy. Cambridge, MA: MIT Press.

Gupta, S., (2002). "Is the PRGF Living Up to Expectations? An Assessment of Program Design", *IMF Occasional Paper No.* 216. International Monetary Fund, Washington, D.C..

Hausman J.A (1978). "Specification Tests in Econometrics" *Econometrica*, 46 1251-1272.

International Monetary Fund (2002). "HIPC Initiative: Status of Implementation", World Bank. Washington. D.C.

Job G., J. Saqib and A. Philippopoulos (1995). Interaction of Human and Physical Capital in a Model of Endogenous Growth, Economics of Planning. 28: 93–118.

Jesus M. and F. Seren (1992). "Human Capital Accumulation and Economic Growth" *Investigacionies Economicus*, Nol. XXV (3)

King, R. and R. Levine (1994). "Capital fundamentalism, economic development and economic growth". Carnegie-Rochester Conference Series on Public Policy, 40, pp.259-292.

Klenow, P. and A. Rodriguez-Clare (1997). "Economic growth: a review essay," *Journal of Monetary Economics* 40: 597-617.

King, R. and S. Rebelo (1990). "Public Policy and Economic Growth: Developing Neoclassical Implications". *Journal of Political Economy*, vol. 98, pp 126-150.

Koopmans, T. C. (1965). "On the Concept of Optimal Economic Growth." In The Econometric Approach to Development Planning. Amsterdam: North Holland.

Kneller, R., M.F Bleany and N. Gemmell (1999). "Fiscal Policy and Growth: Evidence from OECD Countries". *Journal of Public Economics*, Vol. 74, pp. 171 – 190.

Kormendi, R.C., and P.G. Meguire (1985). "Macroeconomic Determinants of Growth: Cross-Country Study", *Journal of Monetary Economics*, 16 (September), pp. 141 –163.

Krugman, P. R. (1988). "Financing vs. Forgiving A Debt Overhang", *Journal of Development Economics* 29, 1988, pp.253-268.

Lensink, R., H. White (1999). "Is there an aid Laffer curve? "*CREDIT Research Paper 99/6*, University of Nottingham.

Landau, D. L., (1983). "Government Expenditure and Economic Growth: A Cross Country Study", *Southern Economic Journal*, 49 (January 1983), pp. 783 – 792.

Landau, D. L., (1985). "Government Expenditure and Economic Growth in the Developed Countries, 1952 – 76", *Public Choice*, No. 3, 1985, 47, pp. 459 – 477.

Landau, D. L. (1986). "Government and Economic Growth in the Less Developed Countries: An Empirical Study for 1960-88", *Economic Development and Cultural Change*, 35, pp. 35-75.

Leeper, Eric M. (1991). "Equilibria Under `Active' and `Passive' Monetary And Fiscal Policies," *Journal of Monetary Economics* 27, February, pp. 129-47.

Leeper, E. M. and C.A Sims (1994). "Toward a Modern Macroeconomic Model Usable for Policy Analysis,"*N BER Macroeconomics Annual*

Levine, R., and D. Renelt (1992). "A Sensitivity Analysis of Cross-Country Growth Regressions" *American Economic Review*, 82(4), pp. 942-963.

Limam Y.R and Miller, S.M. (2004). "Explaining Economic Growth: Factor Accumulation, Total Factor Productivity Growth, and Production Efficiency Improvement" *Working papers 2004-20*, University of Connecticut, Department of Economics.

Lucas Jr, R. (1988). "On the Mechanics of Economic Development," *Journal of Monetary Economics* 22, pp. 3-42.

Mankiw, N.G.; D. Romer; and D.N. Weil (1992). "A Contribution to the Empirics of Economic Growth" *Quarterly Journal of Economics*, 107(2), pp.407-437.

Milbourne R. (1995). "Growth, Capital Accumulation and Foreign Debt" *Economica* (1997) 64, pp.1-13

Miller, S. M. and F.S. Russek (1997). "Fiscal Structures and Economic Growth", *Economic Inquiry*, 35, pp. 603 – 613.

Nelson, R.R. and E.S. Phelps. (1966). "Investment in Humans, Technological Diffusion, and Economic Growth," *American Economic Review*, Papers and Proceedings 56, pp. 69-75.

Nancy B., S. Claessens, and I. Diwan (2003). "Policy Selectivity Forgone: Debt and Donor Behavior in Africa". *Working Paper No. 17,* Center for Global Development, Washington, DC

Pattillo, C., H. Poirson, and L. Ricci (2004). "What Are the Channels Through Which External Debt Affects Growth?". *IMF Working Paper* WP/04/15, Washington, DC.

Pattillo, C., H. Poirson, and L. Ricci, (2002). "External Debt and Growth," *IMF Working Paper* 02/69. International Monetary Fund, Washington.

Raghuram R., (2005). Debt Relief and Growth. *Finance and Development* 42(2), June 2005.

Rogoff, K. S. (2003). "Unlocking Growth in Africa. Aid for Humanitarian Purposes is Desperately Needed, But It Cannot Be The Engine of Growth", *Finance and Development* 40(2), June 2003, pp. 56-58.

Roodman, D (2004). "The Anarchy of Numbers: Aid, Development, and Cross-Country Empirics". *Working Paper Number* 32, July 2004, Center for Global Development.

Romer D. (1996). Advanced Macroeconomics, The Mac Grow Hill- Companies Inc. California, Berkely.

Romer P. (1986). "Human capital and Growth: Theory and evidence" *National Bureau of Economic Research*, Working Paper No. 3173

Romer, P.M. (1990). "Human Capital and Growth: Theory and Evidence", Carnegie – Rochester Conference Series on Public Policy, 40, pp. 47 – 57.

Romer, P.M. (1990). "Capital, Labour and Productivity", Brookings Papers on Economic Activity, Special Issue, pp. 337-420.

Romer, P M. (1990) "Endogenous Technological Change" *Journal of Political Economy* 98(5) part II: S71-S102.

Romer, P.M. (1990). "Human Capital and Growth: Theory and Evidence". *Carnegie-Rochester Conference Series on Public Policy* 32, pp. 251-286.

Sala-i-Martin, X. (1997). "I Just Ran Two Million Regressions," *American Economic Review*, Papers and Proceedings 87, pp. 178-183.

Stijn C., E. Detragiache, R. Kanbur, and P. Wickham (1997). "Analytical Aspects of the Debt Problems of Heavily Indebted Poor Countries", in Zubair Iqbal and Ravi Kanbur (eds.): External Finance for Low-Income Countries, IMF.

Strauss, J., & D. Thomas (1998). Health, nutrition, and economic development. *Journal of Economic Literature,*36, pp. 766–817.

Sachs, J. D. (1986). "The Debt Overhang of Developing Countries", in: Calvo, Guillermo et al., Debt, Stabilization, and Development: Essays in Memory of Carlos Diaz-Alejandro, pp. 80-102.

Sachs, J D. and A. Warner (1995). "Economic Reform and the Process of Global Integration". Brookings Papers on Economic Activity 1: 1-118.

Sachs, J. D. (ed.) (1989). "Developing Country Debt and the World Economy". NBER/ University of Chicago Press. Chicago

Solow, R. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70, pp. 65-94.

Shantayanan D, S. Swaroop, V.H. Zou. (1996). "The Composition of Public Expenditure and Economic Growth", *Journal of Monetary Economics*, 37, pp. 313-344

Turnovsky S.J. (1975). "The Dynamics of Fiscal Policy in an Open Economy" *Journal of International Economics* 6 (1976) pp. 115-142

Thurlow J. (2007). "Is HIV/AIDS undermining Botswana's 'success story'? implications for development strategy:," *IFPRI discussion papers 697*, International Food Policy Research Institute (IFPRI).

Temple, J. (1998). "Initial Conditions, Social Capital, and Growth in Africa". *Journal of African Economies* 7(3), pp. 309-347.

Weil D.N. (2006). "Accounting for The Effect of Health on Economic Growth," *The Quarterly Journal of Economics*, MIT Press, vol. 122(3), pp. 1265-1306

Wooldridge J. M (2002). "Econometric Analysis of Cross Section and Panel Data. Cambrigde M.A. . The MIT Press

World Bank (2007). World Development Report 2007: Development and the Next Generation World Bank, New York, Oxford University Press..

World Bank, (1993). The East Asian Miracle. New York, Oxford University Press.

World Bank (1998). "Assessing Aid – What Works, What Doesn't Work, and Why". *World Bank Policy Research Report*. New York: Oxford University Press.

World Bank (1988). World Development Report, World Bank, Oxford University Press, 1988.

Appendix 1: Derivations of Equations: Chapter 3

Capital accumulation constraint $\dot{k}$

$$\frac{\dot{K}_t}{A_{0t}L_t} = -\frac{\delta K_t}{A_0 L_t} + \frac{Y_t}{A_0 L_t} - \frac{C_t}{A_0 L_t}$$

$$\frac{\dot{K}_t}{A_{0t}L_t} = -\delta k_t + y_t - c_t$$

$$\dot{k}_t = \frac{\dot{K}_t A_{0t} L_t - \dot{A}_{0t} L_t K_t - \dot{L}_t A_{0t} K_t}{A_{0t} {L_t}^2}$$

$$\dot{k}_t = \frac{\dot{K}_t}{A_{0t}L_t} - \frac{\dot{A_{0t}}}{A_t} k_t - \frac{\dot{L}_t}{L} k_t$$

$$\dot{k}_t = \frac{\dot{K}_t}{A_{0t}L_t} - g k_t - n k_t$$

$$\dot{k}_t + g k_t - n k_t = -\delta k_t + y_t - c_t$$

Reduced from of y_t:

$$\tilde{Y}_t = {A_{0t}}^{1-\alpha}[{h_t}^{\gamma} {e_t}^{1-\gamma}]^{1-\alpha}[\omega_y \tilde{K}_t]^{\alpha}$$
$$\tilde{y}_t = [{h_t}^{\gamma} {e_t}^{1-\gamma}]^{1-\alpha}[\omega_y k_t]^{\alpha}$$

$$y_t = {h_0}^{\gamma(1-\alpha)} {\omega_h}^{\beta_h \gamma(1-\alpha)} {h_t}^{\beta_h \gamma(1-\alpha)} \cdot {e_0}^{(1-\gamma)(1-\alpha)} {\omega_e}^{\beta_e(1-\gamma)(1-\alpha)} {h_t}^{\beta_e(1-\gamma)(1-\alpha)} \cdot {\omega_y}^{\alpha} {k_t}^{\alpha}$$

$$y_t = {\Omega_0}^{(1-\alpha)} \omega \; {k_t}^{\theta}$$

$$y_t = {\Omega_0}^{(1-\alpha)} \omega \; {k_t}^{\alpha+\beta_h\gamma(1-\alpha)+\beta_e(1-\gamma)(1-\alpha)}$$

Optimization and first order conditions to derive $\dot{c}/c$

Maximise :

$$\int_0^{\infty} e^{pt} \frac{\check{C}_t^{1-\sigma}}{1-\sigma} dt = \int_0^{\infty} e^{pt} \; {A_{0t}}^{1-\sigma} \frac{\check{C}_t^{1-\sigma}}{1-\sigma} dt$$

$$= \int_0^{\infty} e^{(g(1-\sigma)-p)t} \frac{\check{C}^{1-\sigma}}{1-\sigma} dt$$

Subject to:

$$\dot{k}_t = {\Omega_0}^{(1-\alpha)}\omega \;\; {k_t}^{\theta} - c_t - (\delta + n + g)k_t$$

The Hamiltonian H:

$$H = \frac{c^{1-\sigma}}{1-\sigma} + \lambda\left[{\Omega_0}^{(1-\alpha)}\omega \;\; {k_t}^{\theta} - c_t - (\delta + n + g)k_t\right]$$

$$FOC_c = c^{-\sigma} - \lambda = 0$$

$$\lambda = c^{-\sigma}$$

$$\dot{\lambda}_t = -\frac{dH}{dk} + \rho\lambda = -\lambda\left[{\Omega_0}^{(1-\alpha)}\omega \;\; \theta {k_t}^{\theta-1} - (\delta + n + g)\right] + \rho\lambda$$

$$\frac{\dot{\lambda}_t}{\lambda_t} = -{\Omega_0}^{(1-\alpha)}\omega \;\; \theta {k_t}^{\theta-1} + (\delta + n + g) + \rho$$

(1)

$$\dot{\lambda} = -\sigma c^{-\sigma-1} \cdot \dot{c}$$

$$\frac{\dot{\lambda}}{\lambda} = -\sigma c^{-1} \cdot \dot{c}$$

$$\frac{\dot{\lambda}}{\lambda} = -\sigma\frac{\dot{c}}{c}$$

(2)

Equating equation 1 and 2:

$$-\sigma\frac{\dot{c}}{c} = -{\Omega_0}^{(1-\alpha)}\omega \;\; \theta {k_t}^{\theta-1} + (\delta + n + g) + \rho$$

$$\frac{\dot{c}}{c} = \frac{{\Omega_0}^{(1-\alpha)}\omega \;\; \theta {k_t}^{\theta-1} - (\delta + n + g) - \rho}{\sigma}$$

Phase Diagram Solution Derivations of k^* and k_{max}

$$0 = -{\Omega_0}^{(1-\alpha)}\omega \;\; \theta {k_t}^{\theta-1} + (\delta + n + g) + \rho$$

$${\Omega_0}^{(1-\alpha)}\omega \;\; \theta {k_t}^{\theta-1} = \emptyset + (\delta + n + g)$$

$$k^* = \left(\frac{\rho + (\delta + n + g)}{{\Omega_0}^{(1-\alpha)}\omega \;\; \theta}\right)^{\frac{1}{\theta-1}}$$

$$0 = {\Omega_0}^{(1-\alpha)}\omega \;\; {k_t}^{\theta} - c_t - (\delta + n + g)k_t$$

$$c_t = {\Omega_0}^{(1-\alpha)}\omega \;\; {k_t}^{\theta} - (\delta + n + g)k_t$$

$$\frac{dc}{dk} = {\Omega_0}^{(1-\alpha)}\omega \;\; \theta {k_t}^{\theta-1} - (\delta + n + g) = 0$$

$$k_{tmax} = \left(\frac{{\Omega_0}^{(1-\alpha)}\omega}{(\delta + n + g)}\right)^{\frac{1}{1-\theta}}$$

Appendix 2: Derivations of Equations: Chapter 4

Reduced from of y_t:

$$\tilde{Y}_t = {A_{0t}}^{1-\alpha}[{h_t}^{\gamma}{e_t}^{1-\gamma}]^{1-\alpha}\left[\omega_y \tilde{K}_t\right]^{\alpha}[1-\upsilon_e-\upsilon_h]G^{\mu}$$

$$X_t/_{A_{ot}} = per\ capita, \hat{x}_t$$

$$\tilde{y}_t = [{h_t}^{\gamma}{e_t}^{1-\gamma}]^{1-\alpha}\left[\omega_y k_t\right]^{\alpha}[1-\upsilon_e-\upsilon_h]g^{\mu}$$

$$y_t$$
$$= {h_0}^{\gamma(1-\alpha)}{\omega_h}^{\beta_h\gamma(1-\alpha)}{h_t}^{\beta_h\gamma(1-\alpha)}{\upsilon_h}^{\chi_h(1-\alpha)}g^{\chi_h(1-\alpha)}\cdot {e_0}^{(1-\gamma)(1-\alpha)}$$
$${\omega_e}^{\beta_e(1-\gamma)(1-\alpha)}{h_t}^{\beta_e(1-\gamma)(1-\alpha)}\alpha\,.$$
$${\upsilon_e}^{\chi_e(1-\alpha)}g^{\chi_e(1-\alpha)}\cdot {\omega_y}^{\alpha}{k_t}^{\alpha}\cdot(1-\upsilon_e-\upsilon_h)g^{\mu}$$

where:

$$\theta = \alpha+\beta_h\gamma(1-\alpha)+\beta_e(1-\gamma)(1-\alpha),$$
$$\phi = 1-\upsilon_e-\upsilon_h;\ \Omega = {h_0}^{\gamma}{e_0}^{1-\gamma}$$
$$\upsilon = {\upsilon_h}^{\chi_h\gamma(1-\alpha)}{\upsilon_e}^{\chi_e(1-\gamma)(1-\alpha)}$$
$$\omega = {\omega_h}^{\beta_h\gamma(1-\alpha)}{\omega_e}^{\beta_e(1-\gamma)(1-\alpha)}{\omega_y}^{\alpha},$$

$$y_t = {\Omega_0}^{(1-\alpha)}\omega\ \ {k_t}^{\theta}\upsilon\,\phi^{\mu}g$$

Capital accumulation constraint $\dot{k}$

$$Y = C+I+G+rB$$
$$I = Y-C-G-rB$$

$$\dot{K} = I-\delta K$$

$$\dot{K} = Y-C-G-\partial K-rB$$

$$\frac{\dot{K}_t}{A_{0t}L_t} = -\frac{\delta K_t}{A_0L_t}+\frac{Y_t}{A_0L_t}-\frac{C_t}{A_0L_t}-\frac{r_tB_t}{A_0L_t}$$

$$\frac{\dot{K}_t}{A_{0t}L_t} = -\delta k_t+y_t-c_t-r_tb_t$$

$$\dot{k}_t = \frac{\dot{K}_tA_{0t}L_t-\dot{A}_{0t}L_tK_t-\dot{L}_tA_{0t}K_t}{A_{0t}{L_t}^2}$$

$$\dot{k}_t = \frac{\dot{K}_t}{A_{0t}L_t}-\frac{\dot{A_{0t}}}{A_t}k_t-\frac{\dot{L}_t}{L}k_t$$

$$\dot{k}_t = \frac{\dot{K}_t}{A_{0t}L_t}-\varphi k_t-nk_t$$

$$\dot{k}_t+\ gk_t-\varphi k_t = -(\partial+\varphi+n)k_t$$

$$\dot{k} = y_t - c_t - g_t - r_t b_t - (\partial + n + \varphi)$$

$$MPK = r = \frac{\partial y}{\partial k} = \Omega_0{}^{1-\alpha}\omega\theta k^{\theta-1}\upsilon\phi^{\mu}g$$

$$\dot{k} = \Omega_0{}^{(1-\alpha)}\omega\ \ k_t{}^{\theta}\upsilon\,\phi^{\mu}g - c_t - g_t - \left(\Omega_0{}^{1-\alpha}\omega\theta k^{\theta-1}\upsilon\phi^{\mu}g\right)\ \ b_t - (\partial + n + \varphi)$$

Government Budget Constraint $\dot{b}$

$$b = B_t/A_{0t}L_t$$

$$b = \dot{B}L - \dot{L}B - ALB/A^2L^2\ ^{3435}$$

$$\frac{\dot{B}}{L} - \frac{\dot{L}}{L}b - \varphi b$$

$$\dot{b} + nb + \varphi b = \frac{\dot{B}}{L}$$

$$\dot{b} + nb + \varphi b = g - t - rb$$

$$\dot{b} = g - t + (r - n - \varphi)b$$

$$\dot{b} = g - \tau y + (r - n - \varphi)b$$

$$b\ \ = g\ \ - \tau\left(\Omega_0{}^{1-\alpha}\omega k^{\theta}\upsilon\phi^{\mu}g\right) + \left(\Omega_0{}^{1-\alpha}\omega\theta k^{\theta-1}\upsilon\phi^{\mu}g\right) - n - \varphi)b$$

Optimization and first order conditions to derive $\dot{c}/c$,

Maximise :

$$\int_0^{\infty} e^{pt}\frac{\check{C}_t^{1-\sigma}}{1-\sigma}dt = \int_0^{\infty} e^{pt}\ A_{0t}{}^{1-\sigma}\ \frac{\check{C}_t^{1-\sigma}}{1-\sigma}dt$$

$$= \int_0^{\infty} e^{(\varphi(1-\sigma)-p)t}\ \frac{\check{C}^{1-\sigma}}{1-\sigma}dt$$

Subject to:

$$\dot{k}_t = \Omega_0^{1-\alpha}\ \omega\ k_t^{\theta}\ \upsilon\phi^{\mu}g - c_t - g_t - \Omega_0^{1-\alpha}\ \omega\ \theta\ k_t^{\theta-1}\ \upsilon\phi^{\mu}gb_t - (\delta + n + \varphi)k_t$$

And:

$$\dot{b} = g - \tau\left(\Omega_0^{1-\alpha}\ \omega\ k_t^{\theta}\ \upsilon\phi^{\mu}g\right) + \left(\Omega_0^{1-\alpha}\ \omega\ \theta\ k_t^{\theta-1}\upsilon\ \phi^{\mu}g\right)b_t$$

The Hamiltonian H:

$$H = \frac{c^{1-\sigma}}{1-\sigma} + \lambda\left[\left(\Omega_0^{1-\alpha}\ \omega\ k^{\theta}\ \upsilon\phi^{\mu}g - c\ \ - g\ \ - \Omega 01-\alpha\ \omega\,\theta\,k\theta-1\,\upsilon\phi\mu gb-\delta+n+\varphi k+g-\tau\Omega 01-\alpha\ \omega\ k\theta\ \upsilon\phi\mu g+\Omega 01-\alpha\ \omega\,\theta\,k\theta-1\,\upsilon\phi\mu gb\right.\right.$$

[34] *t* subscripts for all variables relevant, just as is the case in the derivation of *k(t)*
[35]

$$FOC_c = c^{-\sigma} - \lambda = 0$$

$$\lambda = c^{-\sigma}$$

$$\dot{\lambda} = -\frac{dH}{dk} + \rho\lambda = -\lambda\left[\Omega_0{}^{(1-\alpha)}\omega\ \ \theta k\ \ ^{\theta-1}\upsilon\phi^{\mu}g - \right.$$

$$\Omega 01-\alpha\ \ \omega\ \theta(\theta-1)\ k\theta-2\ \upsilon\phi\mu gb-\delta+n+\varphi-\tau\Omega 01-\alpha\ \ \omega\ \theta$$

$$kt\theta-1.\upsilon\phi\mu g+\Omega 01-\alpha\ \omega\,\theta\theta-1k\theta-2\,.\upsilon\phi\mu g.b+\rho\lambda$$

$$\frac{\dot{\lambda}}{\lambda} = -\Omega_0{}^{(1-\alpha)}\omega\ \ \theta k\ \ ^{\theta-1}\upsilon\phi^{\mu}g$$

$$+\left(\Omega_0^{1-\alpha}\ \omega\,\theta(\theta-1)\,k^{\theta-2}\,\upsilon\phi^{\mu}g\right)b$$

$$+(\delta+n+\varphi)+\tau\left(\Omega_0^{1-\alpha}\ \omega\,\theta\,k^{\theta-1}.\upsilon\phi^{\mu}g\right)$$

$$-\Omega_0^{1-\alpha}\ \omega\,\theta(\theta-1)k^{\theta-2}\,.\upsilon\phi^{\mu}g.b\ \ +\rho$$

$$\dot{\lambda} = -\sigma c^{-\sigma-1}\cdot\dot{c}$$

$$\frac{\dot{\lambda}}{\lambda} = -\sigma c^{-1}\cdot\dot{c}$$

$$\frac{\dot{\lambda}}{\lambda} = -\sigma\frac{\dot{c}}{c} \qquad (2)$$

Equating equation 1 and 2:

$$-\sigma\frac{\dot{c}}{c} = -\Omega_0{}^{(1-\alpha)}\omega\ \ \theta k\ \ ^{\theta-1}\upsilon\phi^{\mu}g$$

$$+\left(\Omega_0^{1-\alpha}\ \omega\,\theta(\theta-1)\,k^{\theta-2}\,\upsilon\phi^{\mu}g\right)b$$

$$+(\delta+n+\varphi)+\tau\left(\Omega_0^{1-\alpha}\ \omega\,\theta\,k^{\theta-1}.\upsilon\phi^{\mu}g\right)$$

$$-\Omega_0^{1-\alpha}\ \omega\,\theta(\theta-1)k^{\theta-2}\,\upsilon.\phi^{\mu}g.b\ \ +\rho$$

$$\frac{\dot{c}}{c}$$

$$= \frac{\Omega_0{}^{(1-\alpha)}\omega\ \ \theta k\ \ ^{\theta-1}\upsilon\phi^{\mu}g - \left(\Omega_0^{1-\alpha}\ \omega\,\theta(\theta-1)k^{\theta-2}\,\upsilon\phi^{\mu}g\right)b\ \ - (\delta+n+\varphi) - \tau\left(\Omega_0^{1-\alpha}\ \omega\,\theta\,k^{\theta-1}.\upsilon\phi^{\mu}g\right) + \left(\Omega_0^{1-\alpha}\ \omega\,\theta(\theta-1)k^{\theta-2}\,.\phi^{\mu}g\right).b\ \ -\rho}{\sigma}$$

$$\frac{\dot{c}}{c} = \frac{(1-\tau)\Omega_0{}^{(1-\alpha)}\omega\ \ \theta k\ \ ^{\theta-1}\upsilon\phi^{\mu}g - (\delta+n+\varphi) - \rho}{\sigma}$$

Chapter 4 Section 4.2 Dynamic Equations (36-38)

$$U(c_t) = \int_0^{\infty} e^{(\varphi(1-\sigma)-\rho)t} \frac{\check{C}^{1-\sigma}}{1-\sigma} dt$$

(36)

$$\dot{k}_t = \Omega_0^{1-\alpha}\ \omega\ k_t^{\theta}\ \phi^{\mu} g - c_t - g_t - \Omega_0^{1-\alpha}\ \omega\ \theta\ k_t^{\theta-1}\ \phi^{\mu} g\ b_t - (\delta + n + \psi)k_t$$

(37)

$$\dot{b} = g - \tau\left(\Omega_0^{1-\alpha}\ \omega\ k_t^{\theta}\ \phi^{\mu} g\right) + \left(\Omega_0^{1-\alpha}\ \omega\ \theta\ k_t^{\theta-1}\ \phi^{\mu} g - (n + \varphi)\right)b_t$$

(38)

Appendix 3: Summary Tables of Diagnostic Statistics

Table 13: Summary Diagnostic Statistics for the Estimated Equations of the Model

Summary Statistics for the Estimated Equations of the Model										
	Botswana	**South Africa**	**Malawi**	**Zambia**	**Kenya**	**Tanzania**	**Uganda**	**Cote d'Ivore**	**Ghana**	**Nigeria**
Equation 1 (Production Function)										
Adj. R-squared	0.9721	0.9763	0.9742	0.9437	0.9922	0.9783	0.9923	0.9566	0.9479	0.9110
F Statitistic	163.8600	372.6300	246.9400	114.1900	1147.9200	287.4600	1162.0000	100.3500	78.0600	70.1000
Prob (F-Statistic)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 2 (Labour Effectiveness)										
Adj. R-squared	0.8944	0.9256	0.6532	0.7934	0.8756	0.8292	0.7932	0.6844	0.7209	0.7902
F Statitistic	56.2900	60.2700	86.8200	112.4600	97.3200	127.4900	156.0200	179.0700	106.0500	129.3600
Prob (F-Statistic)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 3 (Education Equation)										
Adj. R-squared	0.9430	0.9538	0.9634	0.9202	0.9742	0.9813	0.9855	0.9649	0.9547	0.9105
F Statitistic	67.3190	140.5100	178.8800	78.9000	341.8600	335.0600	368.8600	187.0800	190.9600	169.0900
Prob (F-Statistic)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 4 (Health Equation)										
Adj. R-squared	0.9852	0.9756	0.9288	0.8903	0.9806	0.9501	0.9662	0.9777	0.9608	0.9309
F Statitistic	140.7000	138.3100	118.5400	74.0500	458.0800	121.7900	258.8800	297.3000	211.1200	91.9800
Prob (F-Statistic)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 14: Summary Results for Endogeniety Tests

Extent of Endogeneity Problem : Hausman Test Results		
Dependent Variable: Measure of Labour effectiveness/Productivity		
Variables Tested	Health , Education	Education, Health
Test Statistic (df)	1.89 (1)	5.69 (2)
Dependent Variable : Per Capita Output		
Variables Tested	Health	Education, Health
Test Statistic (df)	1.45 (1)	4.37 (2)
Dependent Variable: Education		
Variable tested	Health	Education, Health
Test Statistic (df)	1.61 (1)	5.02 (2)
Dependent Variable: Health		
Variables Tested	Education	Education, Health
Test Statistic (df)	1. 73 (1)	4.91 (2)