Government Expenditure and Economic Growth: Theoretical and Empirical Analysis

Dissertation
zur Erlangung des Grades eines Doktors der
wirtschaftlichen Staatswissenschaften
(Dr.rer.pol.)
des Fachbereichs Rechts- und Wirstchaftswissenschaften

der Johannes Gutenberg-Universitaet Mainz
vorgelegt von
MSc. Christine Awiti

in Mainz

im Jahre 2016

Abstract

The discussion on the disparities in income and economic growth across countries has gained momentum in the literature. One strand of the literature has emphasized the differences between countries as a major contributing factor to the differences in growth rates. Government policy is one such unique country specific characteristic. This dissertation analyses the role of government policy and the resultant growth effect through three research papers. The first paper (chapter two) reviews the effects of changes in government policy through taxation. Changes on three types of taxes – taxes on wages, consumption and capital – are analyzed in a static neoclassical growth model. Within the setting of a static model with zero long run growth, the results find for important implications of changes in taxes on the levels of income, consumption and investments in the long run. The second paper (chapter three) looks at the effects of different types of government spending on long run growth through a theoretical endogenous growth setting. We find that government spending on human capital is important for long run growth. Finally, Chapter four using an empirical approach extends the analysis in chapter three and finds that government spending policy is important for long run growth.

Abstract

Die Diskussion um Ungleichgewichte bezüglich Einkommen und wirtschaftlicher Entwicklung im Ländervergleich hat in den letzten Jahren an Bedeutung gewonnen. Die Literatur hat verschiedene Unterschiede zwischen Ländern als Gründe für Wachstumsunterschiede herausgearbeitet. Länderspezifische Politik ist ein solcher Unterschied zwischen Ländern. Die hier vorgelegte Arbeit untersucht politische Handlungsführung und ihren Einfluss auf das Wirtschaftswachstum in drei Artikeln. Der erste Artikel (Kapitel zwei) beschäftigt sich mit Veränderungen in der Steuerpolitik und deren Effekt auf das Wirtschaftswachstum. Unterschiede in drei Steuerarten - Einkommensteuer, Mehrwertsteuer und Kapitalsteuer- werden in einem klassischen Wachstumsmodel überprüft. In einem statischen Model ohne langfristiges Wachstum, zeigen sich auf lange Sicht signifikante Auswirkungen auf Einkommen, Verbrauch und Investitionen. Der zweite Artikel (Kapitel drei) beschäftigt sich mit dem Effekt verschiedener Arten von öffentlichen Ausgaben für eine endogene Wachstumsumgebung. Ausgaben im Bereich Humankapital sind entscheidend für die langzeitliche Entwicklung. Schlussendlich unternimmt Kapitel vier, unter Zuhilfenahme eines empirischen Ansatzes, die Analyse von Kapitel drei und stellt heraus, dass öffentliche Ausgaben wichtig für das langfristige Wirtschaftswachstum sind.

Contents

List of Figures

List of Tables

1 Introduction

Disparities in economic growth across countries is a topic of utmost concern to economists. The question often asked is, given an initial level of income at a given time period, why do some countries on average attain high income per capita growth, while others do not. An important aspect is that individual countries have certain unique qualities and therefore, it is not surprising that growth rates will differ from country to country. One such unique country specific characteristic is government policy.

Governments play a very important role in any economy, since they provide public goods. Public goods have two qualities, they are non-rival and non-excludable. An often cited example of a public good with these qualities is the street lamp, since the use of a street lamp by one individual does not prevent another individual from its use, and at the same time, it is impossible to exclude individuals from the use of a street lamp. It is also these two qualities of public goods that make it difficult for the price mechanism to work in the provision of such goods, and therefore the government steps in by collecting revenue and providing these goods in a manner that is deemed fair to all.

The governments role in providing public goods also means that it has an important role to play in the distribution of resources. This is normally done through revenue collection and resource redistribution through government expenditure. The role of government in influencing economic growth can thus be seen through these two channels.

This thesis thus looks at the role of government policy and the influence of this on economic growth in totality. We use both theoretical and empirical methodology in the analysis, and look at policy implications for this for a small open developing economy, Kenya.

In Chapter two, the thesis analyses the effect of a change in government policy through its influence on taxation. The setting is an exogenous neo classical growth model, with three types of taxes, that is, taxes on capital, consumption and wages.[1] Since in this

[1] Rebelo (1991); Turnovsky & Fisher (1995); Irmen & Kuehnel (2009) look at the effects of taxes on economic growth in an endogenous growth model setting.

model the growth rate of technology is exogenously determined, and assuming a zero population growth, we find that the change in government policy does not affect economic growth in the long run. However, there are still some interesting results, since a change in government policy affects the level of income, capital, consumption and government revenue in the long run. In addition, our setting allows for the net effect of government policy on the level of income since there is a clear trade off between taxation and productive government expenditure.[2][3]

We solve for the theoretical model numerically using data on Kenya from which we can draw some policy implications. We find consistent results where we look at policy changes for individual taxes when they are taken as the only source of revenue in the economy, and when they are taken in combination with other taxes as a source of revenue in the economy.

We then proceed with Chapter three, which analyses the effect of government spending policy on economic growth. Rather than looking at the overall effect of government spending on economic growth, this chapter analyses specifically for the growth effects of government spending policy.[4] Our framework is a combination of the Uzawa-Lucas two sector model of human capital with the Barro (1990) model of government expenditure in an endogenous growth model. However, our main contribution is that government expenditure is now split between the human capital sector and the production of goods sector.

Where Barro (1990) finds that there is an optimal allocation of government expenditure, we find that there is also an optimal allocation of government expenditure when the shares of government expenditure between sectors is endogenously determined. When government expenditure is not optimally allocated, then the growth rate in the long run will be lower by the rate of the miss allocation. In this case, the growth rate always reverts back to the growth rate of human capital.

Using data from Kenya, we solve for the model numerically. Given the data, we find that Kenya would benefit from a higher long run growth rate if the government shifted expenditure from the production sector to the human capital sector.

---

[2] Rebelo (1991) assumes that there is no effect of government spending on household utility, and neither is government spending on the production sector productive.

[3] Irmen & Kuehnel (2009) carry out a survey of government policy and economic growth and use different types of taxes. They analyse productive government expenditure as a stock with different interactions and find that this has implications for long run growth.

[4] Previous research in this area includes Devarajan *et al.* (1996); Agenor & Neanidis (2011).

Chapter four takes an empirical approach. Using a dynamic panel data model, we analyse for the long run growth effects of a change in the government's policy on the allocation of revenue. The dynamic panel data model derives from and follows the empirical model as used by Caselli *et al.* (1996), in which the effect of initial income on growth is measured, that is, convergence, controlling for other determinants of economic growth in the long run.[5] In this research therefore, government policy is considered an important determinant of growth in the long run as we will see in the coming chapters.

Since our empirical model follows the Caselli *et al.* (1996) dynamic panel data model, we proceed by using the same estimation method, that is, the Arellano-Bond estimator. This estimator turns out to be suitable as it addresses the issues in a dynamic panel data model with a short time period and many observations, such as those of our model. We find that government spending on education has a positive and significant effect, while government spending on health and social protection has negative and significant effects.

In chapter five, we give a summary of the key findings of our research, that is, the effect of government policy on economic growth. Since the research also has an applied aspect, we conclude by giving some policy implications based on our findings.

[5] Mankiw *et al.* (1992) using the neoclassical Solow model, measure for the effects of savings and population growth on the variation of income across countries, where the rate of savings and population growth are determined exogenously. They also measure for the effect of initial income on current income, that is, convergence, conditional on savings and population growth. In a later paper, Caselli *et al.* (1996) also test for the effect of convergence on economic growth, conditional on human capital and physical capital, as well as population growth.

2 Taxes and Economic Growth in Kenya: A Theoretical Approach

2.1 Introduction

Background - In developing countries, tax reforms have an important role to play in the development process. An increase in tax revenue due to reforms may increase a government's ability to meet its development objectives. For example, with an increase in revenue, governments can raise the level of human capital through increased spending in the education sector, or alternatively raise the level of infrastructure development through increased spending on infrastructure projects. In addition, a more progressive and pro-poor tax structure due to reforms could be welfare enhancing. In recent years[1], the Government of Kenya undertook tax reforms with the intention of raising revenue to support its ambitious development plan as stated in the Vision 2030 policy development plan. While tax reforms can enhance revenue for development, governments must be careful not to introduce disincentives from reforms that lower levels of income, consumption and capital, essentially leaving individuals worse off than they were before the reforms.

The open question - This research therefore seeks to answer the question, what are the effects of changes in taxes on the levels of income, consumption and capital? We do so by looking specifically at three types of taxes, that is, taxes on consumption, investments and income.

Our message - While focusing on revenue growth, governments must also be careful to balance this with economic growth. An increase in taxes may increase government

[1] In 2013, the Government of Kenya undertook VAT tax reforms, in 2015 a capital gain tax of 5 percent was introduced, in 2017 the income tax brackets were increased to adjust for the bracket creep (reforms on income tax had not been undertaken for over a decade). Source: Kenya Revenue Authority and The National Treasury Budget Statement Reports.

revenue and hence expenditure. However, increases in taxes may also have a disincentive on certain productive economic activities that then end up with a net negative effect on economic growth. For example, from the theory, while an increase in tax on say capital raises revenue for the governments that could be spend on infrastructure, the same raise in tax reduces the marginal productivity of capital and thus consumers may prefer to consume rather than invest. This has implications for the level of capital stock, and therefore consumption and economic growth. Governments, therefore, have to be able to draw a balance between raising revenue and the implications for this on economic growth.

Our framework - The research uses a simple neoclassical growth model where the growth rate of technology is exogenously determined[2]. The model is therefore stationary, with transitional growth effects that depend on the rate of time preference and the marginal productivity of capital. As we are concerned specifically with the effect of taxes on income, consumption and investments, the set up is in a closed economy with one sector, where the government has only the taxes it imposes as a source of revenue, and further operates a balanced budget. The framework has the advantage that it is intuitive and shows clearly the outcomes of changing government policy.

Results - Based on the model setting, we find that while changes in government policy affect transitional growth, there is no effect of changes in taxes on long run growth, since technology is exogenously determined. However, changes in taxes on investments influence the levels of income, capital, government revenue and consumption in the long run, so that there exists some form of relationship between taxes on investments and levels of income, capital and consumption at steady state. There is however a trade off between taxes and the productiveness of government expenditure, since government spends all its revenue on public capital which enters into the production function.

Further related literature - As a major source of revenue for governments, taxes and their effect on economic growth have received a lot of attention in the literature (Rebelo (1991); Turnovsky & Fisher (1995); Irmen & Kuehnel (2009)). Using a neoclassical endogenous framework, Rebelo (1991) looks at the long run effects of changes in tax policy on economic growth and finds that for the class of endogenous growth models used, generally economies with higher tax rates have lower growth rates. Of importance is that Rebelo (1991) makes the assumption that there is no trade off between taxes and government investment since the goods produced by the government do not enter into

[2]Note that in addition to an exogenously determined rate of technology, we assume a zero population growth rate.

the production function, nor do they affect the consumer's marginal utility.

A Key issue in the taxation literature is the elasticity of taxes. Questions researchers have been interested in answering include what the income elasticity of taxation is. In this regard, a lot of research on elasticity of taxation has been done with respect to the US tax reforms of 1981, 1983 and 1986, beginning with Feldstein (1995) who looks at the overall elasticity of income tax. Other work in this area include Slemrod (1996); Goolsbee (2000); Gruber & Saez (2002) who all find different income elasticities of taxation for the United States for the period of the three tax reforms. It is argued that income elasticity is important as governments can use this a tool to determine how much revenue to raise.

Other areas of research on taxation of income have included the effect of progressive taxes on increased revenue (Banerjee & Piketty (2005); Piketty & Qian (2009)), who find that treatment of progressive taxes in two large developing countries, China and India, affect the tax revenues raised in these countries.

Looking at our geographical research area, research carried out on taxes in Kenya have tended to take a sector specific approach (Bouet & Roy (2012); Karingi *et al.* (2001); Kiringai *et al.* (2002); Njeru *et al.* (2005)). In particular, these sector specific taxes have tended to analyse the effect of consumption tax on demand for goods and services, such as is the case with alcohol and cigarettes. Elasticity is also very key in analysis of consumption tax as it gives guidance on how much revenue can be raised from such taxes.

Other research has looked at the effect of changes in tax policy on corporate tax on economic growth. Lee & Gordon (2005) using cross country data for the period 1970 to 1997, and controlling for country effects, find that corporate tax is negatively correlated with economic growth. They also find that an increase in corporate tax tends to decrease economic growth rates. Corporate tax tends to discourage investments as it reduces profits.

Another strand of the literature on the effect of taxation on economic growth has looked at lump sum versus disaggregated tax. In a study of the United states, Yamarik (2000) finds that when disaggregated taxes are used rather than lump sum tax to measure for the effect on economic growth, then the result tends to be consistent with the theory.

Ojede & Yamarik (2012) in a recent study carried out on forty eight states in the United States, using a pooled mean group estimator, find that an increase in income tax does not have a long run effect on economic growth while property and sales taxes have a negative effect.

Studies on the effects of tax different types of taxes on economic growth have in most cases taken an empirical approach (Ojede & Yamarik (2012); Bouet & Roy (2012); Lee & Gordon (2005)). This paper thus contributes to the existing literature by using a theoretical approach to analyse the effects of three types of taxes on economic growth. Secondly, while theoretical research typically either focuses on sector analysis or lumps together all taxes, this research looks at three different types of taxes, that is, consumption tax, wage tax and capital tax. We use a neoclassical exogenous growth model in a closed economy with one sector to carry out this analysis.

Table of contents - The research proceeds as follows. In the next section, we begin with the analysis of an exogenous neoclassical growth model. Section three then introduces the government sector. In this section, we see the different types of taxes in the economy, and take a look at the government's budget constraint. Section four gives a numerical analysis of the effect of changes in taxes on the levels of consumption, capital and government revenue. Section five gives the conclusion on the effect of changes of three different types of taxes on income, consumption and investments.

2.2 Optimal Factor Allocation: A Planner Problem

2.2.1 Households

The model assumes homogenous households with the same preferences and same wage rates, and begins with the same asset level per person. From these assumptions, we can therefore derive equilibrium from a single representative household. We assume further that the current generation takes into account the welfare of future generations. Thus, the current generation maximizes utility subject to a budget constraint over an infinite horizon. The instantaneous utility function is thus defined as:

$$u = u(C) \tag{2.1}$$

The above consumption function satisfies the Inada conditions, that is: u'$(C) \rightarrow \infty$ as C $\rightarrow 0$, and u'$(C) \rightarrow 0$ as C$\rightarrow \infty$

We further assume that the utility increases at a decreasing rate, that is u (C) is increasing in C and is concave. We take wages w and interest rates r as given. The labor market is assumed to be in equilibrium. Thus each individual receives labor of w(t) per unit of time. Individuals consume part of their income and save the remaining. Total income for households is wage and asset income. We take the utility function to be of the isoelastic form as below:

$$u\left(C\right)=\frac{C^{1-\theta}-1}{1-\theta} \tag{2.2}$$

Where theta is the constant elasticity of substitution.

2.2.2 The Planner's Objective Function

$$U=\int_{0}^{\infty}u\left[C\left(t\right)\right]e^{-\rho t}dt \tag{2.3}$$

Equation (2.3) above is the Planner's objective function. This function assumes that total utility facing households at time zero is the weighted sum of all future flows of utility, u (C) which takes all properties as given above. ρ is the rate of time preference where we assume $\rho > 0$.

2.2.3 The Production Sector

There are two factors of production, capital and labour. We assume constant returns to scale for all factors but diminishing returns to each. The production function also satisfy the Inada conditions. If we assume the Cobb-Douglas production function, we can express the production function as below:

$$Y=K^{\alpha}AL^{1-\alpha} \tag{2.4}$$

where $\alpha \in (0,1)$, and alpha is the output elasticity of capital.

The resource accumulation constraint can thus be expressed as:

$$\dot{K}=K^{\alpha}AL^{1-\alpha}-C-\delta K \tag{2.5}$$

2.2.4 The Planner's Solution

We maximise the planner's objective function, (2.3), subject to the resource accumulation constraint, (2.5), the optimization solution to the planner problem will be (see appendix for workings A):

$$\frac{\dot{C}}{C} = \frac{1}{\theta}\left[\alpha A \left(\frac{K}{L}\right)^{-(1-\alpha)} - \delta - \rho\right] \tag{2.6}$$

The growth rate of consumption increases with an increase in the marginal productivity of capital per unit of labour, declines with an increase in depreciation of capital and the rate of time preference. A large rate of time preference means that consumers prefer to consume today, and therefore increase consumption and reduce the level of savings, which in turn reduces future consumption and hence the growth rate of consumption.

2.2.5 Steady State

At steady state, capital and consumption will be (See working in appendix A):

$$C = \left[\frac{\alpha}{\delta + \rho}\right]^{\frac{\alpha}{1-\alpha}} - \delta\left[\frac{\alpha}{\delta + \rho}\right]^{\frac{1}{1-\alpha}} \tag{2.7}$$

$$K = \left[\frac{\alpha}{\delta + \rho}\right]^{\frac{1}{1-\alpha}} \tag{2.8}$$

The levels of consumption and capital depend on the output elasticity of capital, α, the depreciation rate of capital δ and the rate of time preference ρ. The level of capital has an inverse relationship with depreciation and the rate of time preference. The higher the rate of time preference and the depreciation rate, the lower the level of capital. On the other hand, the level of capital is positively related to the output elasticity of capital. The larger the contribution of capital is in the share of output, the larger is the level of capital. There are two reasons for this: firstly, where the income elasticity of capital is high, then increasing capital increases income and therefore the level of savings and consequently investments; and secondly, where the elasticity is high, then returns to investments are also high and therefore this increases individuals incentive to save more.

2.3 The Model With Taxes

We introduce the government sector into the model. The government operates a balanced budget, that is, its expenditure and transfers to households is equal to revenue collected. The revenue is obtained through taxes on all household incomes - wages (τ_w) and assets (τ_i), as well as consumption (τ_c). The taxes are a flat rate and constant over time. Government therefore has the following constraint:

$$G = \tau_w wL + \tau_c C + \tau_i rK \tag{2.9}$$

where G is government expenditure.

2.3.1 The Optimization With Taxes

Just as in section 1 above, the model assumes homogenous households with the same preferences and same wage rates, and begins with the same asset level per person. From these assumptions, we can therefore derive equilibrium from a single representative household. We assume further that the current generation takes into account the welfare of future generations. Thus, the current generation maximizes utility subject to a budget constraint over an infinite horizon. The objective function is thus:

$$U = \int_0^\infty e^{-\rho t} u\left[C\left(t\right)\right] dt \tag{2.10}$$

The above consumption function satisfies the Inada conditions, that is: u'$(C) \to \infty$ as C $\to 0$, and u'$(C) \to 0$, as C $\to \infty$

We further assume that utility increases at a decreasing rate, that is u (C) is increasing in C and is concave. The labor market is assumed to be in equilibrium. Individuals consume part of their income and save the remaining. We take the utility function to be of the isoelastic form as below:

$$u\left(C\right) = \frac{C^{1-\theta} - 1}{1 - \theta} \tag{2.11}$$

2.3.2 The Production Sector

In addition to capital and labour, there is now a third factor of production, that is, government expenditure on public capital. We further assume diminishing returns to each factor of production separately, but constant returns to all factors. The production function can thus be expressed below, assuming a Cobb-Douglas Production function:

$$Y = K^{\alpha} G^{\beta} A L^{1-\alpha-\beta} \tag{2.12}$$

where $\alpha, \beta \in (0,1)$, and α is the output elasticity of capital, with β as the output elasticity of government spending.

The resource accumulation constraint will be:

$$\dot{K} = K^{\alpha} G^{\beta} A L^{1-\alpha-\beta} - C - G - \delta K \tag{2.13}$$

2.3.3 Planner's Solution

Maximising equation (2.10) subject to the resource constraint (2.13) will give us the growth rate of consumption as (See workings in appendix A2):

$$\frac{\dot{C}}{C} = \frac{1}{\theta}\left(\alpha A\left(1-\tau_i\right)\left(\frac{K}{L}\right)^{-(1-\alpha)}\left(\frac{G}{L}\right)^{\beta} - \delta - \rho\right) \tag{2.14}$$

Unlike in equation (2.6), the growth rate of consumption is now affected by taxes in capital so that an increase in taxes on capital reduces the growth rate of consumption. Intuitively, increasing the rate of taxes on capital reduces the marginal productivity of capital so that individuals now choose to consume rather than save. In addition, there is a trade off between taxes and government expenditure. Where initial taxes on capital are lower than the productivity associated with government expenditure in the production sector, then an increase in tax will increase the growth rate of consumption. However, where taxes are higher than the productivity of government expenditure in the production sector, then increasing taxes reduces the growth rate of consumption.

2.3.4 Steady State

The steady state values of consumption, capital and government expenditure can be expressed as below (see workings in Appendix A2):

$$C = AK^{\alpha}G^{\beta} - G - \delta K \tag{2.15}$$

$$K = \left[\frac{\alpha A \left(1-\tau_i\right) G^{\beta}}{\delta+\rho}\right]^{\frac{1}{1-\alpha}} \tag{2.16}$$

$$G = \frac{AK^{\alpha}G^{\beta}\left[\tau_w\left(1-\alpha-\beta\right)+\tau_c+\tau_i\alpha\right]}{1+\tau_c} - \frac{\tau_c\delta K}{1+\tau_c} \tag{2.17}$$

Equation (2.16) and (2.17) gives us two equations in two unknowns for capital and government revenue. Note that there is a trivial solution to the system where, $C = K = G = 0$, for all tax levels. At steady state, all variables are constant. That is, the level of consumption, government expenditure and capital remain the same. At this point, investment is just enough to replace depreciation in capital, and the marginal productivity of capital is equal to depreciation of capital plus the rate of time preference, and the level of consumption, capital and government revenue are as illustrated in equation (2.15), (2.16) and (2.17).

2.3.5 Numerical Solution

In order to proceed with the numerical solution, we first start by stating the exogenous parameter values. There are four exogenous parameters: β, α,ρ, and δ, where β is the elasticity of government expenditure, α is the elasticity of capital, ρ is the discount rate and δ is the depreciation rate.

We use the estimation method to get the parameter values for Kenya. The data used for Kenya is from the World Bank World Development Indicators (2014), and from the Feenstra *et al.* (2013) Penn World Tables version 8.0. The values are described below. In order to calculate the parameters, we use the following equations, which derive from the theoretical model above:

$$Y_t = \left(K_t\right)^{\alpha}\left(AL_t\right)^{1-\alpha}$$

and

$$K_{t+1} = (1 - \delta) K_t + sY_t$$

where Y_t, is the GDP for Kenya for a given time period, t; and K_t, L_t are the stock of capital, and labour force for a given time period, t. s is the savings rate. A_t is the labour productivity and B is the level of technology.

To derive α, we take the we take the labour cost shares for Kenya from 2005 to 2011 from the Feenstra *et al.* (2013) Penn World Tables 8.0. We calculate the average as 0.67, which is equal to $(1 - \alpha)$. α is thus calculated as 0.33.

Table 2.1: Calculating Alpha

Year	Y_t	(1-α)	α	L_t	K_t	A
2000	15672664145	0.72	0.28	11913757	18280669025.49	168.67
2005	18737895401	0.68	0.32	13331637	19182635285.44	137.17
2006	19924122754	0.69	0.31	13757768	22465051172.71	146.16
2007	21317473473	0.67	0.33	14204484	26269267873.22	125.37
2008	21366990286	0.64	0.36	14658340	30586116840.91	93.04
2009	22073583795	0.66	0.34	15129218	35325717476.07	104.43
2010	23928267463	0.67	0.33	15624744	40526360528.44	114.42
2011	25390670678	0.67	0.33	16147730	45974037233.19	113.92

Data Sources: WDI (2014) and PWT 8.0

For the numerical analysis, we use the calculated estimation of alpha, 0.33. Depreciation rate is taken at 0.04. From the data on the World Bank World Development Indicators (2014), we take the average real interest rate for Kenya for the year 2012. We get 0.1, and we therefore take the discount rate, ρ, as 0.06, since from the model above, at steady state, interest rates will be equal to the sum of the rate of time preference and the depreciation rate.

We take β of 0.45.This is in line with Bruckner *et al.* (2012) who carry out an empirical research on the income elasticity of government expenditure. Using a fixed effects estimation and controlling for correlates of government expenditure, they find that medium term income elasticity of government expenditure is about 0.45.

The exogenous parameters can thus be summarized in the table below:

Table 2.2: Exogenous Parameters

Parameter	Rate
β	0.45
α	0.33
ρ	0.06
δ	0.04

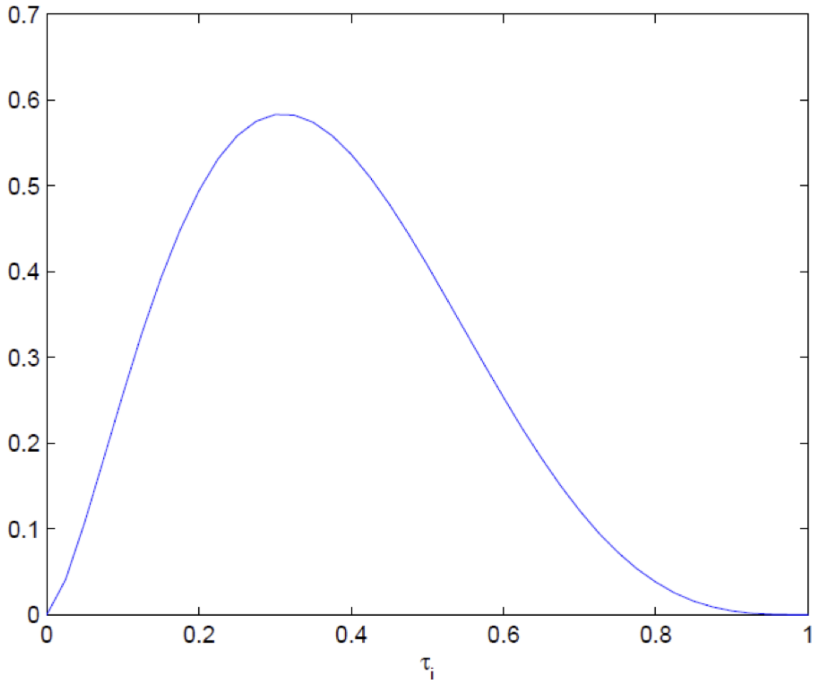
2.4 Analysis at Steady State for Different Tax Rates in Kenya

In this section, we proceed with a numerical analysis at steady state for different rates of the three types of taxes in Kenya. Since this research is concerned with growth rates at steady state, it is important to note that the growth rate of income, consumption, capital and government revenue are zero at steady state. Growth rate of income at steady state is thus determined exogenously by the growth rate of technology or labour. A change in tax rates therefore only affects the growth rate in the transition period. It is however, important to note that a lower tax rate on capital means that even though income at steady state is constant, the level of income is not the same for different rates of tax.

In addition, since taxes are behavior changing, there is a trade off between the level of tax and the effect of this on the level of income at steady state. Intuitively, at very high levels of tax, there exist certain disincentives that lower productivity and therefore reduces the level of output. We thus proceed by analysing what the effects of changes in taxes are on the levels of consumption, government revenue and capital.

2.4.1 Effects of Changes in Individual Taxes on the Levels of Consumption, Government Revenue and Capital

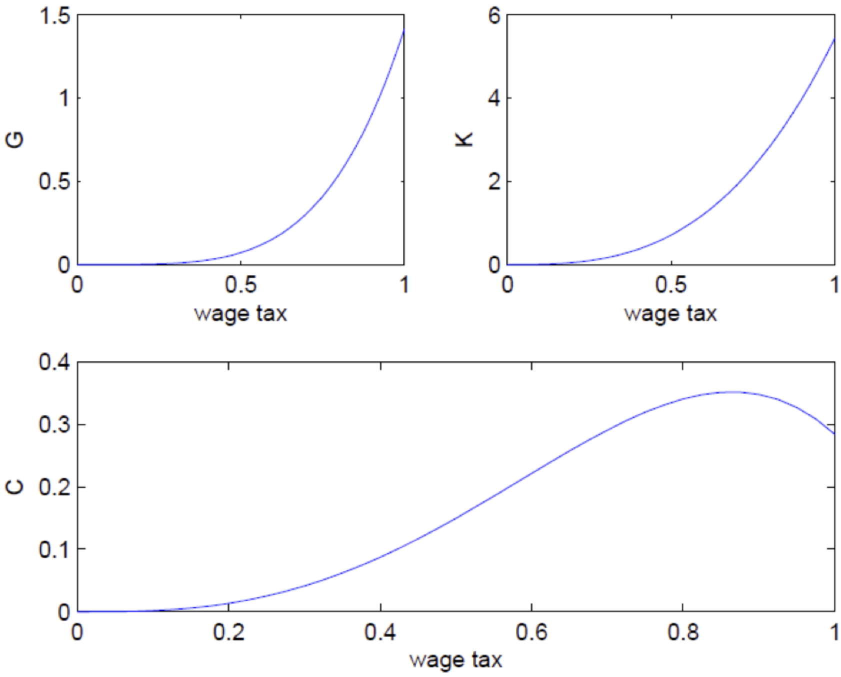
Figure 2.1: Tax Rate on Capital



In this section, we begin by assuming a zero tax rate on consumption and wages, so that the only taxes collected are on capital. Given a rate of time preference $\rho = 0.06$ and an output elasticity of government expenditure of $\beta = 0.45$, we can see that at a low capital tax rate, the level of capital in the economy will increase with an increase in the tax rate. However, at higher tax rates, consumers prefer to consume rather than save, that is, the rate of time preference outweighs the returns from the marginal productivity of government expenditure. The optimal tax rate in this case, given that other taxes are set to zero, will be at about 0.3 or 30%.

Therefore, as long as the government increases tax rates, where taxes are lower than 30% for taxes on capital, then the level of capital, and therefore the level of income will increase at steady state. On the other hand, where the government increases the level of taxes where taxes are higher than 30%, the the opposite would be the case and the level of income and capital would decline at steady state.

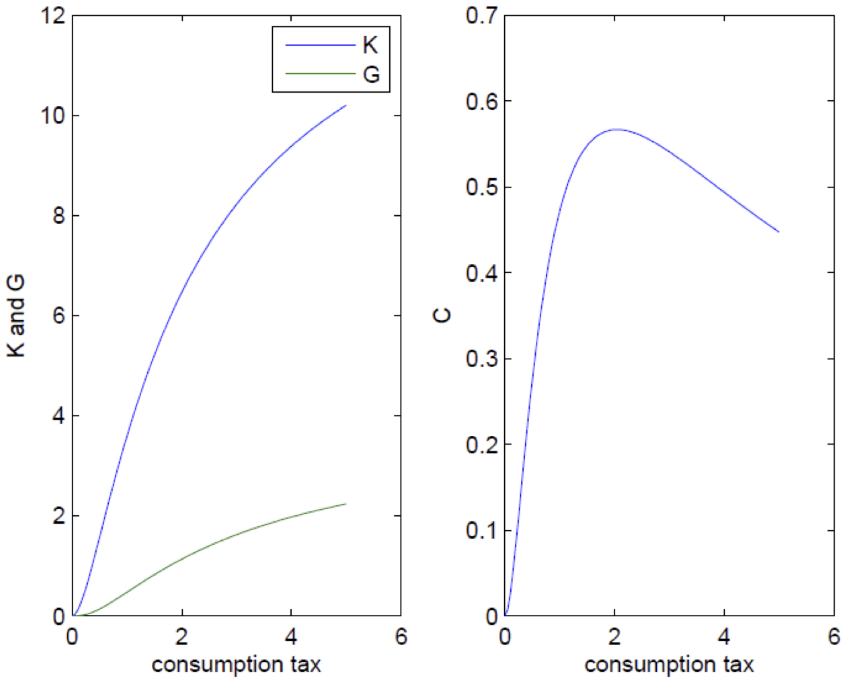
Figure 2.2: Tax Rate on Wages



We now assume zero tax rates on capital and consumption, so that government revenue only comes from taxes on wages. The top figures show us what the effects of increasing taxes on wages are on government revenue and capital, while the bottom figure shows us what this effect is on consumption.

Given a rate of time preference of 0.06, and the output elasticity of government expenditure of 0.45, we see that government revenue and the level of capital increase at an increasing rate with unit increases in tax. On the other hand, the growth rate of consumption is decreasing. Thus, with increasing income tax, consumers prefer to save rather than consume. In addition, since consumers also derive indirect utility from government expenditure through the effect of government spending on public capital, the level of capital, and thus the level of government revenue, increases faster then consumption. In the long run, the level of income will be higher in the steady state, since the level of income in this model is directly related to the level of capital and government expenditure. Note that increase in consumption reaches a peak, at a tax rate of between 80% and 90% on wages, after which consumption begins to decline.

Figure 2.3: Tax Rate on Consumption



Finally, we assume zero tax rates on wages and capital, so that the government only receives its revenue from taxation on consumption. The left hand diagram shows how changes in tax on consumption affect the levels of government revenue and capital. The right hand diagram shows how these taxes affect consumption. In this case, taxes may increase by more than the cost of the consumption good.

With the rate of time preference of 0.06 and the output elasticity of government expenditure of 0.45, with increases in consumption tax, individuals prefer to save rather than consume. From the left hand panel, we see that the level of capital and government revenue seem to grow at a much faster level than the growth rate of consumption.

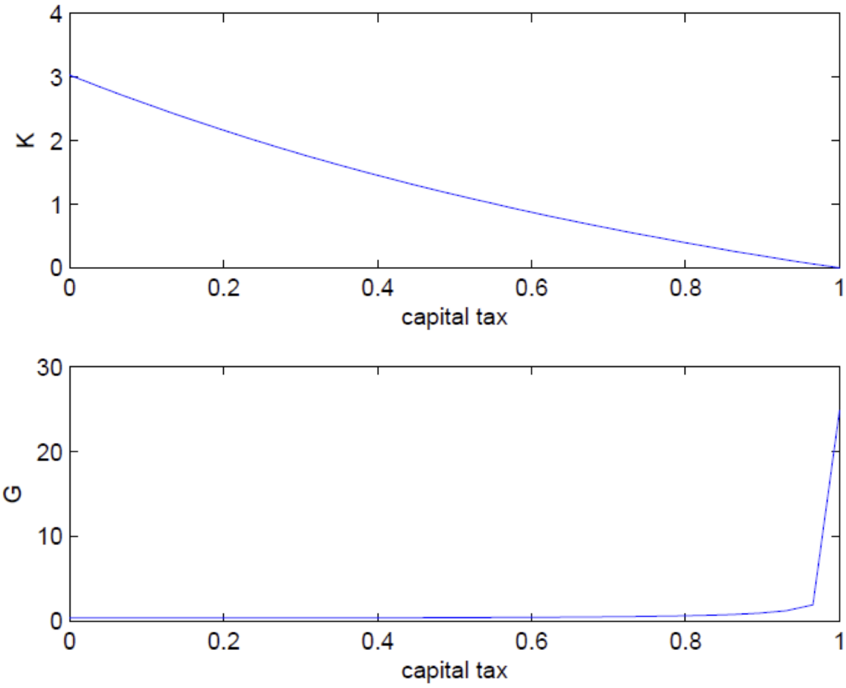
The growth rate of consumption peaks at the point where taxes are twice the cost of the consumption good, after which it starts to decline.

2.4.2 Effects of Changes in Taxes on the Level of Government Revenue and Capital

In this section, we look at the effect on the levels of variables due to a change in one type of tax, given the other two types of taxes. The parameters remain the same, that is,

$\rho = 0.06$, $\beta = 0.45$, $\alpha = 0.33$ and $\delta = 0.04$. Where ρ is the rate of time preference, β is the output elasticity of government expenditure, α is the output elasticity of capital and δ is the rate of depreciation. In addition, the tax rates for the economy are $\tau_c = 0.18$, $\tau_i = 0.05$ and $\tau_w = 0.3$, where τ_c, τ_i and τ_w are taxes on consumption, capital and wages respectively.

Figure 2.4: Varying Taxes on Capital Only



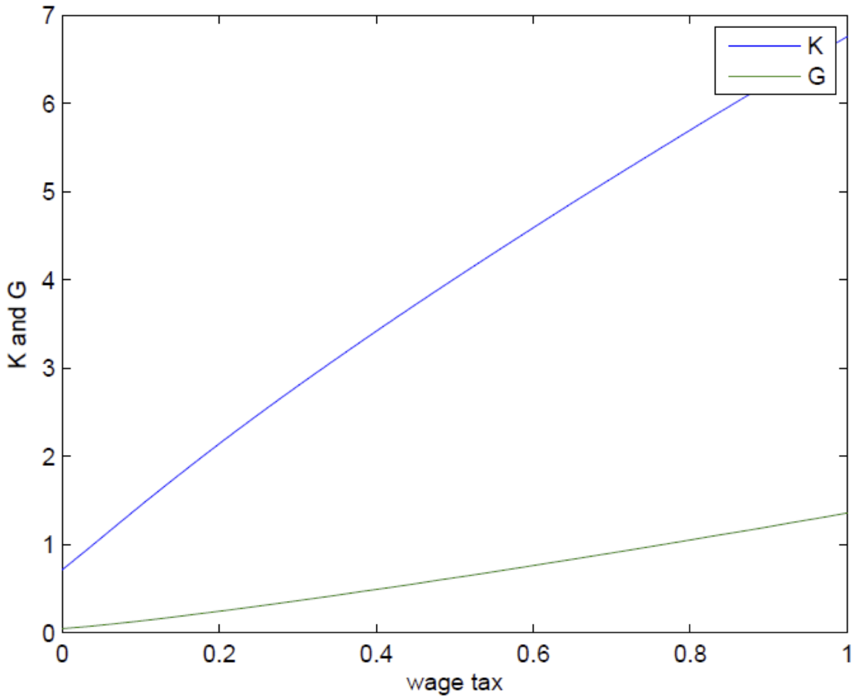
Suppose that the government makes a policy decision to vary taxes on capital, holding taxes on consumption and wages constant. The top diagram above shows the effect of this on the level of capital at steady state, while the bottom diagram shows the effect of this on the level of government revenue at steady state.

With the given rate of time preference, and output elasticity of capital, with an increase in the tax rate of capital, but holding other taxes constant, the net effect is that individuals prefer to consume rather than save and therefore there is a steady decline in the level of capital, the higher the tax rate on capital is. For example, with a zero tax on capital, and with taxes on consumption and wages at 18% and 30% respectively, then the level of capital will be 3. On the other hand, given the same conditions and tax rates, an increase in the rate of taxes on capital to 60% will reduce the level of capital at steady state to just below 1.

Thus at lower capital tax rates, the level of capital at steady state will generally tend to be higher, while at higher tax rates, the level of capital at steady state will be much lower.

On the other hand, increasing the tax rate on capital hardly increases the level of government expenditure, so that a change in the tax rate between 0% to just over 95% does not increase government revenue by more than 1.

Figure 2.5: Varying Taxes On Wages Only

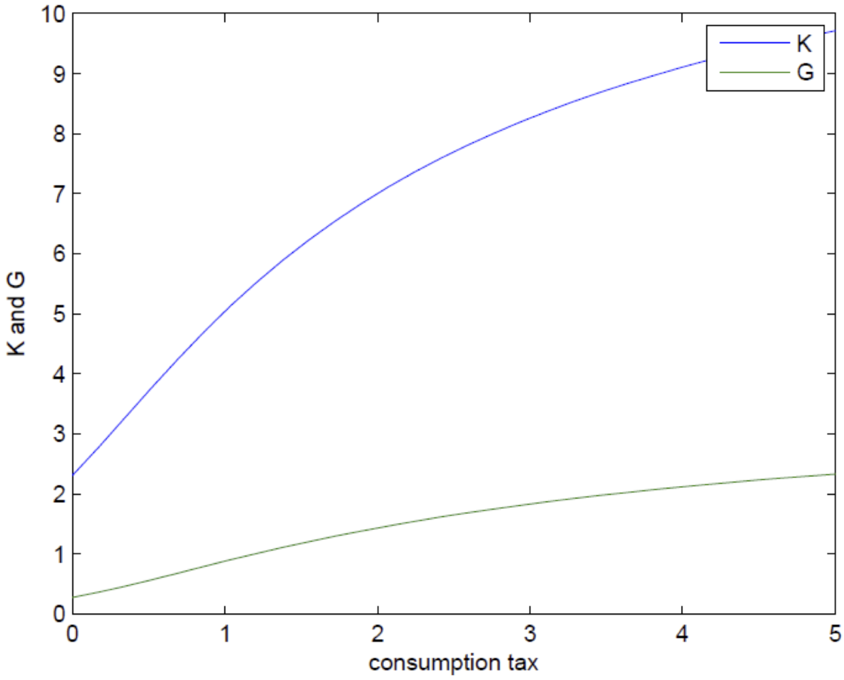


We now look at the case where the government makes the policy decision to vary taxes on wages only, while holding taxes on consumption and capital at 18% and 5% respectively, and given the parameter values as defined above.

From the above diagram, increasing taxes on wages increases the level of capital and government revenue at steady state. However, the level of capital increases faster than the level of government revenue. Given a tax rate on wages of 20%, and given other taxes as mentioned above, then the level of capital will be at 2 at steady state, while that of government revenue will be at 0.2 at steady state. Now suppose the government makes the policy decision to increase the tax rate on wages to 40%, then the level of capital at steady state will now be 3, while the level of government revenue at steady state will be 0.4.

Note that we do not make any assumptions on the household choice of labour supply. Thus from the model, labour supply is inelastic to the tax rate. An increase in tax on wages reduces income and therefore consumption and savings, but also increases marginal productivity of labour so that now for the same wage rate as before, output increases.

Figure 2.6: Varying Taxes on Consumption Only



Finally, we now take a look for the case where government changes policy by varying taxes on consumption, while holding taxes on capital and wages at 5% and 30% respectively.

The government now allows the tax rate on consumption to vary by more than the cost of the consumption good, while holding the other taxes constant. From the diagram above, an increase in the level of capital or government revenue due to increases in the tax rate does not vary both the level of capital and government revenue by much at steady state. With an increase in tax on consumption, given the rate of time preference as 0.06, individuals prefer to consume rather than save, where tax rates are below 100%.

Generally, varying the different taxes while holding the other two constant seems to have a similar effect as when there is only one type of tax collected as revenue.

2.5 Conclusion

The research uses an exogenous neoclassical growth model to analyse the effects of different types of taxes on growth in the long run. Our framework differs from research that has been carried out in this area in the past mainly in three ways.

Firstly, we use an exogenous growth model, where the growth rate is determined by the level of technology which we take as given. One shortcoming of this model is that long run growth depends on the returns to factor inputs, and therefore, for our case where we have decreasing returns, the change in tax policy only affects the growth rate in the transition period. However, there are also some interesting results since in the long run, a change in tax policy still determines the level of income, capital and government revenue. In addition, while previous research such as that of Rebelo (1991) only looks at the effects of changes in taxes, we include productive government expenditure in the production function, and so we can see the trade off between a change in tax policy and the productivity of government expenditure.

Secondly, while past research in this area has tended to look at government expenditure as a stock with congestion effects such as the study of Irmen & Kuehnel (2009), we look at government expenditure as flow variable, which has advantages in terms of the analytics and the effects of changes in taxes on long run levels of capital, income and government expenditure.

Finally, we use the model to analyse Kenya, a developing country, and we are thus able to see some of the policy implications of changes in taxes.

We find that generally, for the case of Kenya, increases in taxes on capital will reduce the level of capital, income and government revenue in the steady state. This is not surprising, since taxes on capital are behavior changing and individuals rather substitute consumption for savings where taxes on capital are high. These results are also found by Rebelo (1991). On the other hand, increasing taxes on wages tends to increase the level of income, capital and government revenue at steady state, while increasing the tax rates on consumption do not seem to change the levels of income, capital and government revenue by very much.

An area for further study could be to include the supply elasticity of labour for Kenya for different tax rates on wages, since from the current model increasing taxes on wages seems to have a rather large increase on the level of income, capital and government revenue in the long run.

2.6 Appendix of Chapter Two

2.6.1 Optimal Factor Allocation - Solution

The current value Hamiltonian will be:

$$H = u\left(C\right) + \lambda\left[K^{\alpha}AL^{1-\alpha} - C - \delta K\right]$$

2.6.1.1 First Order Conditions

The first order conditions that $\frac{\partial J}{\partial C}$ is equal to zero, and the co state condition $\dot{\lambda} = -\frac{\partial J}{\partial K}$ will be:

$$u'\left(C\right) = \lambda \tag{2.18}$$

and

$$\dot{\lambda} = -\lambda\left[\alpha A\left(\frac{K}{L}\right)^{-(1-\alpha)} + \delta\right] \tag{2.19}$$

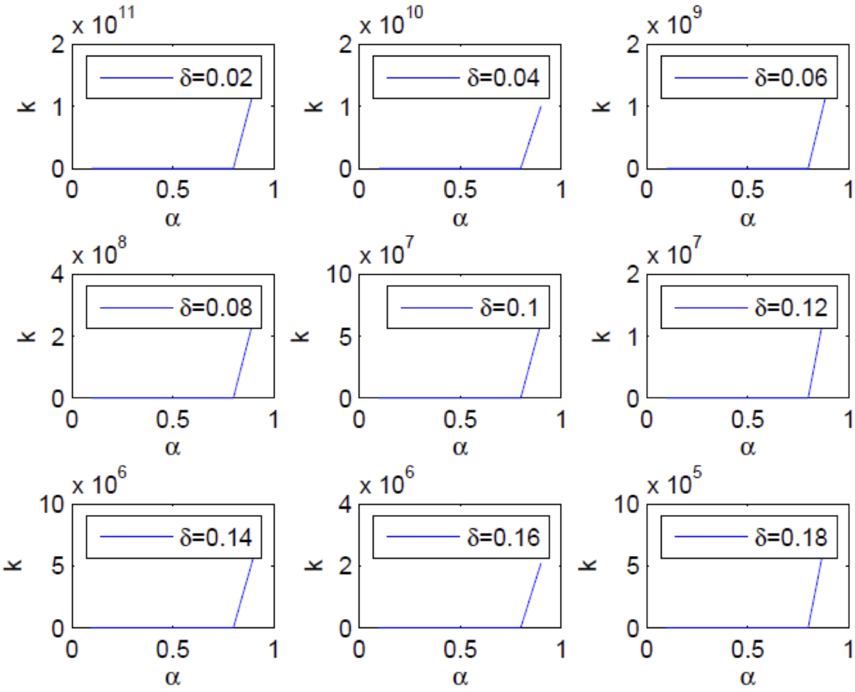
2.6.1.2 Reduced Form Equations

Setting the derivative of K and the time derivative C to zero, and if we set technology and labour to one, we can derive the values of K and C at steady state as:

$$\dot{K} = AK^{\alpha}L^{1-\alpha} - C - \delta K = 0 \tag{2.20}$$

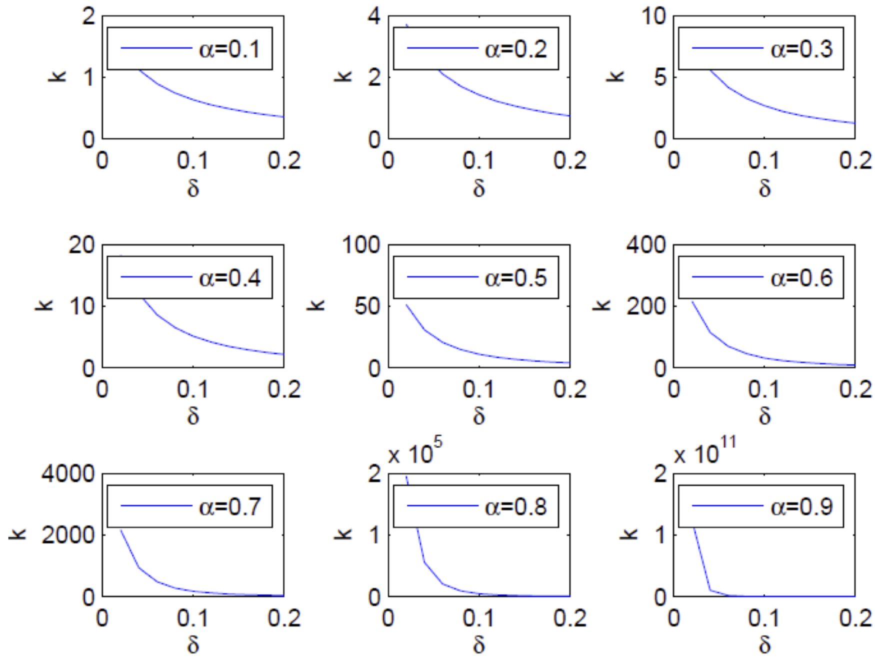
$$\frac{\dot{C}}{C} = \frac{1}{\theta}\left(\alpha A\left(\frac{K}{L}\right)^{-(1-\alpha)} - \delta - \rho\right) = 0 \tag{2.21}$$

Figure 2.7: Numerical Analysis of K and α



The above graph shows the numerical analysis of the relationship between the level capital (K) and it's elasticity (α)at different levels of depreciation (δ). The production function assumes a Cobb-Douglas technology with α of between 0.1 and 0.9. The depreciation rate is also taken to be between 0 and 0.2, with each curve assuming a different depreciation rate. We assume a constant time preference rate of 5%. From the above graphs, the higher the depreciation rate, the more capital is required in the production process and therefore the lesser the level of capital.

Figure 2.8: Numerical Analysis of K and δ



The figure above shows the relationship between level of capital, K, and the depreciation rate δ. Again, the production function assumes a Cobb-Douglas technology with α of between 0.1 and 0.9. The depreciation rate is also taken to be between 0 and 0.2, with each curve assuming a different rate for the elasticity of capital. We also assume a constant time preference rate of 5%. From the above, at lower levels of elasticity, and lower levels of depreciation, less capital is required in the production process.

2.6.2 The Model With Taxes

The current value Hamiltonians will be:

$$H = u\left(C\right) + \lambda\left[K^{\alpha}G^{\beta}AL^{1-\alpha-\beta} - C - G - \delta K\right]$$

2.6.2.1 First Order Conditions

The first order conditions that $\frac{\partial J}{\partial C}$ is equal to zero, and the co state condition $\dot{\lambda} = -\frac{\partial J}{\partial K}$ will be:

$$u'(C) = \lambda \tag{2.22}$$

and

$$\dot{\lambda} = -\lambda \left[\alpha A (1 - \tau_i) \left(\frac{K}{L} \right)^{-(1-\alpha)} \left(\frac{G}{L} \right)^{\beta} + \delta \right] \tag{2.23}$$

2.6.2.2 Reduced Form Equations

We can now Set the time derivative of K and C to zero, and if we set labour to one, and taking into account the government constraint, we can derive the values of K, C and G at steady state as:

$$\frac{\dot{K}}{K} = \left(\frac{K}{L} \right)^{-(1-\alpha)} \left(\frac{G}{L} \right)^{\beta} A - \frac{C}{K} - \frac{G}{K} - \delta = 0 \tag{2.24}$$

$$\frac{\dot{C}}{C} = \frac{1}{\theta} \left(\alpha A (1 - \tau_i) \left(\frac{K}{L} \right)^{-(1-\alpha)} \left(\frac{G}{L} \right)^{\beta} - \delta - \rho \right) = 0 \tag{2.25}$$

$$G = \tau_w w L + \tau_c C + \tau_i r K \tag{2.26}$$

3 Growth Effects of the Allocation of Government Expenditure in An Endogenous Growth Model

3.1 Introduction

Background - About eight years ago, the government of Kenya began the implementation of Vision 2030, an economic blueprint that is meant to get the country to middle income status by the year 2030. In order for the country to achieve middle income status, it needs to grow at a rate of 10% per annum until the year 2030. While the government has identified several areas from where growth could be attained, the question arises, given its limited resources, what is the most efficient allocation of these resources that will help it achieve the targeted growth. Government fiscal policy would therefore play an important role, and therefore so does the allocation of government spending.

This phenomenon is not unique to Kenya, in fact many governments, developing and developed alike, are faced with the question of how best to allocate the given limited resources in order to achieve maximum growth. The allocation of government expenditure is thus not a new topic, and has been the subject of a lot of debate in the literature. The debate has taken two strands, with one strand looking at long-run growth effects of government expenditure on recurrent and non recurrent expenditure such as the study of Devarajan *et al.* (1996), while the other strand looks at the growth effects of the allocation of government expenditure between infrastructure on the one hand and expenditure on the social sector such as education and health on the other such as the study of Agenor & Neanidis (2011). It has been argued that not only can the right allocation of government expenditure have growth enhancing effects, but that this growth could also be inclusive and poverty reducing, thereby raising incomes for the poor.

The open question - This research therefore asks the question; does the allocation of government expenditure matter for economic growth? The research answers this question in a setting with an endogenous growth model, where we distinguish between physical and human capital in a two sector set up.

Our message - Government Expenditure is important for the provision of public goods. Public goods are goods that have the properties of non- rivalry and non-excludability, which make it difficult for the private sector to provide these goods due to lack of an efficient pricing mechanism. However, these goods are also still considered necessary for the smooth flow of an economy, and therefore the government's role in the provision of public goods is very important. Consequently, it is very important that the government allocate resources as efficiently as possible so as to maximise growth, thereby increasing income and possibly also reducing poverty levels.

Our framework - To carry out the analysis of government policy on economic growth, we propose an endogenous model with physical and human capital such as the Uzawa-Lucas model. We then combine this model with the Barro (1990) model of government expenditure in an endogenous growth model. Our point of departure from Barro (1990); Rebelo (1991); Turnovsky & Fisher (1995) is that we then analyse the sectoral optimal allocation of government expenditure much like Devarajan *et al.* (1996) and Agenor & Neanidis (2011). However, while Devarajan *et al.* (1996) use a CES production function to analyse the allocation of government expenditure, this research uses a two sector approach.[1] This is similar to Agenor & Neanidis (2011) who also carry out a sectoral analysis, but rather look at human capital as consisting of health and education sectors, where health has an effect on the human capital.[2]

Results - The research finds that there is an optimal allocation of government expenditure. Where the allocation of government expenditure is optimal, then the marginal productivity of government spending is the same for both sectors. At this point, marginal productivity for the shares of human capital in both the human capital sector and the production of goods sector is the same and in addition, the marginal productivity of human capital and physical capital is the same. The margin productivity of physical and human capital is also the economy's interest rate. Growth rate in the long run is thus the same for human capital, physical capital, consumption and income.

[1] Devarajan *et al.* (1996) look at two types of government spending, that is, productive and non productive in a one sector model with a CES production function.

[2] In the framework of Agenor & Neanidis (2011) government expenditure is allocated between the production of goods sector, human capital sector and the health sector. Health impacts human capital and human capital is a factor of production in the goods sector. In addition, government spending on infrastructure is important for all three sectors.

Further related literature - In his seminal paper, Aschauer (1989) looks at the growth effects of productive government expenditure in a framework where government expenditure has an effect on productivity in the economy. Testing for this empirically, he finds that non military government expenditure stocks are indeed important for productivity. Following this research on government expenditure and productivity, came the debate on the effect of government expenditure and economic growth. Barro (1990) looks at the growth effects of government expenditure in an endogenous growth model and finds that there is indeed an optimal level of government expenditure.

Since the Barro (1990) research, several research has looked at the effects of government expenditure on economic growth in an Ak (one sector) endogenous growth framework (Rebelo (1991); Futagami *et al.* (1993); Turnovsky & Fisher (1995); Turnovsky (1997); Gomez (2004, 2008)). Some of this work has extended the Barro (1990) model to include government expenditure as a stock with congestion (Futagami *et al.* (1993); Turnovsky (1997); Glomm & Ravikumar (1994, 1997); Gomez (2004, 2008)). Gomez (2008) extends the Ak framework to include physical and human capital, in a model where investment on public capital is irreversible and includes congestion.

A second strand of literature that looks at the growth effects of government expenditure, looks specifically at the allocation of government expenditure on economic growth (Devarajan *et al.* (1996) and Agenor & Neanidis (2011)). This is perhaps a combination of the Aschauer (1989) and Barro (1990) research.

Devarajan *et al.* (1996), using a one sector endogenous growth framework, introduce two types of government expenditure, that is, productive and non-productive. They then use a CES production function to analyse the growth effects of the allocation of government expenditure between productive and non-productive sectors. They find that allocation of government spending matters and that government spending on the productive sector is only productive up to a certain point after which productivity declines.

Agenor & Neanidis (2011) also analyse the growth effects of the allocation of government spending in a multiple sector framework, which includes the production of goods sector, education and health sectors. They split government spending into spending on infrastructure, education and health. They point out the externalities associated with shifts in government spending between sectors, where revenue is held constant.

This research develops a model with physical and human capital. However, unlike the Agenor & Neanidis (2011) framework, we do not split the effects of human capital. In addition, we follow the Uzawa-Lucas model, where we assume a human capital intensive sector in the production of human Capital. Our similarity with Agenor & Neanidis (2011) is with government expenditure that is split between the two sectors.

Table of contents - The rest of this research is organised as follows; in the following section, we look at the text book Uzawa Lucas model of physical and human capital. The set up of this model is in a closed economy with no government. In section three, we expand the model from section two by introducing government policy, thereby combining the Uzawa Lucas and the Barro (1990) model of government spending in an endogenous growth model. The model will incorporate two types of government expenditure, that is spending on infrastructure and spending on education. Section four analyses the long-run growth effects of changes in the allocation of government expenditure keeping government revenue constant, and then looks at an application of the model to the Kenyan economy. Section five concludes.

3.2 An Endogenous Growth Model with Physical and Human Capital

We begin with an endogenous growth model. This model follows the Uzawa-Lucas model of human capital. We follow the analysis as is done by Barro & i Martin (2004).[3]

3.2.1 Household Preferences

The model assumes homogenous households with the same preferences, perfect capital markets and perfect foresight. Households begin with the same level of assets. From these assumptions, we can therefore derive equilibrium from a single representative household. The objective function is thus:

$$U = \int_0^\infty u(c)e^{-\rho t}dt \tag{3.1}$$

The function above assumes that total utility facing a household at time zero is the weighted sum of all future utility. ρ is the rate of time preference and is assumed to be $\rho > 0$. The instantaneous utility function satisfies the inada conditions and is assumed

[3]Barro & i Martin (2004) carry out an analysis of the Uzawa Lucas Model. This can be found in pp.251-252, and 274-276. Section 3.2 above therefore follows this analysis as is shown in their textbook "Economic Growth".

to be concave, that is, consumption of private goods are assumed to be such as those of normal goods. We take the utility function to be of the isoelastic form as below:

$$u(c) = \frac{c^{1-\theta} - 1}{1 - \theta} \tag{3.2}$$

Households are faced with the following budget constraint:

$$\dot{a} = w + ra - c \tag{3.3}$$

Where a is the assets per household, w is the wage income per household, and r is the interest rate, or rate of return on assets.

3.2.2 Production of Goods

Physical capital, K, Human capital H, and technology, A, are used in the production of aggregate output. A fraction of labour z, is used to produce goods in this sector. Following the Uzawa-Lucas model, H is assumed to derive from the total number of workers multiplied by the total human capital per worker, where the two, human capital per worker and total number of workers, are perfect substitutes. Assuming a Cobb-Douglas production technology, we can express the production function as below:

$$Y = AK^{\alpha} (zH)^{1-\alpha} \tag{3.4}$$

where $0 < \alpha < 1$, and α is the share of physical capital in output.

3.2.3 The Human Capital Sector

Human capital is produced using technology B, and the share of human capital that is not used up in the production sector, $1 - z$. This sector is human capital intensive and therefore does not use up any form of physical capital.

$$\dot{H} = B[(1 - z) H] - \delta H \tag{3.5}$$

3.2.4 The Planner's Solution

The resource accumulation constraint can be expressed as:

$$\dot{K} = AK^{\alpha}\left(zH\right)^{1-\alpha} - C - \delta K \tag{3.6}$$

In solving for the Planner's solution, we begin by inserting equation (3.2) into equation (3.1). The Current-value Hamiltonian can be expressed, using equation (3.4) and equation (3.5) as:

$$\begin{aligned} J = u\left(C\right) + \nu\left[AK^{\alpha}\left(zH\right)^{1-\alpha} - C - \delta K\right] \\ +\mu\left[B\left[\left(1-z\right)H\right] - \delta H\right] \end{aligned} \tag{3.7}$$

ν and μ are the co-state variables associated with the constraints in equation (3.5) and (3.6). Given the optimality conditions, following from the first order condition that $\frac{\partial J}{\partial C} = 0$ and the co-state condition $\dot{\nu} = -\frac{\partial J}{\partial K}$, and given the transversality condition $lim_{t\to\infty}\nu Kexp - \rho t = 0$, the growth rate of consumption will be (see Appendix for workings of the optimality conditions):

$$\frac{\dot{C}}{C} = \frac{1}{\theta}\left(A\alpha\left(\frac{K}{zH}\right)^{-(1-\alpha)} - \delta - \rho\right) \tag{3.8}$$

The expression $\left(A\alpha\left(\frac{K}{zH}\right)^{-(1-\alpha)} - \delta\right)$is also the net marginal product of capital net of depreciation, and is equal to the rate of return r. If the net marginal product exceeds the rate of time preferences, then the growth rate of consumption is positive. The net marginal product of capital depends on capital and the share of human capital in the production sector.

The expression below follows from the first order conditions that $\frac{\partial J}{\partial z}$ are equal to zero (see appendix equation (3.43)):

$$\frac{\mu}{\nu} = \frac{AK^{\alpha}\left(zH\right)^{-\alpha}\left(1-\alpha\right)}{B} \tag{3.9}$$

Equation (3.9) is an expression of the shadow price of human capital. It captures the idea that the marginal product of human capital is the same for both the goods production sector as well as the human capital sector. Using the the shadow price of human capital and the condition that $\dot{\mu} = -\frac{\partial J}{\partial H}$, we get the growth rate of a change in human capital to be (see workings in the appendix, also follows Barro & i Martin (2004)):

$$\frac{\dot{\mu}}{\mu} = -B + \delta \tag{3.10}$$

3.2.5 Reduced Form Equations

From the resource accumulation constraint and the change in capital equations, we can get the growth rates of capital and human capital as:

$$\frac{\dot{K}}{K} = Az^{(1-\alpha)} \left(\frac{K}{H}\right)^{-(1-\alpha)} - \frac{C}{K} - \delta \tag{3.11}$$

and

$$\frac{\dot{H}}{H} = B\left(1 - z\right) - \delta \tag{3.12}$$

Differentiating the first order condition that $\frac{\partial J}{\partial z} = 0$ with respect to time and inserting equations (3.9), (3.10), (3.11) and (3.12) gives us the growth rate of z as below (See Appendix for workings):

$$\frac{\dot{z}}{z} = \frac{(1-\alpha)\,B}{\alpha} + Bz - \frac{C}{K} \tag{3.13}$$

We follow Barro & i Martin (2004), we define the following ratios; $\chi = \frac{C}{K}$ and $\omega = \frac{K}{H}$. χ, ω and $\frac{\dot{z}}{z}$ give us a system of equations, for which the growth rate at steady state will be equal to zero. Solving for this will give the following values at steady state, where the state variable ω will begin at some value $\omega\,(0)$(complete workings are in Appendix A):

$$\omega = \left(\alpha\frac{A}{B}\right)^{\frac{1}{1-\alpha}} \frac{\theta - 1}{\theta} + \frac{\delta\,(1-\theta) + \rho}{B\theta} \tag{3.14}$$

$$\chi = B\left(\frac{1}{\alpha} - \frac{1}{\theta}\right) + \frac{\delta\,(1-\theta) + \rho}{\theta} \tag{3.15}$$

$$z = \frac{\theta - 1}{\theta} + \frac{\delta\,(1-\theta) + \rho}{B\theta} \tag{3.16}$$

3.2.6 Balanced Growth Path

We can now derive the reduced form growth rate of capital and human capital in the long run by inserting equations (3.14), (3.15) and (3.16) above into equation (3.11) and (3.12):

$$\frac{\dot{K}}{K} = \frac{\dot{H}}{H} = \frac{1}{\theta}(B - \delta - \rho) \tag{3.17}$$

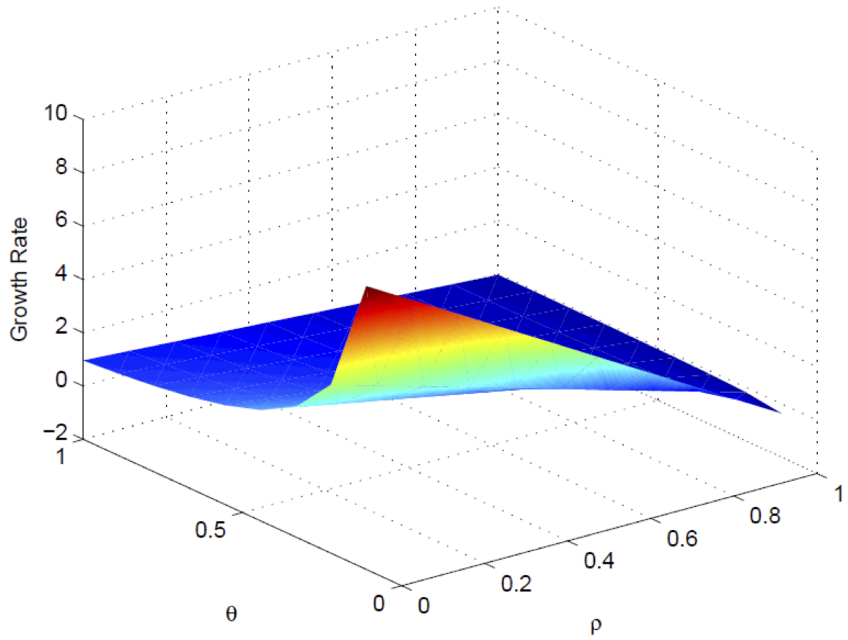
When we solve for the growth rate of output and consumption, we get the growth rates as below:

$$\frac{\dot{Y}}{Y} = \frac{\dot{C}}{C} = \frac{1}{\theta}(B - \delta - \rho) \tag{3.18}$$

The expression $(B - \delta)$is the net marginal product of capital at steady state. This is also the rate of interest or the price of investment. This expression is equal to the marginal product of human capital, which means that at steady state, the marginal product of capital and human capital, as well as the interest rate must be the same. In the long run therefore, the growth rate of output, consumption, capital and human capital, as shown in equations (3.17) and (3.18) will be the same.

The diagram below represents the growth rate at Balanced Growth Path.

Figure 3.1: A Graphical Presentation of the Balanced Growth Path



The growth rate depends on θ and ρ, which are the elasticity of substitution and the rate of time preference respectively. A large θ means individuals are less willing to give up consumption today for more consumption tomorrow, and therefore save less, while the opposite is the case for a small θ. A high ρ means that consumption today is preferred to consumption tomorrow, and therefore reduces the consumption growth rate.

From Figure (3.1) above, we begin with a rate of time preference of 0.01, and at this rate, with a low elasticity of substitution, here also 0.01, then individuals are more willing to save, and give up consumption today for consumption tomorrow. The growth rate is therefore high. However, where the rate of time preference is high and the elasticity of substitution is large, then the growth rate in the Balanced growth path is low, as is shown in the diagram above. On the other hand, where elasticity of substitution is low and the rate of time preference is high, then the growth rate is much lower than if the opposite were the case, that is, if the elasticity of substitution is high and the rate of time preference is low. In this case, preference for consumption today is higher than the preference for consumption tomorrow.

3.3 Endogenous Growth with Government Policy - Composition of Government Expenditure

The government operates a balanced budget, that is, its expenditure is equal to revenue collected. The revenue is obtained through a flat rate tax on output. The government spends part of its revenue on the education sector and the invests the rest in public capital, which is used in the production sector. Government therefore has the following constraint:

$$G = vG + (1 - v)\,G \tag{3.19}$$

and

$$G = \tau Y$$

where $\tau \in (0, 1)$

3.3.1 The Production of Goods

In addition to physical capital, K, human capital H, and technology, A, government public investment G, is now also used in the production of aggregate output. Like in the previous section, a fraction of labour z, is used to produce goods in this sector, where H is assumed to derive from the total number of workers multiplied by the total human capital per worker, where the two, human capital per worker and total number of workers, are perfect substitutes. A fraction of government expenditure v is used for public capital in the production sector. Assuming a Cobb-Douglas production technology, the production function can be expressed as:

$$Y = AK^{\alpha} (vG)^{\beta} (zH)^{1-\alpha-\beta} \tag{3.20}$$

We assume constant returns to scale to factors of production, where $\alpha, \beta \in (0, 1)$

3.3.2 Human Capital Sector

Technology B, and the share of human capital that is not used up in the production sector, $1-z$, as well as the share of government expenditure not used up in the production sector $1 - v$ are used in the production of human capital. Government spending in this sector includes spending on materials that are used in the production of human capital such as books. The human capital production function can be expressed as:

$$\dot{H} = B \left[(1-z) H\right]^{1-\eta} \left[(1-v) G\right]^{\eta} - \delta H \tag{3.21}$$

Like in the production sector, we assume constant returns to scale to factor inputs, $\eta \in (0, 1)$

3.3.3 Welfare Maximising Equilibrium - A Planner Approach

The resource accumulation constraint can be expressed by equation (3.21) and the equation below:

$$\dot{K} = AK^{\alpha} (vG)^{\beta} (zH)^{1-\alpha-\beta} - C - G - \delta K \tag{3.22}$$

Taking into account equation (3.1), (3.2), (3.21) and (3.22), the current value Hamiltonian can be expressed as:

$$\begin{aligned} J = u\left(C\right) + \nu \left[AK^{\alpha}\left(vG\right)^{\beta}\left(zH\right)^{1-\alpha-\beta} - C - G - \delta K\right] \\ +\mu\left[B\left[\left(1-z\right)H\right]^{1-\eta}\left[\left(1-v\right)G\right]^{\eta} - \delta H\right] \end{aligned} \tag{3.23}$$

We then assume a Planner who has complete information and therefore maximises the consumer's lifetime utility by selecting C, z and v, with ν and μbeing the co-state variables associated with equations (3.21) and (3.22) respectively. The first order optimality conditions for z and v are presented in the appendix in equation (3.54) and (3.55). From equation (3.54) we derive the shadow price of human capital as below:

$$\frac{\mu}{\nu} = \frac{\left(1-\alpha-\beta\right)AK^{\alpha}\left(vG\right)^{\beta}\left(Hz\right)^{-\alpha-\beta}}{\left(1-\eta\right)B\left[\left(1-z\right)H\right]^{-\eta}\left[\left(1-v\right)G\right]^{\eta}} \tag{3.24}$$

The shadow price of human capital shows that the marginal product of human capital must be the same in both the human capital sector and the goods sector. Inserting the shadow price of human capital into the first order optimality condition for v leads to the following condition:

$$\frac{z}{1-z}\frac{\beta}{1-\alpha-\beta} = \frac{\eta}{1-\eta}\frac{v}{\left(1-v\right)} \tag{3.25}$$

Equation (3.25) is the condition derived by taking into account the shadow price of human capital in equation (3.24) which implies that the marginal product of human capital must be the same in both the goods sector and the human capital sector. In addition, the above condition implies that the marginal product of government expenditure must be the same for the two sectors, and that the share of government expenditure, and the share of human capital in both sectors are positively related, so that given β and η, then an increase in output can only be achieved by increasing both z and v (Barro & i Martin (2004)).

This implies therefore, that at the point where marginal productivity for human capital and for government expenditure are the same in both the human capital and the goods production sector, then the ratio of government expenditure to human capital must be equal to 1, since increasing one of these factor inputs without increasing the other has no effect on output.

With this in mind, the growth rates of the co state conditions ν and μ, as well as the growth rates of consumption, C, capital, K, human capital, H, as well as the growth rate of z can now give us a system of equations from which we can solve for the optimal Balanced Growth Path. Note that the value of z in the Balanced Growth Path is proportional to the value of v, which means that we can determine the value of v explicitly in the Balanced Growth Path. The growth rates are as shown in the appendix, equations (3.59), (3.60), (3.61), (3.62), (3.63) and (3.64).

As with the Uzawa-Lucas model, we define the values $\omega = \frac{K}{H}$ and $\chi = \frac{C}{K}$. Where we set the state variable $\omega(0) = \omega_0$, and the steady state growth rates of ω, χ, and z as equal to zero, together with the transversality condition that $lim_{t \to \infty} \nu K exp - \rho t = 0$, then the steady state values of ω, χ and z are as given in the appendix, equations (3.65), (3.66) and (3.67). Inserting these steady state values into the growth rates of income, capital, consumption and human capital give us the growth rates of income, capital, consumption and human capital in the Balanced Growth Path as below:

$$\frac{\dot{Y}}{Y} = \frac{\dot{C}}{C} = \frac{\dot{K}}{K} = \frac{\dot{H}}{H} = \frac{1}{\theta}(B - \delta - \rho) \tag{3.26}$$

Equation (3.26) gives us the optimal Balanced Growth Path growth rate of income, consumption, capital and human capital, in an economy with government policy. Note that the growth rate is the same as the growth in equation 3.17 and equation 3.18. At this growth rate, the marginal productivity for human capital is the same for both the human capital and production of goods sector, and the same is the case for the marginal productivity of government expenditure. This implies that government spending is efficient, that is, the government reallocates resources where they are most needed as seen through the marginal productivity of capital. The Balanced Growth Path depends positively on B, which is the technology of human capital, depends inversely on θ, the elasticity of substitution, and negatively on ρ, the rate of time preference.

As in Barro (1990), we note that in a centrally planned economy such as the one defined above, this growth rate is also Pareto Optimal. In a market economy, price is the main resource allocation mechanism, and therefore individuals who are willing and able to pay will benefit. The allocation of resources is therefore not always going to be efficient in a market economy as price may not always be a good determinant of efficiency.

The value $(B - \delta)$ is also the economy's interest rate, since this is the marginal product for physical and human capital. The marginal product for physical and human capital must be the same in the long run.

3.4 Long Run Effects of Changes in Government Policy

In this section, we proceed by analysing the steady state effects of changes in government expenditure. In this case, government revenue does not change, rather, instead there is a change from one type of spending to another. We will begin by analysing the steady state effects of a change in government expenditure from human capital sector to the production of goods sector, after which we will proceed to look at the steady state effects of a change in government expenditure from production of goods sector to human capital sector.

3.4.1 An Increase in Government Spending in the Production of Goods Sector

Suppose that the government makes a decision to shift expenditure from the human capital sector to the production of goods sector. Since government revenue remains the same, an increase in the share of government spending on the goods sector can only be achieved by a decrease in the share of government spending on the human capital sector. This is illustrated below:

$$\partial v = -\partial (1 - v)$$

There are two major implications for this shift:

1. *From the condition in equation (3.25), the implication is that the ratio of the share of government expenditure to the share of human capital in the human capital sector is now less than one as expressed below*

$$\frac{1 - v}{1 - z} \leq 1 \tag{3.27}$$

2. *However, from the same condition, increasing the share of government expenditure in the production of goods sector without increasing other factor inputs, does not*

increase output. Therefore, the ratio of the share of government expenditure to the share of human capital that is useful in the production sector remains 1, without any growth in production

$$\frac{v}{z} \equiv 1 \tag{3.28}$$

Equation (3.28) is a transversality condition and sets an upper bound on the growth rate of income. Taking the implications from equations (3.27) and (3.28) above into account, we can now rewrite the economy resource accumulation constraint, and the change in human capital as below:

$$\dot{K} = Az^{1-\alpha}\left(\frac{K}{H}\right)^{\alpha} - C - G - \delta K \tag{3.29}$$

and

$$\dot{H} = B\left[(1-z)\,H\right]^{1-\eta}\left[(1-v)\,G\right]^{\eta} - \delta H \tag{3.30}$$

Note that while the equation for change in human capital (3.30) appears not to change, the values of $(1-z)$ and $(1-v)$are not optimally chosen since v is now lower than it would be at optimal levels. Thus, the new value v is as represented below:

$$v^{\star} = v + v * (\partial v)$$

From the above two equations, we can now rewrite the Hamiltonians (Appendix, equation (3.68)).The system of equations for our analysis, that is, the growth rate of the co state conditions for capital and human capital ν and μ, the growth rate of capital, human capital and consumption are as expressed in the appendix equations (3.69), (3.70), (3.71), (3.72) and (3.73). From the appendix we see that the system can be reduced into a system of two equations for ω and χ. Solving for the values of ω and χ and inserting these values into the growth rates of capital, human capital, consumption and income give us the Balanced Growth Path of capital, human capital, consumption and income as below:

$$\frac{\dot{Y}}{Y} = \frac{\dot{C}}{C} = B\,(1-z)^{1-\eta}\,(1-v^{\star})^{\eta} - \delta \tag{3.31}$$

and

$$\frac{\dot{K}}{K} = \frac{\dot{H}}{H} = B\left(1-z\right)^{1-\eta}\left(1-v^{\star}\right)^{\eta} - \delta \tag{3.32}$$

The growth rate of income, consumption and capital is now the same as the growth rate of human capital. The growth rate depends on technology, B, the share of human capital in the human capital sector $(1-z)$, and the share of government expenditure in the human capital sector $(1-v^{\star})$.

Intuitively, production of output depends on capital, human capital and government expenditure, and we assume constant returns to factors of production. Output therefore increases with an increase to all factor inputs. For the case above, where government reduces spending on the human capital sector, and assuming constant returns to factors in the human capital sector as well, then change in human capital declines by the amount of decline in government expenditure, that is, $-\partial v$. The growth rate of human capital is now lower than it was before. The marginal productivity of all factor inputs in the human capital sector increases.

This lower growth rate is now carried to the production of goods sector, since the factor input, human capital, is much lower. Therefore, output and capital also decline by the rate of decline of government spending.

Note that $B\left(1-z\right)^{1-\eta}\left(1-v^{\star}\right)^{\eta} - \delta$ is also the marginal product of physical and human capital in both sectors. In the long run, the marginal product is the same for both physical and human capital and is also equal to the economy interest rate or reward to physical capital.

This results support the finding of Devarajan *et al.* (1996) who find that increasing government expenditure on what is considered productive spending such as infrastructure, is only beneficial up to a given point, after which spending is better shifted to non-productive sectors such as government spending on consumption.

3.4.2 An Increase in Government Spending in the Human Capital Sector

Now let us look at a scenario where government increases spending on the human capital sector, holding revenue constant. As with the previous section, increasing spending on the human capital sector means a similar decline in spending on the production of goods sector. This can be illustrated below:

$$\partial (1 - v) = -\partial v \tag{3.33}$$

Similarly, as with the section above, there will be two major implications:

1. *The condition in equation (3.25) implies that the ratio of government spending to human capital in the production sector is now less than one as illustrated below:*

$$\frac{v}{z} \leq 1 \tag{3.34}$$

2. *The share of government spending to human capital in the human capital sector remains equal to one, since an increase in government spending on human capital does not increase the growth rate of human capital unless there is a corresponding increase in the share of human capital. This is illustrated below:*

$$\frac{1 - v}{1 - z} = 1 \tag{3.35}$$

Note that v now decreases by the amount $-\partial v$. v is now no longer optimal and can be expressed below:

$$v^{\star} = v - v * \partial v$$

Equation (3.35) is a transversality condition that bounds the growth rate of human capital, so that even with an increase in the share of government spending in the human capital sector, it is not possible for human capital to grow to infinity. Thus human capital only increases with an increase in both factors of production in the human capital sector.

Based on this, the new resource accumulation constraint and equation for growth rate of human capital will be:

$$\dot{K} = Az^{1-\alpha} \left(\frac{K}{H}\right)^{\alpha} \left(\frac{v^{\star}G}{zH}\right)^{\beta} - C - G - \delta K \tag{3.36}$$

and

$$\dot{H} = B (1 - z) H - \delta H \tag{3.37}$$

Equations (3.36) and (3.37) will give us the new Hamiltonians (Appendix equation (3.76)). From the hamiltonians, we can now compute the growth rates which give us the system of equations from which we can solve the optimality conditions. Equations (3.77), (3.78), (3.79), (3.80) and (3.81) in the appendix give us the growth rates of capital, human capital, consumption and the growth rates of the co state conditions for the equations for the change in capital and human capital.

Reducing the system into two equations for χ and ω, solving for these and inserting them into the growth rates of income, consumption, capital and human capital give us the following growth rates in the Balanced Growth Path:

$$\frac{\dot{K}}{K} = \frac{\dot{H}}{H} = B\left(1 - z\right) - \delta \tag{3.38}$$

and

$$\frac{\dot{Y}}{Y} = \frac{\dot{C}}{C} = B\left(1 - z\right) - \delta \tag{3.39}$$

Equations (3.38) and (3.39) give us the growth rates of capital, human capital, income and consumption in the Balanced Growth path. The growth rate depends on B, the technology used in the human capital sector as well as z, the share of human capital used in the human capital sector. A larger z, which is the share of human capital in the production of goods sector, will reduce the growth rate in the Balanced Growth Path. However, the increase is bound by the transversality condition in equation (3.34) so that z can only increase by the proportion by which government expenditure increased in the human capital sector. Government spending in the human capital sector must therefore decrease, given the condition in equation (3.34) to achieve optimal growth in the Balanced Growth Path

$B\left(1 - z\right) - \delta$ is the marginal productivity of human capital as well as the marginal productivity of physical capital. From equations (3.38) and (3.39) above, the marginal productivity for physical and human capital must be the same in the long run. This is also the interest rate for capital in the economy.

3.4.3 An Application of Government Policy

In this section, we show the effects of changes in the share of government expenditure by setting the shares of human capital and government expenditure in both sectors as exogenous rather than endogenously determined. In doing so, we first solve for the growth rates in the Balanced Growth Path. From the Appendix section (3.6.5), the growth rates of capital, human capital, consumption and income are the same and are equal to:

$$\frac{\dot{Y}}{Y} = \frac{\dot{C}}{C} = B\left(1 - z\right)^{1-\eta}\left(1 - v\right)^{\eta} - \delta \tag{3.40}$$

and

$$\frac{\dot{K}}{K} = \frac{\dot{H}}{H} = B\left(1 - z\right)^{1-\eta}\left(1 - v\right)^{\eta} - \delta \tag{3.41}$$

Equation (3.40) and (3.41) above are the equations for growth in the Balanced Growth Path, where the share of human capital and the share of government expenditure are exogenously determined. The model parameters are B, which is the technology parameter in the human capital sector, η, which is the output parameter for government expenditure in the human capital sector, δ, the depreciation rate, z, the share of human capital in the production of goods sector and v, the share of government expenditure in the production of goods sector.

For the parameters we use Kenya country statistics from the Kenya Economic Survey (of Statistics (2009-15)). We select $\eta = 0.27$ and $\delta = 0.04$. The choice of η is based on the of Public Expenditure for Economic Development (2013) data, which shows that Kenya has a total government expenditure to GDP ratio of 0.27. Following the Barro (1990) model, the optimal government expenditure is that where the share of government spending to income is also the same as the output elasticity of government expenditure. Since $(B - \delta) = r$, which is the interest rate, and the interest rate for Kenya is at 11% as per the current Central Bank interest rate, then we calculate $B = 0.15$.

From the data in the Kenya Economic Survey (of Statistics (2009-15)), government spending on development expenditure is 2.1 times that of government spending on the education sector. We thus take a $v^{\star} = 0.67$.

The data on labour in the various sectors for Kenya shows that formal employment in education sector was 1.8 times more than formal employment in the category "professional, scientific and technical". This is in line with the model's assumption that the education sector is human capital intensive.From this, we take the $z^{\star} = 0.35$. $v^{\star}$ and $z^{\star}$ indicate that these are exogenously determined and are not necessarily the optimal shares.

Figure 3.2: Changing Government Policy

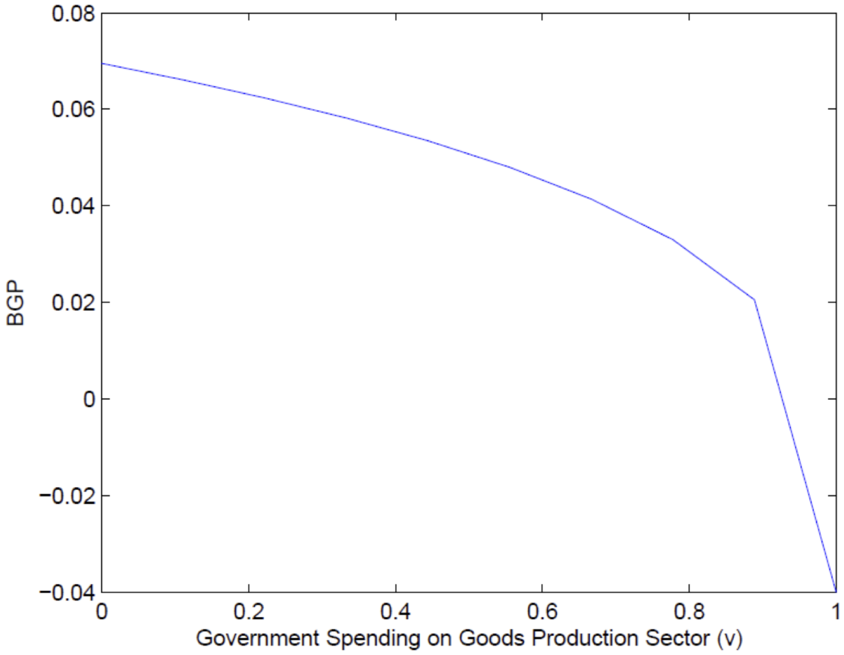


Figure (3.2) above shows how changes in government policy might affect growth rates in the long run.

At $v = 0.67$, the long run growth rate is 0.042, given a $z = 0.35$ and $\eta = 0.27$. A reduction in v, that is, an increase in government spending on human capital sector, could increase growth in the long run, given the parameter values above. In the case of Kenya, therefore, the government would need to increase spending on the human capital sector in order to achieve higher growth in the long run.

Given the parameters above for the data for Kenya, the graph implies that in order to increase the long run growth for the economy, the government needs to invest more on the human capital sector, as compared to spending on the production of goods sector.

3.5 Conclusion

Government expenditure is important for economic growth, and the main arguments for government expenditure are the public good case. Public goods normally have two qualities, they are non-rival and non-excludable, so that it would be difficult to price such good since it is difficult to determine exactly how much they are worth to individual consumers. The Government therefore steps in to provide public goods that are much needed in the economy.

An important question arising from government expenditure is whether government spending is optimal such that given a specific level of government expenditure, growth is maximised. Non optimal spending implies that resources are not being used in such a way as to generate maximum value from them. Governments also have the additional problem of a budget constraint, which further limits how they can provide for public goods in an economy.

This research looks at the allocation of government expenditure between two sectors and the effect of this on economic growth. Using the Uzawa Lucas model, and combining this with the Barro (1990) model of government spending and economic growth in an endogenous model, the research first determines the optimal allocation of government spending in an endogenous growth model. We find that optimal allocation of government spending is where the marginal product of government expenditure are the same for both the human capital and the production of goods sector. At this point, the marginal product of human capital is also the same for the two sectors, and human capital and government expenditure have a positive relationship, such that an increase in one unit of human capital will require a unit increase of government expenditure for productivity to increase.

In addition, the growth rate in the long run will be the same for human capital, physical capital, consumption and income. The marginal product for human capital and physical capital will be the same, and will be equal to the interest rate in the economy. The growth rate therefore depends on the savings rate and the technology, as is the case with standard endogenous growth models.

The chapter then proceeds by looking at two different scenarios for changes in government policy in the case where government spending is exogenously determined. We find that there are certain optimality conditions that need to be fulfilled, and where these are not fulfilled, then growth rates in the long run are not optimal. In particular, based on the condition that in optimality, marginal productivity for all factors have to be the same in both sectors, then increasing one factor input without increasing the others does not increase the level of output. Therefore an increase in government expenditure from one sector to another without increasing the revenue levels lowers the long run growth rate by the amount increased. The long run growth rate then depends on the growth rate of human capital.

Finally, we analyse the model based on data from Kenya, a developing country. We find that government spending on the production of goods sector is higher than government spending on human capital. Policy implications for this are that in the long run, the economy will grow at a rate that is lower than the optimal growth rate. This is an important finding, since for a developing economy, a higher growth rate in income has implications for for poverty levels and for the future development path that the country would like to take.

3.6 Appendix of Chapter Three

3.6.1 Endogenous Growth With Physical and Human Capital - A Planner Approach

From the Hamiltonians in equation (3.7), we can derive the following First Order Conditions that $\frac{\partial J}{\partial C}$ and $\frac{\partial J}{\partial z}$ are equal to Zero:

$$u'(C) = \nu \tag{3.42}$$

and

$$A(1-\alpha)H\left(\frac{K}{zH}\right)^{\alpha}\nu - HB\mu = 0 \tag{3.43}$$

The co-state condition $\dot{\nu} = -\frac{\partial J}{\partial K}$, and $\dot{\mu} = -\frac{\partial J}{\partial H}$ can be expressed as:

$$\dot{\nu} = -\nu\left[A\alpha z^{1-\alpha}\left(\frac{K}{H}\right)^{-(1-\alpha)} - \delta\right] \tag{3.44}$$

and

$$\dot{\mu} = -\mu\left[B(1-z) - \delta\right] - \nu A(1-\alpha)\left(\frac{K}{H}\right)^{\alpha} z^{(1-\alpha)} \tag{3.45}$$

We proceed by finding the growth rates of ν, μ, K and H. The growth rates of K and H are derived from the resource accumulation constraint and the equation for change in human capital, (3.6) and (3.5) respectively. The growth rates of the co state conditions for capital and human capital are derived from equations (3.44) and (3.45) above. In addition, we eliminate the shadow price of human capital for the co state condition of human capital. The growth rates can thus be presented below as:

$$\frac{\dot{K}}{K} = Az^{(1-\alpha)} \left(\frac{K}{H}\right)^{-(1-\alpha)} - \frac{C}{K} - \delta \tag{3.46}$$

$$\frac{\dot{H}}{H} = B\left(1-z\right) - \delta \tag{3.47}$$

$$\frac{\dot{\nu}}{\nu} = -\left[A\alpha z^{1-\alpha} \left(\frac{K}{H}\right)^{-(1-\alpha)} - \delta\right] \tag{3.48}$$

$$\frac{\dot{\mu}}{\mu} = -B + \delta \tag{3.49}$$

To get the growth rate of z, we differentiate equation (3.43) with respect to time and insert equations (3.46), (3.47), (3.48) and (3.49):

$$\frac{\dot{z}}{z} = \frac{(1-\alpha)\,B}{\alpha} + Bz - \frac{C}{K}$$

Following Barro & i Martin (2004), in order to find the steady state values, we begin by defining the following ratios $\omega = \frac{K}{H}$ and $\chi = \frac{C}{K}$. At steady state, the growth rates of ω, χ and z will be equal to zero, and where we set one of the variables, $\omega\left(0\right) = \omega_0$, we can define the growth rates as:

$$\frac{\dot{\omega}}{\omega} = Az^{1-\alpha}\omega^{-(1-\alpha)} - \chi - B\left(1-z\right) = 0 \tag{3.50}$$

$$\frac{\dot{\chi}}{\chi} = \frac{1}{\theta}\left(A\alpha z^{1-\alpha}\omega^{-(1-\alpha)} - \delta - \rho\right) - Az^{1-\alpha}\omega^{-(1-\alpha)} + \chi + \delta = 0 \tag{3.51}$$

$$\frac{\dot{z}}{z} = \frac{(1-\alpha)\,B}{\alpha} + Bz - \chi = 0 \tag{3.52}$$

Solving for equations (3.50), (3.51) and (3.52) gives us the values of ω, χ and z at steady state.

3.6.2 Endogenous Growth with Government Policy - A Planner Approach

From the Hamiltonians in equation (3.23), we can derive the first order conditions that a change in C, z and v are equal to zero as below:

$$u'(C) = \nu \tag{3.53}$$

$$\begin{aligned} \tfrac{\partial J}{\partial z} &= \nu (1-\alpha-\beta) AK^{\alpha} (vG)^{\beta} (zH)^{-\alpha-\beta} \\ &-\mu (1-\eta) B [(1-z) H]^{-\eta} [(1-v) G]^{\eta} = 0 \end{aligned} \tag{3.54}$$

$$\begin{aligned} \tfrac{\partial J}{\partial v} &= \nu\beta A (vG)^{-(1-\beta)} K^{\alpha} (zH)^{1-\alpha-\beta} \\ &-\mu\eta B [(1-v) G]^{-(1-\eta)} [(1-z) H]^{1-\eta} = 0 \end{aligned} \tag{3.55}$$

The co state conditions for the equations of the resource accumulation constraint and the growth rate of human capital, $\dot{\nu} = -\frac{\partial J}{\partial K}$ and $\dot{\mu} = -\frac{\partial J}{\partial H}$, respectively can be expressed below. In addition, note the government revenue constraint. Since $G = \tau Y$, where τ is the tax rate, or in other words, the rate at which the Planner appropriates resources for government revenue, then G is a portion of income as expressed below:

$$\dot{\nu} = -\nu \left[A\alpha z^{1-\alpha} \left(\frac{K}{H}\right)^{-(1-\alpha)} \left(\frac{vG}{zH}\right)^{\beta} - \delta \right] \tag{3.56}$$

$$\begin{aligned} \dot{\mu} &= -\mu \left[B (1-z) \left(\tfrac{(1-v)G}{(1-z)H}\right)^{\eta} - \delta \right] \\ &-\nu A (1-\alpha-\beta) z^{1-\alpha} \left(\tfrac{K}{H}\right)^{\alpha} \left(\tfrac{vG}{zH}\right)^{\beta} \end{aligned} \tag{3.57}$$

$$G = \tau AK^{\alpha} (vG)^{\beta} (zH)^{1-\alpha-\beta} \tag{3.58}$$

Since the values of the variables K, H and C do not therefore affect the dynamics of the system, then following Barro & i Martin (2004) we rather express the system in terms of the ratios $\omega = \frac{K}{H}$ and $\chi = \frac{C}{K}$. Taking into account the condition that the ratio of the share of government expenditure to human capital, $\frac{v}{z} = 1$, the growth rates of μ, ν, K, H and C are expressed below. Note that we take into account the government revenue constraint in the resource accumulation constraint, which gives as the growth rate of capital as being less the amount of resources allocated for government expenditure.

$$\frac{\dot{\mu}}{\mu} = -B + \delta \tag{3.59}$$

$$\frac{\dot{\nu}}{\nu} = -A\alpha z^{1-\alpha}\omega^{-(1-\alpha)} + \delta \tag{3.60}$$

$$\frac{\dot{K}}{K} = (1-\tau)\, Az^{1-\alpha}\omega^{-(1-\alpha)} - \chi - \delta \tag{3.61}$$

$$\frac{\dot{H}}{H} = B\,(1-z) - \delta \tag{3.62}$$

$$\frac{\dot{C}}{C} = \frac{1}{\theta}\left(A\alpha z^{1-\alpha}\omega^{-(1-\alpha)} - \delta - \rho\right) \tag{3.63}$$

The growth rate of z can be determined by getting the time derivative of equation (3.54) and inserting equations (3.59), (3.60), (3.61), (3.62) and (3.63):

$$\frac{\dot{z}}{z} = \frac{1}{\alpha}B - B\,(1-z) - \tau Az^{1-\alpha}\omega^{-(1-\alpha)} - \chi \tag{3.64}$$

Where we set the state variable $\omega\,(0) = \omega_0$, the steady state growth rates of ω, χ, and z are equal to zero, the transversality condition that $lim_{t\to\infty}\nu Kexp - \rho t = 0$, then the steady state values can be defined as:

$$\chi = B\left[\frac{(1-\tau)}{\alpha} - \frac{1}{\theta}\right] + \frac{\delta\,(1-\theta)+\rho}{\theta} \tag{3.65}$$

$$\omega = \left(\frac{\alpha A}{B}\right)^{\frac{1}{1-\alpha}}\left(\frac{\theta-1}{\theta} + \frac{\delta\,(1-\theta)+\rho}{B\theta}\right) \tag{3.66}$$

$$z = \frac{\theta-1}{\theta} + \frac{\delta\,(1-\theta)+\rho}{B\theta} \tag{3.67}$$

3.6.3 Changes in Government Policy - A shift towards spending on the production sector

The Hamiltonians can now be expressed as below:

$$\begin{aligned} J = u\left(C\right) + \nu \left[AK^{\alpha}\left(zH\right)^{1-\alpha} - C - G - \delta K\right] \\ +\mu\left[B\left[\left(1-z\right)H\right]^{1-\eta}\left[\left(1-v\right)G\right]^{\eta} - \delta H\right] \end{aligned} \tag{3.68}$$

The growth rates of K, H, C, $\mu$and ν can be defined as:

$$\frac{\dot{K}}{K} = \left(1-\tau\right)Az^{1-\alpha}\left(\frac{K}{H}\right)^{-(1-\alpha)} - \frac{C}{K} - \delta \tag{3.69}$$

$$\frac{\dot{H}}{H} = B\left(1-z\right)\left(\frac{1-v^{\star}}{1-z}\right)^{\eta} - \delta \tag{3.70}$$

$$\frac{\dot{C}}{C} = \frac{1}{\theta}\left[A\alpha z^{1-\alpha}\left(\frac{K}{H}\right)^{-(1-\alpha)} - \delta - \rho\right] \tag{3.71}$$

$$\frac{\dot{\mu}}{\mu} = -B\left(1-\eta\right)\left(\frac{1-v^{\star}}{1-z}\right)^{\eta} + \delta \tag{3.72}$$

$$\frac{\dot{\nu}}{\nu} = -A\alpha z^{1-\alpha}\left(\frac{K}{H}\right)^{-(1-\alpha)} + \delta \tag{3.73}$$

Defining the ratios $\omega = \frac{K}{H}$ and $\chi = \frac{C}{K}$, setting the state variable $\omega\left(0\right) = \omega_0$, and the steady state growth rates of ω and χ are equal to zero, the transversality condition that $lim_{t\to\infty}\nu Kexp - \rho t = 0$, then the steady state values can be defined as:

$$\begin{aligned} \chi = \left(1-\tau\right)\left[\tfrac{\delta(1-\theta)+\rho+\theta B(1-z)^{1-\eta}(1-v)^{\eta}}{\alpha}\right] \\ -B\left(1-z\right)^{1-\eta}\left(1-v^{\star}\right)^{\eta} \end{aligned} \tag{3.74}$$

$$\omega = \left[\frac{\alpha A}{\delta\left(1-\theta\right)+\rho} + \frac{\alpha A}{\theta B\left(1-z\right)^{1-\eta}\left(1-v^{\star}\right)^{\eta}}\right]^{\frac{1}{1-\alpha}} z \tag{3.75}$$

3.6.4 Changes in Government Policy - A Shift Towards Spending on the Human Capital Sector

Taking into account equations (3.36) and (3.37), the new Hamiltonians becomes:

$$\begin{aligned} J = u\left(C\right) + \nu\left[AK^{\alpha}\left(vG\right)^{\beta}\left(zH\right)^{1-\alpha-\beta} - C - G - \delta K\right] \\ +\mu\left[B\left[\left(1-z\right)H\right] - \delta H\right] \end{aligned} \tag{3.76}$$

We proceed by defining the growth rates of K, H, C, ν and μ as below:

$$\frac{\dot{K}}{K} = (1-\tau)\, A z^{1-\alpha} \left(\frac{K}{H}\right)^{-(1-\alpha)} \left(\frac{v^{\star}}{z}\right)^{\beta} - \frac{C}{K} - \delta \tag{3.77}$$

$$\frac{\dot{H}}{H} = B\,(1-z) - \delta \tag{3.78}$$

$$\frac{\dot{C}}{C} = \frac{1}{\theta}\left(\alpha A z^{1-\alpha} \left(\frac{K}{H}\right)^{-(1-\alpha)} \left(\frac{v^{\star}}{z}\right)^{\beta} - \delta - \rho\right) \tag{3.79}$$

$$\frac{\dot{\nu}}{\nu} = -\alpha A z^{1-\alpha} \left(\frac{K}{H}\right)^{-(1-\alpha)} \left(\frac{v^{\star}}{z}\right)^{\beta} + \delta \tag{3.80}$$

$$\frac{\dot{\mu}}{\mu} = -B + \delta \tag{3.81}$$

Defining the ratios $\omega = \frac{K}{H}$ and $\chi = \frac{C}{K}$, setting the state variable $\omega\,(0) = \omega_0$, and the steady state growth rates of ω and χ are equal to zero, the transversality condition that $lim_{t\to\infty} \nu K exp - \rho t = 0$, then the steady state values can be defined as:

$$\chi = (1-\tau)\left[\frac{\delta\,(1-\theta) + \rho + \theta B\,(1-z)}{\alpha}\right] - B\,(1-z) \tag{3.82}$$

$$\omega = \left[\frac{\alpha A \left(\frac{v}{z}\right)^{\beta}}{\delta\,(1-\theta) + \rho + \theta B\,(1-z)}\right]^{\frac{1}{1-\alpha}} z \tag{3.83}$$

3.6.5 Changes in Government Policy - An Application

This section solves for the Balanced Growth path growth rates where the share of human capital and the share of government expenditure in both sectors are exogenously determined. We begin with the current value Hamiltonians as below:

$$\begin{aligned} J = u\,(C) + \nu \left[A K^{\alpha} (vG)^{\beta} (zH)^{1-\alpha-\beta} - C - G - \delta K\right] \\ +\mu \left[B\,[(1-z)\,H]^{1-\eta}\,[(1-v)\,G]^{\eta} - \delta H\right] \end{aligned} \tag{3.84}$$

Households then choose consumption and take the shares of factor inputs into the production of goods and human capital sector as given. The First Order Condition that a change in the Hamiltonians due to a change in consumption is equal to zero and the co-state conditions that $\dot{v} = -\frac{\partial J}{\partial K}$ and $\dot{\mu} = \frac{\partial J}{\partial H}$ are as given in equations (3.53), (3.56) and (3.57).

Expressing the system in terms of growth rates of K, H, C, ν and μ will yield the following equations:

$$\frac{\dot{K}}{K} = (1-\tau)\, Az^{1-\alpha} \left(\frac{K}{H}\right)^{-(1-\alpha)} \left(\frac{v}{z}\right)^{\beta} - \frac{C}{K} - \delta \tag{3.85}$$

$$\frac{\dot{H}}{H} = B\,(1-z) \left(\frac{1-v}{1-z}\right)^{\eta} - \delta \tag{3.86}$$

$$\frac{\dot{C}}{C} = \frac{1}{\theta}\left(\alpha Az^{1-\alpha} \left(\frac{K}{H}\right)^{-(1-\alpha)} \left(\frac{v}{z}\right)^{\beta} - \delta - \rho\right) \tag{3.87}$$

$$\frac{\dot{\nu}}{\nu} = -\alpha Az^{1-\alpha} \left(\frac{K}{H}\right)^{-(1-\alpha)} \left(\frac{v}{z}\right)^{\beta} + \delta \tag{3.88}$$

$$\frac{\dot{\mu}}{\mu} = -\,(1-\eta)\, B \left(\frac{1-v}{1-z}\right)^{\eta} + \delta \tag{3.89}$$

The system can be reduced to two equations in two unknowns. Defining the ratios $\omega = \frac{K}{H}$ and $\chi = \frac{C}{K}$, setting the state variable $\omega(0) = \omega_0$, and the steady state growth rates of ω and χ are equal to zero, the transversality condition that $lim_{t\to\infty} \nu K exp - \rho t = 0$, then the steady state values of ω and χ can be defined as:

$$\chi = (1-\tau)\left[\frac{\delta(1-\theta)+\rho+\theta B(1-z)\left(\frac{1-v}{1-z}\right)^{\eta}}{\alpha}\right] - B\,(1-z)\left(\frac{1-v}{1-z}\right)^{\eta} \tag{3.90}$$

and

$$\omega = \left[\frac{\alpha A \left(\frac{v}{z}\right)^{\beta}}{\delta\,(1-\theta) + \rho + \theta B\,(1-z)\left(\frac{1-v}{1-z}\right)^{\eta}}\right]^{\frac{1}{1-\alpha}} z \tag{3.91}$$

Inserting these values into the growth rates of capital, human capital, consumption and income give us the growth rates in the Balanced Growth Path.

4 Government Expenditure and Economic Growth: An Empirical Analysis

4.1 Introduction

The background - Governments have different goals, one of which is economic growth. A key tool for fostering economic growth is fiscal policy. Governments can influence and therefore encourage certain economic activities that enhance growth through suitable tax regimes, as well as earn revenue from taxes collected. However, the government can also enhance economic growth through government expenditure. By spending on certain sectors that are productive, the government ensures that there is an increase in income and thus economic growth. Government policy therefore influences growth, since it directly or indirectly influences allocation of resources through government expenditure.

In a widely quoted research Mankiw *et al.* (1992) use an exogenous neoclassical growth model to analyse empirically the variation in income across countries. In addition, they look at conditional convergence, that is, for countries that begin at a given level of income, can the level of capital and population growth explain part of the growth rate around the steady state?[1],[2]

[1]Note that in the exogenous neoclassical growth model, countries converge to their steady state growth rates. Mankiw *et al.* (1992) also point out that in an endogenous growth model with one sector (the Ak model) there is no convergence, since the economy is permanently on the Balanced Growth Path.

[2]Mankiw *et al.* (1992) pp.10, also point out that in the Augmented Solow Model, an increase in savings will increase the level of human capital, which then positively impacts physical capital and hence increases the level of income at steady state. While Mankiw *et al.* (1992) look at the effect of human capital on the variation of income in the Augmented Solow Model, the Uzawa-Lucas model shows that this effect of human capital on income is also the economy's endogenous growth rate in the Balanced Growth Path.

In a later study, Caselli *et al.* (1996) look at economic growth and convergence, where convergence is conditional on investments, population growth and schooling. Following Caselli *et al.* (1996) we argue that since government policy is important for the reallocation of resources, government policy is also important in explaining economic growth. Consequently, convergence is also conditional on government expenditure.

The open question - This research therefore asks the question, could a difference in government policy have an impact on economic growth? Specifically in this research, we take government policy to mean government's decision on spending allocation for different sectors in the economy. Since we use a dynamic panel data model and therefore an Arellano & Bond (1991) estimation, we begin by replicating the study of Caselli *et al.* (1996). We thus use data from Feenstra *et al.* (2013) Penn World Tables (PWT 6.0 and 8.0). Once we confirm that results from both versions of the data set are similar, we add the government expenditure sectoral data from the Statistics of Public Expenditure for Economic Development (2013) ,(1980-2010). This research therefore tests for the growth effects of the composition of government expenditure.

Further related literature That government policy is important for economic growth is an issue that has been discussed extensively in the literature. Governments affect policy through their revenue-raising mechanism and expenditure. This research focuses on the latter. Specifically, we take a look at the composition effects of government spending. A large part of the previous literature on the composition of government expenditure does not analyse cross-country-data sets but rather looks at variation within country and takes a time series approach (Zheng & Kuroda (2013); Schaltegger & Torgler (2006); Colombier (2011)).

Zheng & Kuroda (2013), using an IV and 3SLS estimator, look at the growth and income inequality effects of different types of government spending for 286 cities in China. Both the studies by Colombier (2011) and Schaltegger & Torgler (2006) are country specific for Switzerland. Colombier (2011) uses an Auto Regressive Distributed lag model with an error correction for regions in Switzerland over a period of 45 years to test for a long run relationship between government expenditure and economic growth, and finds that spending on infrastructure and education has a positive effect on growth.

However, Schaltegger & Torgler (2006) use a dynamic panel data model with a fixed effects estimation for the period 1981-2001. While they use a four year average to take care of the cyclical effects, one shortcoming of using a fixed effects estimation for a dynamic panel data model is that since they end up with a small number of time periods (T=5), and endogeneity of the lagged dependent variable leads to inconsistent estimates if it is not corrected for (for instance by applying the estimator proposed for by Arellano & Bond (1991)). Schaltegger & Torgler (2006) find that where government spending is used for payment in operations budget, then there is a negative effect of government spending on economic growth. This is especially the case where the size of the government is large. On the other hand, government spending on capital budgets has no effect on economic growth.

Cross country empirical research on the composition of government expenditure include Devarajan *et al.* (1996). Devarajan *et al.* (1996) use a theoretical set up with two types of government expenditure, that is, productive and non productive. They then carry out an empirical analysis using panel data for 43 developing countries over 20 years. The estimator used in this study is the Least Squares Dummy Variable. They find that developing countries tend to overspend on productive expenditure such as infrastructure, since such spending is only beneficial up to a certain point after which spending on recurrent expenditure would be of more benefit.

From the literature, there are mixed results on the growth effects of the allocation of government spending on infrastructure as well as government spending on other sectors such as education and administration. For both developing and developed countries, spending on education or knowledge infrastructure has been found to have a positive effect on economic growth (Devarajan *et al.* (1996); Colombier (2011); Zheng & Kuroda (2013)). Zheng & Kuroda (2013) find that government spending on knowledge infrastructure increases economic growth while at the same time reducing inequality. On the other hand, spending on infrastructure has mixed results, with both positive and no effects for rich countries (Schaltegger & Torgler (2006); Colombier (2011)) and positive effects for poor countries up to a given point (Devarajan *et al.* (1996)). Zheng & Kuroda (2013) find a trade off in inequality and economic growth for government expenditure on infrastructure for China, with an increase in spending on infrastructure increasing economic growth for more industrialised regions, at the expense of the less industrialised regions and therefore increasing income inequality.

We thus proceed by carrying out a cross country study on the growth effects of the composition of government expenditure. We argue that cross country regressions have an advantage over the above single country studies and/or developing country studies in terms of variability.

Our framework - The empirical model follows the dynamic growth model as in Caselli *et al.* (1996). From this set up, we derive a Dynamic Panel Data Model, with per capita income as the lagged dependent variable. Dynamic Panel data models have several issues that need to be addressed, including the time invariable component of the error term, small time period, large number of observations and the endogeneity of the lagged dependent variable. In order to address these issues we follow Caselli *et al.* (1996) and use the estimator proposed by Arellano & Bond (1991).

Results - We find that the composition of government expenditure does indeed have an effect on economic growth in a conditional convergence model. In particular, government spending on education is positive and significant, while government spending on health and social protection is negative and significant. We also find for conditional convergence, so that initial income has a significant effect on current growth rates conditional on government spending policy, savings, population growth and schooling.

The outline - The paper proceeds as follows, in the following section we present the empirical model as presented in Caselli *et al.* (1996). We then proceed with the data analysis in section three. Section four presents the results from and the replication of Caselli *et al.* (1996). In addition, this section presents the results from the additional time period (1991 - 2010). Once we have looked at the convergence results including the additional time period, we now present the results from the analysis of the composition of government expenditure and economic growth in section five. Section six concludes by giving a summary of the findings and policy recommendations.

4.2 An Economic Growth Model with Lagged Dependent Variable as Presented in Caselli *et al.* (1996)

The empirical model is presented below:

$$lnY_{i,t} - lnY_{i,t-1} = \beta_1 lnY_{i,t-1} + \beta_2 G_{i,t} + \beta_3 X_{i,t} + u_{i,t} \tag{4.1}$$

$Y_{i,t}$ is the income for country i at time t. The left hand side is therefore the growth rate of income while the right hand side is the lagged income.[3],[4] In this case, the coefficient of lagged income is a measure of convergence towards the steady state values of income, where the initial level of income at time $(t-1)$, is not the same as the steady state level of income (Baumol (1986); Barro & i Martin (1992); Mankiw *et al.* (1992); Islam (1995); Caselli *et al.* (1996)). When there is no convergence, then income at period $(t-1)$ is at the steady state level and $\beta_1 = 0$.

$G_{i,t}$ is a vector of government expenditure variables for country i at time t. This is the composition of various types of government expenditure and each type of government expenditure is measured as a share of the total government expenditure. $X_{i,t}$ is a vector of control variables and includes population growth, investments, schooling for male and female, as well as the life expectancy at birth for country i at time t. Convergence is thus conditional on government expenditure and the given control variables.

There are several issues that arise from the dynamic panel data model such as in equation (4.1) above. Firstly, there are the time invariant country characteristics contained in the error term:

$$u_{i,t} = v_i + e_{i,t} \tag{4.2}$$

Secondly, a lag in the dependent variable brings about the problem of endogeneity of $Y_{i,t-1}$ and v_i. Thirdly the variables of interest, the government expenditure variables, may be endogenous. Finally, we have a panel of very small T and large N. While for a panel with large T, the shock effects for the countries that affect the error term tend to disappear with time, this is not the case for a small T panel and therefore this needs to be addressed.

Islam (1995) introduced the fixed effects estimation for the fixed effects panel data model to take care of the country specific time invariant effects. He found that there existed large differences in technology between rich and poor countries. Once this was addressed using panel data analysis, the convergence rate tends to be higher than as

[3]As noted in Barro & i Martin (1992), in the Ramsey, Cass and Koopman (RCK) and Solow neoclassical model, where capital, k, at a given time $t\,(0)$ is below $k^{\star}$, then the growth rate of capital per unit of effective labour declines monotonically towards the steady state, where steady state levels are determined exogenously by the level of technology. Where output per unit of effective labour is a function of capital per unit of effective labour, then the growth rate of output per unit of labour also declines towards the steady state levels. Equation (4.1) thus represents the growth rate of output per unit of effective labour on the left hand side, and initial output per effective worker on the right hand side.

[4]See for example Mankiw *et al.* (1992) and Caselli *et al.* (1996).

was seen before in the literature. Using a fixed effects estimation would therefore be one solution to take care of equation (4.2) above. However, the lagged dependent variable would still be correlated to the error term which causes a downward bias in the estimate of the coefficient of the lagged income. This may explain why using a fixed effect estimator leads to higher convergence rates. In addition, the fixed effects model does not sufficiently address the issue of possible endogeneity in the government expenditure variables.

A solution for endogeneity would be to use external instrumental variables. However, we do not find strong external instruments for the government expenditure variables. We thus follow Caselli *et al.* (1996) and use a Difference GMM estimator (Arellano & Bond (1991)), that addresses the issues of correlation between the lagged dependent variable and the error term, possible endogeneity of the government expenditure variables as well as the time invariant country specific effects by using internal instruments and building first differences.

Specifically, the Difference GMM estimator will use lagged values in levels of the independent variables as instruments for equation (4.2) above. We make the assumption that there is no T order serial correlation, that is, $E\left(e_{i,t}e_{i,t-1}=0\right)$, we instrument $\triangle lnY_{i,t-1}$, with $lnY_{i,t-2}$, $lnY_{i,t-3}$ .... $lnY_{i,1}$ and $\triangle G_{i,t}$ with $G_{i,t-1}$ ... $G_{i,1}$ - all available lags are used as instruments. The moment condition below thus holds:

$$E\left(Y_{i,t-2}\triangle e_{i,t}\right)=0$$

and

$$E\left(G_{i,t-1}\triangle e_{i,t}\right)=0$$

From the above, the validity of instruments will be determined by the level of serial correlation, that is, we assume no serial correlation of the error term where the lag of the instrument for $\triangle lnY_{i,t-1}$, is $lnY_{i,t-2}$, and $\triangle G_{it}$, is $G_{i,t-1}$.

In addition, since the validity of the instruments is ensured by lack of serial correlation in the error term, we use five year averages for all variables.[5] We then report AR(1) and (2) tests, which test the hypothesis that the error term is not serially correlated.

[5]See Caselli *et al.* (1996) who use five year intervals to take care of the serial correlation of the error term.

4.3 Data

We use the data set which has been used by Caselli *et al.* (1996). While Caselli *et al.* (1996) use 97 countries from Barro & Lee (2013), we use 73 countries as some countries drop out from the data set due to various reasons such as secession (see appendix for the list of countries used). In addition, we add 20 years to increase the data period from 1960 to 2010. Government spending data is available from 1980. Since, we use five year averages to take care of cyclical effects, we thus end up with 6 periods from a total of 30 years, that is 1980 to 2010. For data on GDP, population growth and investments, the source is the Feenstra *et al.* (2013) Penn World Tables 8.0 (PWT 8.0). For the data on schooling, we use data from the Barro and Lee data set (Barro & Lee (2013)). The source of data for government expenditure is Statistics of Public Expenditure for Economic Development (2013) - SPEED, from the International Food Policy Research Institute. And finally, other data are from the WDI Indicators (2014), World Bank.

The table below provides summary statistics for the variables.

Table 4.1: Summary Statistics

Variables	N	mean	sd	min	max
Male Schooling	1,365	1.714	1.410	0.014	6.281
Female Schooling	1,365	1.379	1.363	0.002	5.723
Investment †	1,086	0.206	0.112	0.0140	1.685
GDP Per Capita (Income)	1,176	9,685	13,571	145.5	136,356
Population Growth	1,080	0.0179	0.0143	-0.0451	0.175
Education⋆	506	13.37	6.102	0.631	40.26
Health⋆	495	8.066	4.642	0.428	27.65
Defense⋆	494	9.131	8.659	0.0357	78.22
Transport⋆	281	5.478	3.458	0.149	19.70
Transport and Communication⋆	476	6.042	4.071	0.245	33.29
Social Protection⋆	500	16.61	14.73	0.000114	51.82
Total Government Spending†	531	217.3	4,225	0.137	97,389

Source: Data was obtained from various sources and includes the PWT 8.0, SPEED, and Barro and Lee data set for schooling

⋆Indicates that the variables are a percentage of Government Expenditure

†Indicates that the variables are a percentage of GDP

The average of secondary education for the population above 25 years ranges from 0.002 to 5.723 years for females and from 0.014 to 6.281 years for males. This variance comes about because the sample includes both developed and developing countries. In Austria, which has the highest average schooling years, it is mandatory to have 9 years of schooling, 5 years of which are secondary. Malawi has the lowest number of years for schooling for the period 1960 - 1965.

For the GDP pa capita, we have a minimum of USD 145 and a maximum of USD 136,356. These are for Liberia for the year 1995, and Kuwait for the year 1970. Liberia was in the middle of a civil war in the 1990s and for Kuwait, this is in fact a boom in its income due to increasing oil prices, after which its GDP per capita averages USD 50,000.

In the year 1965, Malta had real investment that was one and a half times the GDP. In the previous period, the investment was at 90% of GDP. However, beyond these two periods, the real investments to GDP ratio is about 0.5. This is in line with most developed countries, including France, Germany and Great Britain. This is also slightly lower than the Scandinavian countries, who have an investment to GDP ratio of between 0.6 and 0.7.

The summary above also includes data collected for government expenditure variables. All expenditure variables are taken as a percentage of total government expenditure. However, one expenditure variable, the total government expenditure, is taken as a percentage of GDP. This is because in the second part of the research, where we look at the composition of government expenditure, we use the total government expenditure as a percentage of GDP as a control variable for the other types of government spending. Government expenditure not included in the sample are government spending on mining, agriculture and other, which constitute the remaining 42% of government expenditure. Government spending on mining and agriculture constitute about 13% of total government expenditure, and the remaining 29% is for the other category.

For the variable total government spending as a percentage of GDP, the lowest value is 0.14% for Mali. This value has increased in the later period, but only up to 0.25% of GDP. Mali is an oil producing country. This therefore means that depending on the oil prices and the oil production, GDP is much higher than government spending. On the other hand, the country with the highest government spending is Zimbabwe at 97,389% of GDP. Taking Zimbabwe out of the sample reduces the mean share of government expenditure to GDP to 3.245%, with the maximum government expenditure to GDP at 11.486%.

4.4 Results

4.4.1 Results from Caselli *et al.* (1996)

Since Caselli *et al.* (1996) test the Solow model and measure convergence, we begin by presenting the following equation that approximates the speed of a country's convergence around the steady state as presented in Mankiw *et al.* (1992):

$$lnY_t - lnY_{t-1} = \left(1 - e^{-\lambda t}\right) lnY^\star - \left(1 - e^{-\lambda t}\right) lnY_{t-1} \tag{4.3}$$

and

$$\lambda = (n + g + d)(1 - \alpha) \tag{4.4}$$

From equation (4.3), the left hand side is the growth rate of income per capita. $Y^\star$ is the steady state level of income, while Y_{t-1} is initial income. Note that initial income is not the same as the steady state level of income, and in addition, the current steady state is not the steady state with the Golden Rule level of investments. This implies that there is convergence.[6] Caselli *et al.* (1996) refer to this as the 'proxy' steady state.[7]

From equation (4.3) and (4.4), λ is a measure of the convergence rate, which is a measure of how quickly an economy is approaching its steady state. It is defined as the proportional change in growth rate of income due to a change in income. The coefficient of λ is calculated using a nonlinear combination as below:[8]

$$\lambda = \left(-\frac{1}{5} * (ln\left[1 + \beta_1 lnY_{t-1}\right])\right)$$

where β_1 is the coefficient of the lag of income. The value $-\frac{1}{5}$ is income elasticity with respect to population growth/labour.

From equation (4.4), n is the population growth rate, g is the growth rate of technology and d is the depreciation rate. $(n + g)$ is a measure of efficiency units of labour. We follow

[6]The Golden Rule investments is that level of investments that maximises consumption so that higher levels of investments reduces consumption level. At lower levels of investments consumption is not maximised such that consumers would benefit from increasing the level of investment.

[7]In the Solow Model, the growth rate is therefore a transitional growth rate and not a steady state growth rate. Since we follow Caselli *et al.* (1996) and measure the Solow model, then the effect of variables on growth rate of income is in the transitional period, rather than at steady state.

[8]See appendix for a comparison of λ as adapted and modified from Caselli *et al.* (1996)

the literature (Mankiw *et al.* (1992) and Caselli *et al.* (1996)) and take $(g + d) = 0.05$. $(n + g + d)$ thus represents the labour growth rate. We use population growth rate as a proxy of the growth rate of labour.

α is the share of capital in income, which is also calculated and reported in the results. Just as with λ, the coefficient of α is calculated using a nonlinear combination as below:

$$\alpha = \left\{ \left(\frac{\beta_3 Investments}{-\beta_1 ln Y_{t-1}} \right) / \left(\frac{1 + \beta_3 Investments}{-\beta_1 ln Y_{t-1}} \right) \right\}$$

where β_1 is the coefficient of the lagged income variables with respect to change in income, and β_3 is the coefficient of investment with respect to change in income, where investments belongs to a vector $X_{i,t}$ of control variables. α is thus the income elasticity of capital.

We now proceed to report the results. The following results are those reported by Caselli *et al.* (1996) page 13, for the Textbook Solow model:

$$\begin{gathered} ln\,(Y_{i,t}) - ln\,(Y_{i,t-5}) = -0.473\,(0.079)\,ln\,(Y_{t-5}) \\ +0.074\,(0.0371)\,ln\,(s) - 0.474\,(0.167)\,ln\,(n + g + d) \end{gathered} \tag{4.5}$$

Standard errors are in parentheses. The results of equation (4.5) can be interpreted to mean that there is convergence conditional on investments and population growth. Investments, represented by $ln\,(s)$, has a positive and significant effect on growth rate, while population growth has a negative and significant effect on economic growth. A 1 percentage point increase in investment will increase the growth rate by 0.07 percentage points, while a 1 percentage point increase in population growth lowers growth in income by 0.47 percentage points.

The results for the lagged dependent variable, investments and population growth are all significant.

Similarly, from Caselli *et al.* (1996), the restricted regression for the Solow textbook model gives the following results:

$$\begin{gathered} ln\,(Y_{i,t}) - ln\,(Y_{i,t-5}) = -0.49\,(0.140)\,ln\,(Y_{t-5}) \\ +0.0566\,(0.0778)\,[ln\,(s) - ln\,(n + g + d)] \end{gathered} \tag{4.6}$$

Similarly, in equation (4.6) there is convergence towards the steady state. Convergence is conditional on the population investments restriction, that is, from the Solow model, taking the restriction that the coefficient for investment and population growth are opposite and equal in size (Mankiw *et al.* (1992)). Note however, that the coefficient for the population investments restriction is positive, but not significant.

4.4.2 Replication of Results Using STATA

While Caselli *et al.* (1996) use GAUSS to run the above regressions, using the same data, we use the Difference GMM estimator in STATA to replicate the results. We report the results in table (4.2).

Regression 1 is similar to equation (4.5) above. This is the unrestricted regression and like in equation (4.5), the coefficients of the log of lagged dependent variable, investments and population growth are all significant. The coefficients for investments in both equations are not very different at 0.074 and 0.094. Similarly, the coefficients for the population growth variable are comparable at 0.474 and 0.488. The second regression, 2, is similar to equation (4.6) and is the restricted equation for the textbook Solow model. For both regressions, the restriction is not significant.

The results can also be interpreted to mean that there exists convergence conditional on investment and population growth. For both regressions, the rate of convergence has been calculated and is represented by λ. The interpretation of λ is that convergence exists at the rate of 13.5% for regression 1 and 11.1% for regression 2. For both regressions, convergence is significant at 1%.[9]

In addition, the share of capital in output is calculated and is denoted by α. The share of capital in the unrestricted equation is 16.1% and is significant at the 5% level. In regression 2, α is not significant. The value of 16.1% is much lower than in the literature, which suggests that α should be equal to 33%.

We compare the coefficients from the regressions using GAUSS and STATA, and check if the estimates are different. We look at the coefficients at the 95% confidence interval.

For the lagged dependent variable, we report confidence intervals of -31.8 to -62.7 percent per period for the GAUSS results, while for the STATA results we report -26.9 to -71 percent per period. In both cases, there exists convergence at the 1% level of significance.

[9] Note that Mankiw *et al.* (1992), using a different estimation method, find much lower convergence rates of about 0.6%. Caselli *et al.* (1996) point out that large convergence rates such as the ones reported in their study mean that differences in GDP per capita between countries is due to the levels at steady state rather than the distance from steady state.

We then report a confidence interval of 14.7 to 0.2 percent per period and 20.1 to -1.3 percent per period for GAUSS and STATA respectively for the variable investments. While for the variable population growth, we report confidence intervals of -14.6 to -80.1 percent per period and -8.7 to -88.8 percent per period for GAUSS and STATA respectively.

The results from the confidence intervals further support the finding of convergence for the Difference GMM estimator when used both in GAUSS and STATA.

Table 4.2: Textbook Solow Model - Replicating Caselli *et al.* (1996)[a b c d]

Variables	(1)[e]	(2)[f]
Lagged Income	-0.490	-0.427
	[0.112]***	[0.140]***
Investment	0.094	
	[0.054]*	
Population Growth	-0.488	
	[0.204]**	
Population_Investment Restriction		0.075
		[0.072]
λ	0.135	0.111
	[0.044]***	[0.049]***
Restriction F	3.688	
p-value	0.055	
α	0.161	0.150
	[0.096]**	[0.154]
Observations	382	382
No of Countries	97	97
Hansen Test χ^2	22.85(19)	19.24(14)
Prob > χ^2	0.244	0.156
AR(1)	-3.17	-2.50
Prob > Z	0.002	0.013
AR(2)	0.34	0.25
Prob > Z	0.734	0.803

[a]Robust standard errors in parentheses
[b]***p<0.01,**p<0.05,*p<0.1
[c]Note: All the regressions above use the Difference GMM estimator
[d]Data Source: PWT 8.0
[e]Unrestricted Regression
[f]Restricted Regression

4.4.3 Results Replicating Caselli *et al.* (1996) Using PWT 8.0 Data

We now proceed by using data from a more recent version of the PWT, version 8.0. As with Caselli *et al.* (1996), we have six periods, that is, five year averages between 1960 and 1985. The variables used are exactly the same as in Caselli *et al.* (1996), however, we now have a smaller sample of 73 countries. We then proceed with the Arellano-Bond difference GMM estimator.

Table (4.3) compares the results from Caselli *et al.* (1996) to the results from the PWT 8.0. Note that for the comparison, while we use two different data sets, the countries are the same.

Coefficients of investments for all specifications below are positive and significant. Similarly, the coefficients of population growth, which is a proxy for growth of labour, are all negative and significant. The coefficients from all regressions are significant at the 1% level.

We then compare conditional convergence results, conditional on investments and population, for all the specifications. For all regressions, the convergence rates range between 5% and 7% and are therefore not very different.

Comparing the regressions in table (4.2) and (4.3), we find that generally the signs for all coefficients are the same. However, the coefficients for the regressions in table (4.2) are a little larger, with significance for investment, population and the population investment restriction at 10%, 5% and not significant respectively. In table (4.2) we use data from PWT 6.0 with 97 countries. Table (4.3) compares regressions run using data from both PWT 6.0 and PWT 8.0, with 73 countries in both cases.

Since the estimator used is exactly the same for all regressions, the differences in the coefficients could be due to the quality of the data, since, although the data source is the same, the versions used are different with our results using a newer version. However, the main difference is from the number of countries used in the sample. With the same countries, the coefficients are not very different and are all significant at the 1% level.

Table 4.3: Comparison of the Caselli *et al.* (1996) Results with this Paper's Results - Textbook Solow Model [a b c]

Variables	(1)[de]	(2)[f,e]	(3)[d,g]	(4)[f,g]
Lagged Income	-0.308	-0.221	-0.268	-0.262
	[0.029]***	[0.024]***	[0.022]***	[0.025]***
Investment	0.288		0.125	
	[0.38]***		[0.023]***	
Population Growth	-0.407		-0.318	
	[0.137]***		[0.095]***	
Population_Investment Restriction		0.192		0.167
		[0.032]***		[0.031]***
λ	0.074	0.050	0.062	0.060
	[0.009]***	[0.006]***	[0.013]***	[0.006]***
Restriction F	0.56		3.751	
p-value	0.452		0.052	
α	0.484	0.466	0.318	0.389
	[0.044]***	[0.050]***	[0.042]***	[0.044]***
Observations	291	291	290	290
No of Countries	73	73	73	73
Hansen Test χ^2	31.72(19)	37.04(14)	31.23(19)	21.91(14)
Prob > χ^2	0.034	0.001	0.038	0.008
AR(1)	-3.51	-3.56	-3.11	-3.29
Prob > Z	0.000	0.000	0.002	0.001
AR(2)	1.97	0.70	1.62	1.60
Prob > Z	0.049	0.090	0.105	0.109

[a] Robust standard errors in parentheses
[b] ***p<0.01,**p<0.05,*p<0.1
[c] Note: All the regressions above use the Difference GMM estimator
[d] Unrestricted Regression
[e] Data Source: PWT 6.0
[f] Restricted Regression
[g] Data Source:PWT 8.0

4.4.4 Additional 4 Periods (20 Years)

In this section, we include an additional 20 years of data to the initial 30 years. This data is for the period 1991 to 2010. This gives the research an additional 4 periods to make a total of 10 periods. The data therefore covers the period 1960 to 2010.

The table below presents a comparison of six regressions. All regressions now use the same data source, that is, PWT 8.0 (Feenstra *et al.* (2013)). The first two regressions are for the initial six periods, with regression (1) being an unrestricted regression while regression (2) is restricted. Regression (3) and (4) include the new 4 periods, that is, the additional 20 years. Regression (3) is unrestricted, while regression (4) is restricted. Finally, regression (5) and (6) only have the additional 4 periods, that is the new 20 years. All regressions are run using the Difference GMM estimator as used by Caselli *et al.* (1996). However, regressions (3), (4), (5) and (6) now have less countries. Zimbabwe drops out due to very high inflation levels after the year 2000. Mali, Rwanda, Liberia and Sierra Leone also drop out due to unavailability of data. The latter three countries underwent periods of war in the 1990s. Finally, Malta also drops out due to spending on investments that are much higher than income. We end up with a sample of 67 countries.

We begin the analysis by looking at the unrestricted regressions, that is, (1), (3) and (5). For all the three unrestricted equations, we can interpret the results to mean that there is convergence. However, the coefficient in equation (1) is lower than in equation (3) and (5). This is supported by the value of λ, so that lambda is 0.062, 0.034 and 0.037 for regressions (1), (3) and (5) respectively. This means that convergence takes place at the rate of 6%, 3% and 4% respectively. A higher convergence rate means that economies are closer to their steady state, while a lower convergence rate means that economies are further away from their steady states. An economy converges to its steady state level at a slower rate if the initial levels of income, capital and technology are low. This should be the case for developing countries who's initial levels of income, investments and technology tend to be much lower than that of developed countries. In addition to the convergence rate, the share of capital in income, α, is calculated for all three equations. The share is found to be 31%, 32% and 31% for regression (1), (3) and (5) respectively. In the standard growth accounting, the share of capital in output is normally expected to be around 30%, which is not very different from our results.

Table 4.4: A Comparison of Results, Including the Additional 4 Periods [a b c d]

	Six Periods (1960-1990)		Ten Periods (1960-2010)		New Four Periods (1990-2010)	
Variables	(1)[e]	(2)[f]	(3)[e]	(4)[f]	(5)[e]	(6)[f]
Lagged Income	-0.268	-0.262	-0.156	-0.137	-0.171	-0.074
	[0.022]***	[0.025]***	[0.003]***	[0.002]***	[0.045]***	[0.029]**
Investment	0.125		0.075		0.078	
	[0.023]***		[0.002]***		[0.025]***	
Population Growth	-0.318		-0.332		-1.058	
	[0.095]***		[0.021]***		[0.348]***	
Restriction		0.167		0.096		0.099
		[0.031]***		[0.002]***		[0.023]***
λ	0.062	0.060	0.034	0.028	0.037	0.015
	[0.013]***	[0.006]***	[0.000]***	[0.000]***	[0.010]***	[0.006]***
α	0.318	0.389	0.325	0.413	0.313	0.571
	[0.042]***	[0.044]***	[0.007]***	[0.005]***	[0.106]***	[0.108]***
Observations	290	290	603	603	268	268
No of Countries	73	73	67	67	67	67
Hansen Test χ^2	31.23(19)	21.91(14)	66.64(114)	66.90(79)	21.36(19)	21.06(14)
Prob > χ^2	0.038	0.008	1.000	0.832	0.317	0.100
AR(1)	-3.11	-3.29	-4.57	-4.84	-4.36	-4.51
Prob > Z	0.002	0.001	0.000	0.000	0.000	0.000
AR(2)	1.62	1.60	-0.30	-0.38	-1.37	-1.07
Prob > Z	0.105	0.109	0.767	0.701	0.170	0.284

[a] Robust standard errors in parentheses
[b] ***p<0.01,**p<0.05,*p<0.1
[c] Note: All the regressions above use the Difference GMM estimator
[d] Data Source: PWT 8.0
[e] Unrestricted Regression
[f] Restricted Regression

For all three regressions, the coefficient for investment has the expected positive sign and is highly significant. A 1 percentage point increase in investments increases the growth rate of income by 0.13 percentage points in the first regression, while for the other two regressions, an increase of 1 percentage points in investments increases growth in income by 0.07 percentage points. The differences here are most likely due to the additional time periods as well as difference in the number of countries. They are however not very different.

As expected, the coefficient for for population growth is negative and also significant at the 1% level for all three unrestricted regressions. However, of interest is that while regression (1) and (3) have coefficients of -0.318 and -0.332 respectively, the coefficient of the population growth variable is -1.058. This can be interpreted as an increase in population growth by 1% will reduce the the growth in income by 1%, which shows a strong negative relationship between population growth and growth of income. Since we take population growth as a proxy of labour efficiency units, the strong relationship could be due to the actual population growth rate being higher than the growth rate of labour efficiency.

We now interpret the results from regressions (2), (4) and (6) which are the restricted regressions. The coefficient of the restriction is significant at the 1% level for all three equations. In addition, the coefficient for lagged income is negative in all three regressions, which is an indication of convergence. This is further confirmed with a λ of 0.060, 0.028 and 0.015, which means a convergence rate of 6%, 3% and 2% for regressions (2), (4) and (6) respectively. Similarly, the differences in the convergence rate could be attributed to the different time periods. Regression (2) has six periods between 1960 and 1990 and shows a faster convergence rate, while regression (6) has four subsequent periods between 1990 and 2010 and shows a slower covergence rate. The period after 1990 saw many developing countries in Africa go into debt distress with most of these economies going into fiscal consolidation. Resources were used to pay off debt rather than invest, which saw a general decline in the levels of capital. These economies thus moved further away from their steady state given the initial level of capital. This could be one explanation why convergence during this period was much lower.

In Section 4.3 and 4.4, we have used a dynamic panel data model and applied the Arellano & Bond (1991) estimation, which turns out to be a suitable estimation for this model. We begun by replicating a study that has been widely cited, and that also uses a dynamic panel data model with the same estimator to test for convergence in economic growth. In addition to replicating the study, we also use the same estimator for an updated data set and compare the results. We find that the sample used matters, and that when we use the same countries for both the new and old data set, the results are not very different. In addition, we include a new time period, that is, 20 additional years from 1991 - 2010. The results are not very different from the previous results. We find convergence conditional on investments and population growth. Investments has a positive effect on economic growth while population growth has a negative effect. This is also in line with the literature.

4.5 Government Expenditure, Conditional Convergence and Economic Growth: An Arellano Bond Estimation

Having confirmed convergence in the results in the previous section, we now proceed to analyse the allocation effects of government spending policy on economic growth in this section. Since the data on government expenditure variables is limited, that is, from 1980 to 2010, the estimations with the government expenditure variables include observations from this time period only and use the Difference GMM estimator as previously used for the convergence regressions. In addition, due to unavailability of data on government expenditure, we end up with 59 countries.[10] Table (4.5) below thus reports the results from the specification in equation (4.1).

Table (4.5) presents five different specifications. Regression (1), (3) and (4) include government expenditure on education while regressions (2) and (5) include the schooling variables. Government expenditure on education and schooling both test for the effect of education on economic growth. We therefore do not include both variables in the same regression as the two are strongly correlated. Including the two variables would result in misspecification of the model.

Regressions (1), (2), (3) and (4) include the variable for government spending on health, while regressions (1), (2) and (5) include the life expectancy variable. A healthy population tends to have a longer life expectancy, and therefore the life expectancy variable may capture health. We therefore exclude life expectancy in some of the regressions. However, the health variable has a negative and highly significant coefficient only in the second regression. This regression excludes government spending, but rather includes the schooling variables for both males and females. The negative and significant results in this case may be driven by the schooling variables, since from the literature

[10]See Appendix for list of countries

schooling and health are correlated, that is, healthy individuals are able to learn better, but also education improves health through better information on nutrition and disease prevention. The coefficient of life expectancy is positive and highly significant for all specifications, indicating that life expectancy has a positive effect on economic growth.

In addition, some social protection programmes target health specifically, and therefore health may be correlated with social protection. We thus exclude the social protection variable in regression (4). For all four regressions that include social protection, the coefficient is negative and statistically significant.

The variables defense, investments, population growth and initial income are included in all specifications.

To interpret the results, we first note that the total share of government spending as a ratio of GDP is used as a control for government spending. We thus interpret the coefficient of spending on education as the effect of a change in growth of income due to a change in government spending on education, when holding total government spending constant. For all three regressions, government spending is positive and significant at the 1% level, with the coefficients being 0.050, 0.089 and 0.139 for regression (1), (3) and (4) respectively. This means that holding total government spending constant, a percentage point increase in spending on education will increase economic growth by 0.05, 0.09 and 0.14 percentage points respectively. Increasing government spending on the education sector means an increase in human capital, which leads to an increase in efficiency of labour and thus an increase in output. These finding supports the theoretical finding in Chapter three, that in the absence of an endogenously and optimally determined allocation of government spending, the the economy's growth rate will revert back to the growth rate of human capital.

On the other hand, for all five regressions, we find a negative coefficient for spending on defense, which is also significant at the 1% level. We can thus interpret this as, holding total government spending constant, a 1 percentage point change in government spending on defense reduces the growth rate of income by between 0.02 and 0.09 percentage points. While it is important for governments to ensure security, since an economy can only thrive in a secure environment, the results imply that there is a threshold for government spending on defense, after which governments are better off spending on other productive sectors of the economy.

Similarly, a 1 percentage point increase in government spending on social protection, holding total government spending constant, reduces economic growth by between 0.01

and 0.03 percentage points. In some cases, social protection takes the form of a safety net program. This often includes welfare programs that ensure that individuals are not left worse off in case of a negative unexpected income shock. Social protection thus smoothes consumption, rather than enhancing investments, which in term does not necessarily enhance growth.

Suppose that the government makes a policy decision to reduce government spending on defense, and increase government spending on education by the same amount of the reduction, holding total government spending constant. From specification (1), reducing government spending on defense by 1 percentage point increases growth by 0.05 percentage points. Increasing government spending on education by 1 percentage point on the other hand will increase growth by 0.05 percentage points. The net effect of a policy shift in government spending from defense to education, then increases economic growth by 0.1 percentage points. This would be an important policy aspect for a government that is interested in growth enhancing policies.

However, one would have to be careful about applying the same policy shift in government spending to, for example, social protection. Since social protection also has an income redistribution mechanism, then the government must make a decision on which of the two, income redistribution or growth, is a priority. In this study, we only look at the growth effects of policy shifts and therefore do not analyse in detail the trade off between income growth and income redistribution.

For all regressions, the results show convergence, with the lagged income having negative and significant coefficients at the 1% level. However, for regressions (1), (3) and (4), the value of the coefficient is lower. These regressions also include government expenditure. The convergence conditional on government expenditure is therefore lower than in the regressions where government expenditure is not included. A lower convergence rate means that economies are further away from their steady state values. Government expenditure on education could thus signify a large investments that takes longer for the economy to revert back to its steady state. Interestingly, since schooling is also a variable for human capital, then the coefficient for the lag of income should be low for regressions (2) and (5). However, it can be argued that the variables for male and female schooling are stock variables for human capital, while government spending on education is a flow. A higher coefficient thus indicates a higher level of stock of human capital at steady state. The lower coefficient for initial income where there is government expenditure on education then indicates that economies start at a lower level of human capital and thus take a much longer time to converge to their steady state values.

Table 4.5: Government Expenditure, Conditional Convergence And Economic Growth [a b c d]

Variables	(1)	(2)	(3)	(4)	(5)
Lagged Income	-0.199	-0.460	-0.193	-0.210	-0.471
	[0.008]***	[0.012]***	[0.011]***	[0.016]***	[0.016]***
Investment	-0.000	0.008	0.014	0.001	-0.005
	[0.012]	[0.007]	[0.013]	[0.017]	[0.006]
Population Growth	-0.422	-0.174	-0.419	-0.577	-0.230
	[0.034]***	[0.025]***	[0.063]***	[0.074]***	[0.050]***
Life Expectancy	0.636	0.425			0.420
	[0.079]***	[0.056]***			[0.052]***
Male Schooling		0.424			0.338
		[0.021]***			[0.016]***
Female Schooling		-0.061			
		[0.015]***			
Education[e]	0.050		0.089	0.139	
	[0.015]***		[0.020]***	[0.025]***	
Health[e]	0.005	-0.021	0.014	0.012	
	[0.006]	[0.008]***	[0.008]*	[0.013]	
Defense[e]	-0.046	-0.021	-0.093	-0.082	-0.020
	[0.005]***	[0.005]***	[0.011]***	[0.017]***	[0.005]***
Social Protection[e]	-0.011	-0.018	-0.025		-0.024
	[0.003]***	[0.005]***	[0.008]***		[0.004]***
Total Expenditure[f]	0.004	0.005	0.052	0.042	-0.000
	[0.015]	[0.010]	[0.020]***	[0.019]**	[0.011]
Observations	203	203	203	205	214
ID	59	59	59	59	60
Hansen Test χ^2	49.19(49)	50.13(54)	44.46(44)	41.66(39)	52.43(44)
Prob > χ^2	0.466	0.624	0.452	0.356	0.180
AR(1)	-3.52	-3.31	-3.33	-3.31	-2.87
Prob > Z	0.000	0.001	0.001	0.001	0.004
AR(2)	-0.57	-0.55	-1.21	-1.05	-0.47
Prob > Z	0.569	0.583	0.228	0.296	0.638

[a] Robust standard errors in parentheses
[b] ***p<0.01,**p<0.05,*p<0.1
[c] Note: All the regressions above use the Difference GMM estimator
[d] Data Source: PWT 8.0
[e] share of total government spending
[f] Share of GDP

Similarly, the coefficient of population growth, though negative and significant for all specifications, has lower values in the specifications with schooling variables and higher values in the specifications with the variable government spending on education. The current stock of human capital increases labour efficiency, thereby canceling out the negative effect of increasing labour on economic growth. However, spending on education now only generates human capital in the future.

While male schooling has a positive and significant effect on economic growth, female schooling has a negative and significant effect. It is not clear why this is the case. For all the specifications, investments has an insignificant coefficient.

An important point to note is that the allocation of government spending yields different results from the effect of government spending on economic growth when government expenditure is in levels. With level effects, the interpretation of the results would be to look at the general growth enhancing effect of an increase on sectoral government expenditure. On the other hand, with allocation of government expenditure, we look at the sectoral effects of a change in government expenditure holding total expenditure constant. This means that increasing government spending on, say, the education sector, comes with a reduction in government spending on another sector.

This has important implications for policy, especially since governments are often faced with the question of the best possible allocation of expenditure that will achieve maximum growth given limited revenue.

Finally, for all five regressions; from the Hansen J test we do not reject the null hypothesis that the overidentification is valid since for all equations the P - value > 0.1. The Hansen J checks for the validity of the overidentifying restrictions, that is, it tests for the validity of the restrictions that there are more instruments than endogenous regressors. The Arellano-Bond test for autocorrelation tests the null hypothesis that there is no autocorrelation of oder AR(1) and AR(2). Similarly, for all five regressions, we do not reject the null hypothesis of no autocorrelation for oder 2.

4.6 Conclusion

In this chapter, we take an empirical approach to analyse the effects of government policy on economic growth. Specifically, we look at the growth effects of the allocation of government expenditure. In so doing, we follow the Caselli *et al.* (1996) empirical model, which turns out to be a dynamic panel data model, where the lag of income per capita is included as a right hand side variable. In addition, we include a vector of the composition of government expenditure, our main variables of interest, as explanatory variables.

We begin by replicating the Caselli *et al.* (1996) research using their data and we find similar results, that is, there exists convergence so that initial income has an effect on economic growth, investments/saving has a positive effect on economic growth, and that population growth has a negative effect on economic growth. We proceed with data from an updated data set for the same time period as in Caselli *et al.* (1996) from which we find similar results.

One of the two contributions of this research to the literature is the addition of four periods, that is, an additional twenty years of data from 1991 to 2010. Using the same estimator with the additional periods yields results that are similar to Caselli *et al.* (1996), as well as our findings from the updated data set.

The second contribution, and perhaps the main topic of the thesis, is the analysis of the growth effects of the allocation of government expenditure. In order to capture the allocation of government expenditure, we use sector specific government expenditure as a ratio of total government expenditure. The data on government expenditure is derived from a new database, Statistics of Public Expenditure for Economic Development (2013), and is available for six periods, that is, thirty years from 1980 to 2010. We find that the growth effects of the allocation of government expenditure is positive and statistically significant for education, while it is negative and in some cases significant for spending on health and social protection.

These results have important policy implications for governments. Generally, where governments want to achieve economic growth, then a shift to spending on education is very important. An important point to note in the policy implications of the results above, is that although in general spending on education can be seen as especially important for economic growth, governments have to take into account individual circumstances and that the exact allocation of government expenditure is country specific.

4.7 Appendix Of Chapter Four

4.7.1 A Comparison Between The Caselli *et al.* (1996) Results And Our Results

Table 4.6: Comparison Of Table 1 In Caselli *et al.* (1996) With Results From This Paper

Textbook Solow Model						
	MRW	OLS	KLV	Caselli et al paper	Caselli Data	New Data
lambda unrestricted	0.00606	0.00621	0.0626	0.128	0.135	0.0626
SE	[0.00182]	[0,00219]	[0,0124]	[0,030]	[0,044]	0.0135
delta1 + delta2 = 0 test		-0.398	0.798	-2.549	3.688	3.7513
p-value		[0,691]	[0,372]	[0,011]	[0,055]	0.0528
lambda restricted		0.00588	0.0652	0.135	0.111	0.0609
SE		[0,00202]	[0,0121]	[0,055]	[0,049]	0.0069
Implied alpha		0.757	0.335	0.104	0.150	0.3896
SE		[0,048]		[0,147]	[0,154]	0.0447
Countries	98	97	98	97	97	73
Observations	98	479	490	382	382	209

Robust standard errors in parentheses
***p<0.01,**p<0.05,*p<0.1
Source: Caselli et al (1996), pp. 14, modified

Table (4.6) is as taken from the Caselli *et al.* (1996) research page 14. The 6th and 7th columns, "Caselli Data" and "New Data" respectively are the only addition to the table, and are a comparison of the regressions we run for the updated data with same time period as Caselli et al, and same estimator.

The column labeled "MRW" are the results from the Mankiw *et al.* (1992) research, while "KLV" are results from the Villanueva *et al.* (1993) as quoted in Caselli *et al.* (1996). The 3rd and the 5th columns are from Caselli *et al.* (1996), with the third being results from an OLS regression and the 5th column being results from the Arellano Bond estimator.

The variables "lambda" measure convergence for both the restricted and unrestricted equations. "delta1+delta2" test the hypothesis that the signs of savings and population growth in the Solow model are opposite in signs and equal in value, while "alpha" is the output elasticity of capital.

The replicated Caselli *et al.* (1996) results are similar in signs and magnitude to the results from the original Caselli et al (1996) research. Convergence rate, that is, "lambda" for both the restricted and the unrestricted regressions range between 11% and 14%.

From the “new data”, and using the same estimator, we find a convergence rate of 6% for both the restricted and unrestricted regressions. This is also the case for the Knight, Loayza and Villanueva (1993) results as quoted in Caselli *et al.* (1996). On the other hand, the Mankiw *et al.* (1992) results and the OLS regression by Caselli *et al.* (1996) find a convergence rate of about 0.6%. Note thatMankiw *et al.* (1992) also use an OLS estimator.

For the “implied alpha”, our results are similar to the Knight, Loayza and Villanueva (1993) results with 0.38 and 0.33 respectively. The implied alpha is also the output elasticity of capital and is normally estimated at around 0.33 or 33%. The Caselli *et al.* (1996) replication and original paper both find a low alpha of 0.15 and 0.1 respectively, while the OLS has a seemingly high alpha of about 0.75.

4.7.2 List of Countries

The list of countries are as below:

Benin, Botswana, Cameroon, Central Africa Republic, Egypt, Ghana, Kenya, Lesotho, Liberia, Malawi, Mali, Mauritius, Niger, Rwanda, Senegal, Sierra Leone, South Africa, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

Barbados, Canada, Costa Rica, El Salvador, Guatemala, Jamaica, Mexico, Panama.

Argentina, Bolivia, Brazil, Chile, Colombia, Equador, Paraguay, Peru, Uruguay, Venezuela.

Bangladesh, India, Indonesia, Israel, Japan, Jordan, Malaysia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand.

Austria, Belgium, Cyprus, Denmark, Finland, France, Greece, Ireland, Italy, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland.

Turkey, United Kingdom, Australia, New Zealand.

Countries included in Caselli et al. *(1996), but not included in our research:*

Algeria, Congo, Gambia, Sudan, Swaziland, Tanzania, Zaire.

Dominican Republic, Haiti, Honduras, Trinidad and Tobago.

United States of America, Guyana, Nicaragua.

Hong Kong, Iran, Iraq, Korea, Syria, Taiwan, Yemen.

West Germany, Yugoslavia, Papua New Guinea.

Countries not included in the Government Expenditure Regression:

Benin, Central Africa Republic, Liberia, Mali, Niger, Rwanda, Senegal, Sierra Leone, Togo, Zimbabwe.

Equador, Peru.

Malta

5 Conclusion

This research looks at the growth effects of government policy using both theoretical and empirical methodology. The role of government is important in an economy since it fills a gap by providing public goods. In so doing, they collect revenue and make spending decisions. Governments are thus able to influence the allocation of scarce resources through their revenue collection and spending policies, which in turn influences economic growth.

In the first chapter, we begin by giving a brief background to the thesis, by introducing the problem and briefly looking at the framework used to analyse the research questions in the following chapters.

The second chapter takes a theoretical approach and analyses the growth effects of changes in government policy on revenue collection. Using a neoclassical growth model, we look at three types of taxes, and analyse how changes in these taxes would affect economic growth. Using data for Kenya, we find that although there is no effect of a change in taxes on economic growth in the long run, there are long run effects of changes in taxes on the levels of income, capital and consumption. In addition, in our framework, taxes on capital generally have an inverse relationship with the levels of income, capital and consumption.

The third chapter analyses theoretically for the effects of the allocation of government spending on economic growth. The framework is a two sector growth model that combines the Uzawa-Lucas and the Barro (1990) model of government expenditure in and endogenous growth model. The contribution to the literature is the analysis of the allocation effects of government spending in an endogenous two sector model with physical and human capital. The key finding here is that the allocation of government expenditure matters, and in cases where the allocation of government expenditure is not optimally selected, the the growth rate of income in the long run will revert to that of human capital. Using data from Kenya, we find that increasing government spending on the human capital sector would increase long run economic growth.

Chapter two and three therefore look at the revenue raising and government spending policies, and the effect of this on economic growth using a theoretical framework. Chapter two uses an exogenous neoclassical growth framework, while chapter three uses a two sector endogenous growth framework with physical and human capital.

In chapter four, the research now uses an empirical framework to analyse the effect of the allocation of government spending on economic growth. Based on the empirical model, that is, the dynamic panel data model, the most suitable estimator selected is the Arellano-Bond estimator. This chapter contributes to the debate in two ways, firstly, it analyses conditional convergence and in so doing includes an additional 20 year period. Secondly, we analyse the growth effects of the allocation of government expenditure. We find for conditional convergence and that a change in government spending on education has a positive and significant effect, while a change in government spending on social protection and defense has a negative and significant effect, when holding total government expenditure constant.

This research therefore finds that government policy does matter for economic growth. There are thus important policy implications for governments for both revenue collection and allocation of government expenditure.

Bibliography

Agenor, Pierre Richard, & Neanidis, Kyriakos C. 2011. The allocation of public expenditure and economic growth. *The Manchester School*, **79**(4), 899–931.

Arellano, Manuel, & Bond, Stephen. 1991. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies*, **58**(2), 277–297.

Aschauer, David Alan. 1989. Is public expenditure productive? *Journal of Monetary Economics*, **23**(1989), 177–200.

Banerjee, Abhijit, & Piketty, Thomas. 2005. Top Indian incomes, 1922-2000. *World Bank Economic Review*, **19**(1), 1–20.

Barro, Robert, & Lee, Jong-Wha. 2013. A New Data Set of Educational Attainment in the World, 1950-2010. *Journal of Development Economics*, **104**(2013), 184–198.

Barro, Robert J. 1990. Government Spending in a Simple Model of Endogenous Growth. *Journal of Political Economy*, **98**(5), 103–125.

Barro, Robert J., & i Martin, Xavier Sala. 1992. Convergence. *Journal of Political Economy*, **100**(2), 223–251.

Barro, Robert J., & i Martin, Xavier Sala. 2004. Economic Growth. *Cambridge, MIT Press.*

Baumol, William J. 1986. Productivity Growth, Convergence and Welfare: What the Long-Run Data Show. *American Economic Review*, **76**(5), 1072–1085.

Bouet, Antoine, & Roy, Devesh. 2012. Trade protection and tax evasion: Evidence from Kenya, Mauritius and Nigeria. *The Journal of International Trade and Economic Development*, **21**(2), 287–320.

Bruckner, Markus, Chong, Alberto, & Gradstein, Mark. 2012. Estimating the permanent income elasticity of government expenditures: Evidence on Wagner's law based on oil price shocks. *Journal of Public Economics*, **96**(11-12), 1025–1035.

Caselli, Francesco, Esquivel, Gerardo, & Lefort, Fernando. 1996. Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics. *Journal of Economic Growth*, **1**(3), 363–389.

Colombier, Carsten. 2011. Does the composition of public expenditure affect economic growth? Evidence from the Swiss case. *Applied Economic Letters*, **18**(16), 1583–1589.

Devarajan, Shantayanan, Swaroop, Vinaya, & fu Zou, Heng. 1996. The composition of public expenditure and economic growth. *Journal of Monetary Economics*, **37**(1996), 313–344.

Feenstra, Robert C., Inklaar, Robert, & Timmer, Marcel P. 2013. The Next Generation of the Penn World Table. *available for download at www.ggdc.net/pwt.*

Feldstein, Martin. 1995. The Effect of marginal tax rates on taxable income: A panel study of the 1986 tax reform act. *Journal of Political Economy*, **103**(3), 551–572.

Futagami, Koichi, Morita, Yuichi, & Shibata, Akihisa. 1993. Dynamic analysis of an endogenous growth model with public capital. *The Scandinavian Journal of Economics*, **95**(4), 607–625.

Glomm, Gerhard, & Ravikumar, B. 1994. Public investment in infrastructure in a simple growth model. *Journal of Dynamics and Control*, **18**(6), 1173–1187.

Glomm, Gerhard, & Ravikumar, B. 1997. Productive Government Expenditures and Long-Run Growth. *Journal of Dynamics and Control*, **21**(1), 183–204.

Gomez, Manuel A. 2004. Optimal fiscal policy in a growing economy with public capital. *Macroeconomic Dynamics*, **8**(4), 419–435.

Gomez, Manuel A. 2008. Fiscal policy, congestion and endogenous growth. *Journal of Public Economic Theory*, **10**(4), 595–622.

Goolsbee, Austan. 2000. What Happens When You Tax The Rich? Evidence From Executive Compensation. *Journal of Political Economy*, **108**(2), 352–378.

Gruber, Jon, & Saez, Emmanuel. 2002. The elasticity of taxable income: evidence and implications. *Journal of Public Economics*, **84**, 1–32.

Indicators, World Development. 2014. *Washington DC: World Bank*, **doi:10.1596/978-1-4648-0163-1. License: Creative Commons Attribution CC BY 3.0 IGO**.

Irmen, Andreas, & Kuehnel, Johanna. 2009. Productive Government Expenditure and Economic Growth. *Journal of Economic Surveys*, **23**(4), 692–733.

Islam, Nazrul. 1995. Growth empirics: A panel data approach,. *Quarterly Journal of Economics*, **110**(4), 1127–1170.

Karingi, Stephen N., Kimenyi, Mwangi S., & Ndung'u, Njuguna. 2001. Beer Taxation in Kenya: An Assessment. *KIPPRA Working Paper.*

Kiringai, Jane, Ndung'u, Njuguna, & Karingi, Stephen N. 2002. Tobacco Excise Tax in Kenya: An Appraisal. *KIPPRA Working Paper.*

Lee, Young, & Gordon, Roger H. 2005. Tax structure and economic growth. *Journal of Public Economics*, **89**(5-6), 1027–1043.

Mankiw, Gregory N., Romer, David, & Weil, David. 1992. A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, **107**(2), 407–437.

Njeru, James, Ojwang'i, Douglas, Ronge, Eric, & Wanjala, Bernadette. 2005. Implicit taxation of the agricultural sector in Kenya. *KIPPRA Working Paper.*

of Public Expenditure for Economic Development, Statistics. 2013. *International Food Policy Research Institute.*

of Statistics, Kenya National Bureau. 2009-15. Economic Survey. *Nairobi, Government Press.*

Ojede, Andrew, & Yamarik, Steven. 2012. Tax policy and state economic growth: The long-run and short-run of it. *Economic Letters*, **116**(2), 161–165.

Piketty, Thomas, & Qian, Nancy. 2009. Income Inequality and Progressive Income Taxation in China and India, 1986-2015. *American Economic Journal:Applied Economics*, **1**(2), 53–63.

Rebelo, Sergio. 1991. Long-Run Policy Analysis and Long-Run Growth. *The Journal of Political Economy*, **99**(3), 500–521.

Schaltegger, Christoph A., & Torgler, Benno. 2006. Growth Effects of Public Expenditure on the State and Local Level: Evidence from a Sample of Rich Governments. *Applied Economics*, **38**(10), 1181–1192.

Slemrod, Joel. 1996. High Income Families and the Tax Changes of the 1980s: The Anatomy of Behavioral Response. *In: Martin Feldstein and James M. Poterba (Eds) Empirical Foundations of Household Taxation.*

Turnovsky, Stephen J. 1997. Fiscal Policy in a Growing Economy With Public Capital. *Macroeconomic Dynamics*, **1**(3), 615–639.

Turnovsky, Stephen J., & Fisher, Walter J. 1995. The composition of government expenditure and its consequences for macroeconomic performance. *Journal of Economic Dynamics and Control*, **19**(4), 747–786.

Villanueva, Delano, Knight, Malcolm D., & Loayza, Norman. 1993. Testing the neoclassical theory of economic growth - A panel data approach. *International Monetary Fund Staff Papers*, **40**(3), 512–541.

Yamarik, Steven. 2000. Can tax policy help explain state-level macroeconomic growth? *Economic Letters*, **68**(2), 211–215.

Zheng, Dan, & Kuroda, Tatsuaki. 2013. The Role of Public Infrastructure in Chinas Regional Inequality and Growth: A Simultaneous Equations Approach. *The Developing Economies*, **51**(1), 79–109.