The impact of Education Expenditure, Tertiary Enrolment and Innovation on Economic Growth in South Africa.

By

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Student No. 200951037

Submitted to the Faculty of Commerce, Administration and Law in Fulfillment of the Requirements for the M Com (Economics) Degree

University of Zululand

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Declaration

I, the undersigned, hereby acknowledge that the contents of this dissertation is my own work, except where otherwise specified, and has not been submitted, in part or full, to any other University for the purpose of obtaining a degree.

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Abstract

The primary focus of this study is to employ a Cob-Douglas production function to estimate relationship between the GDP and it determinants viz. labour, capital, tertiary enrolment, education expenditure and innovation for South African economy over a period 1983 to 2012. This task will be accomplished by applying cointegration techniques, Johansen's (1988) vector autoregression (VAR) methodologies and error correction mechanisms to capture short run disequilibrium between GDP and it determinants. Specifically the main objective of this study is to investigate how labour, capital, education expenditure, tertiary enrolment and innovation impacted on economic growth in South Africa. Moreover this study will attempt to study the dynamic interactions between the variables - economic growth, labour, capital, tertiary enrolment, expenditure on education and innovation - under consideration in order to identify long and short run relationship. However before the empirical analysis is conducted the study will first attempt to explain the relevant theories of growth and the experiences of the emerging economies, which will then serve as basis for examining South African growth experiences and policy prescription, for the purposes of understanding the South African growth phenomenon and choosing appropriate determinates of economic growth.

The study found that the VECM, FMOLS, CCR, DOLS and ARDL methods strongly suggest the existence of a long run cointegrating relationship between economic growth, labour, capital, enrolment, expenditure and innovation that is consistent with economic theory in all cases except for the ARDL model. The ARDL model generated a negative long run coefficient capturing the effect of education expenditure on economic growth; while the remainder of the models all concurs that there is a positive relationship. Moreover all the single equation models agree that labour, capital, education expenditure, enrolment and patents all have a statistically positive impact on economic growth.

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List of Acronyms Used

ADF – Augmented Dickey Fuller Test

ARDL- Autoregressive Distributed Lag

CCR- Canonical Cointegration Regressions

DBSA - Developmental Bank Of South Africa -

DF – Dickey Fuller

DFGLS – DF with Generalized Least Squares Detrending

DHET- Department of Higher Education and Training

DOE- Department of Education

DOLS- Dynamic Ordinary Least Squares

DTI -Department of Trade and Industry

ECM – Error Correction Model (or Mechanism)

ERS – Elliot, Rothenberg and Stock Point Optimal Test

FMOLS- Fully Modified Ordinary Least Squares

GDP – Gross Domestic Product

GLS – Generalized Least Squares

KPSS – Kwiakowski, Philips, Schmidt and Skin Test

LDC -Less Developed Countries

NEDLAC – National Economic Development and Labour Council

OECD – Organisation for Economic Cooperation and Development.

OLS – Ordinary Least Squares

NDP - National Development Plan

NPC-National Development Commission

SETA- Sector Education and Training Authorities

NSA- National Skills Authorities

NSFAS- National Student Financial Aid Scheme

SASSETA- Safety And Security Sector Education and Training Authorities

SSP- Sector Skills Plan

VAR – Vector Autoregression (model)

VECM – Vector Error Correction Model

Chapter 1: Introduction

1.0 Introduction

The primary focus of this study is to employ a Cob-Douglas production function to estimate relationship between the GDP and it determinants viz., labour, capital, tertiary enrolment, education expenditure and innovation for South African economy over a period 1983 to 2012. This task will be accomplished by applying cointegration techniques, Johansen's (1988) vector autoregression (VAR) methodologies and error correction mechanisms to capture short run disequilibrium between GDP and it determinants. The primary objective of this study is to investigate how labour, capital, education expenditure, tertiary enrolment and innovation impacts on economic growth in South Africa. Moreover this study will attempt to study the dynamic interactions between the mentioned variables in order to identify long and short run relationships. Before the empirical analysis is conducted the study aims to provide a brief summary of the traditional growth theories that focus on capital and labour. it will also incorporate modern growth theories that identify the linkages between economic growth, education, investment on education and innovations. Moreover, the experiences of the emerging economies, will then serve as the basis for examining South Africa's growth experiences and policy prescriptions, for the purposes of understanding the South African growth phenomenon and choosing appropriate determinates of economic growth.

Mainstream economics sees labour productivity as the central problem for the understanding of economic development. A high growth rate in labour productivity in the 1990s for South Africa was considered by Blinder and Yellen (2002) as the driving force of the outstanding economic performance. According to studies by Kitov and Kitov (2008), in developing economies economic growth is the main stimulus to productivity increases. This study will assess to what extent tertiary enrolment, expenditure on education and innovation has impacted on economic growth. To the best of my knowledge only one study was done that focused on South Africa by Babatunde and Babatunde (2005), they found that education and economic growth tend to move in the same direction, The details of this study is discussed in chapter three of this dissertation. Their study employed the VAR model, and their study used the primary education as a measure of the human capital, the innovation were not even considered in their model. Given that little is known about the relationship between the above mentioned variables for the

South African economy, it is imperative that more studies be conducted for the purpose to inform policy.

1.1 Background

Education, training and innovation are central to South Africa's long term development; they are considered to be the core elements in eliminating poverty and reducing inequality, and developing the foundations of an equal society. Education empowers people to define their identity, take control of their lives, raise healthy families, take part confidently in developing a just society, and play an effective role in the growth and development of the economy NPC (2011). Education, training and innovation are not a solution to all problems, but are a society's ability to solve problems. Schools and tertiary institutions are the building blocks for development of individuals in the country. Countries with better educated citizens have a comparative advantage when it comes to the productivity of their work force.

Low productivity among South African labour is a major concern to South Africa's economic participants or stakeholders (government and firms), compared to other emerging economies such as Brazil, China, Indonesia, Kenya and Egypt. The economy of the country depends on its rate of productivity, if the country is more productive its GDP is higher, and a higher GDP implies economic growth. There are various factors that contribute to the productivity of the country, such as natural endowments, technology, investment, the socio-political disposition and human capital. Education is however important factor influencing the long term economic growth and prosperity of a country. Many studies have found a positive relationship between education and productivity, for example Fernando (2004), Colombe et al., (2004).

South Africa shares some common characteristics with other developing countries. For instance, Egypt has established standard assessments that cut across the various types of institutions delivering education, there are similar developments in South Africa with the introduction by government of Annual National Assessments. Another commonality relates to administrative complexities. The Egyptian system is highly complex with the responsibility of providing education being shared between the federal government, the states, and local government. In the case of South Africa, the national government is responsible for policy oversight, while the actual delivery happens at provincial level, which may be slightly less

complex than Egypt, but, nevertheless still creates problems in South Africa, (Denise and Mehmet, 2012).

South Africa urgently needs to expand and improve its higher education sector. The country needs to enlarge its skills base significantly, to give young people a better chance of finding employment, and produce a larger supply of better-trained teachers and tertiary educators. All of these goals can be addressed by expanding access to and improving the quality of education institutions, both at the secondary and higher levels. Another problem in South Africa is that the concept of multi-purpose college institutions has never been applied. In the past there were teaching, nursing, or police colleges, but middle level, post-school institutions – which are not universities – have never been developed extensively in this country, CDE Round Table (2011). South Africa does not exhibit an appropriate sense of urgency with respect to the country's crisis in education. Despite comparatively high government expenditure, and very poor outcomes in terms of student performances, the severity of the situation is not sufficiently recognised, NCHE (2011). Hence, this study will attempt to quantify the impact of education expenditure on economic growth, employment creation and capital formation over both the short and long term.

Creativity and innovation are considered crucial tools for enhanced productivity, economic growth and sustainable development. Education and training are seen to contribute to the promotion of these capacities. Expansion of the size, quality and diversity of post-school education in South Africa is vitally important and without this, it is hard to see how we can meet critical national goals. Growing the economy, developing a highly trained civil service, encouraging business expansion, reducing unemployment, and strengthening the home-grown supply of well-trained educators all depend on access to tertiary education and its quality. Investing in education and skills has long been considered a key driver of increased productivity and economic growth both in the academic literature and by practitioners. Despite this widespread belief that the investment in human capital development is a key determinant of economic growth, the empirical estimates especially focusing on developing countries like South Africa are less than conclusive (OECD 2011b). Hence this serves as added justification to quantify the impact of state education expenditure, tertiary enrolment rate and innovation (proxy by patent registration) on economic growth in the South African economy

This study has never been conducted before in the context of South Africa. The statistically tested relationship between economic growth, public expenditure on education, tertiary enrolment rates, and innovation, and will produce critical insights into the workings of the South African economy. The findings of this study will produce vital information to policy makers for planning purposes.

Finally, The study conducts the statistical analysis using advanced methodologies that are currently in vogue, which include the vector error correction models (VECM), fully modified ordinary least squares (FMOLS), dynamic ordinary least squares, canonical cointegration regressions (CCR) and autoregressive distributed lag (ARDL) approaches.

This study is divided into six chapters. Chapter one is outlined above. Chapter two, outlines the main theoretical approaches modelling the linkages between human capital, spending on education, innovation, tertiary enrolment and economic performance, together with a methodological description of the empirical analyses erected upon such theory. The theoretical basis of education on economic growth is rooted in the endogenous growth theory. Endogenous growth economists believe that improvements in productivity can be linked to a faster pace of innovation and extra investment in human capital. Endogenous growth theorists argue the need for government and private sector institutions and markets which nurture innovation, and provide incentives for individuals to be inventive.

Chapter three, reviews evidence from labour economics, it also attempts to provide a summary of a vast empirical literature, the emphasis will be on how the conventional findings should be interpreted, and to what extent we can infer actual effects of education enrolment (tertiary enrolment), innovation, education expenditure on productivity and other variables that contribute to economic growth. The rest of chapter three firstly sets out the empirical work, micro studies. The micro-level approach aims to explain the variation in individual earnings by regressions, where the independent variables are usually years of schooling and a proxy for experience – such as years of experience or age. Secondly this chapter elaborates on macro studies and the last part deals with South African literature which includes the National Development Plan, government policy documents and empirical studies.

The first objective of chapter four is to specify the theoretical model known as the Cobb Douglas Function that will be used to estimate the statistical relationship between economic growth (the

dependent variable) and a set of causal factors (independent variables) including education expenditure, tertiary enrolment, innovation, labour and capital. In addition the sources, frequencies, and units of measurement of mentioned variables will be described and a justification for their selection will be presented. The second objective of this chapter is to specify the econometric methodologies used in this study, which begins with the stationarity tests followed by the test for cointegration, thereafter the Johansen (1990) and Johansen and Juselius (1991) VAR/VECM approach to estimating cointegrating relations will be outlined. The validity and reliability of the results obtained by the VAR/VECM methodology will be verified by comparing them to the single equations methodologies of FMOLS, DOLS, CCR as well as the results obtained from the single equation ARDL model that incorporates an error correction component.

Chapter five, this chapter gives a detailed account of the empirical estimation procedure that was undertaken, together with a presentation and interpretation of the results. As mentioned previously the primary focus of the empirical investigation is to derive the long run cointegration relationship between economic growth and it determinants and exploit these relationships to derive short run models, which include error correction models that explains the adjustment of the economic growth as a result of a temporary deviation from it long run equilibrium due to the temporary shock on it determinants base on the estimated model. This chapter also presents the results from the single equation cointegrating models and compares them to the results obtained from the VAR/VECM models. Lastly, the chapter summarises the overall findings of the empirical investigations.

Chapter six, concludes the study by summarising the quantitative investigation, discussing the overall significance of the result and its relevance to macroeconomic policy prescriptions. Additionally s few strengths and main weaknesses of this study, which future studies ought to rectify are mentioned.

Chapter 2: Theoretical Literature Review

2.0 Introduction

The aim of this section is to outline the main theoretical approaches modelling the linkages between human capital, spending on education, innovation, tertiary enrolment and economic performance, together with a methodological description of the empirical analyses erected upon such theory. The theoretical basis of education on economic growth is rooted in the endogenous growth theory. Endogenous growth economists believe that improvements in productivity can be linked to a faster pace of innovation and extra investment in human capital. Endogenous growth theorists argue the need for government and private sector institutions and markets which nurture innovation, and provide incentives for individuals to be inventive.

2.1 The Solow (or neo-classical) model

The Solow growth model is the starting point to determine why growth differs across similar countries it builds on from the Cobb-Douglas production model by adding a theory of capital accumulation developed in the mid-1950s by Robert Solow. Capital stock is "endogenized": converted from an exogenous to an endogenous variable and the accumulation of capital is a possible engine of long-run economic growth. The Solow growth model expanded on Cobb-Douglas production model and adds an equation describing the accumulation of capital over time Demographics: the Solow model assumes that population growth is exogenously determined with a constant rate of increase equal to $n \geq 0$. The Solow-tradition growth theory is based on the following production function:

$$Y(t) = F[K(t), A(t), L(t)] \quad \text{.....(1)}$$

Where Y is output, K is physical capital, A is an index of overall productivity, and L is the labour force; there are constant returns to scale and decreasing returns to capital. With these assumptions, income growth can come from the increased efficiency of productive inputs, i.e. an increase in A, or the augmentation of such inputs, i.e. an increase in K and/or L. Positive growth rates can be sustained if and only if the decreasing returns to the accumulation of capital are offset by population growth, or if the marginal productivity of capital is constantly shifted upwards by technical progress.

In balanced growth equilibrium - i.e. given a constant savings rate - there will be no depreciation of the capital stock and, assuming $A(t)$ is constant, output and capital will grow at the rate of

population growth. Differences in the time path of the scale factor *A(t)* explain countries' different growth experiences. This exogenous source of growth has been interpreted as technical progress. Policy has little scope in affecting long-run growth in this setting. Investment and savings behaviour impacts on the level of per capita income, but has no effect on the long-run growth rate. Policies can raise the long-term growth rate by speeding up technical innovation or knowledge accumulation, but the theory itself suggests no mechanisms whereby this could be achieved. There are neither invention costs - costs associated with the development of new technologies - nor adoption costs - costs associated with making use of new technologies. Consider the definition of the aggregate production function, where GDP is modelled as a function of the aggregate stock of physical capital in the economy, its labour force, and time, capturing an otherwise unmodeled 'technical progress. Solow-Swan model anticipate that the aggregate output depends on the quantities of physical capital and the labour. However, empirical research shows that the primary source of the economic growth is the level of technology. The mechanisms that produce new technology and enhance human capital formation are widely discussed by the studies on economic growth. Both theoretical models and empirical research show that, in addition to learning-by-doing, education is one of the main instruments to improve the human capital. Furthermore, for the developing economies, Barro and Lee (2000) stressed that the well educated human resources can also help facilitate the absorption of advanced technology.

The Solow growth model is not directly relevant to this study because it mostly focuses no exclusion of human capital as a factor that can influence the economic growth. The Solow model only focused on capital and labour, Ehrenberg and Smith (2009). However if labour input can be expanded to include human capital then the model becomes relevant, however Romer (1990) eventually captures this point in his endogenous growth model. However capital and labour are important control variables in the econometric modelling that are covered in chapter 4

2.3 The 'New Growth Theories'

In contrast to the traditional neo-classical Solow growth model, these recently emerged "new growth economics" theories emphasize the endogenous determination of growth rates, which are determined within the model and can thus be affected for example, by government policies, instead of being driven by exogenous technological progress. While education has no role in traditional neo-classical theories of economic growth, these new approaches have explicitly

brought the role of education to the fore. They provide the theoretical argument for assuming that education can affect national economic growth through two main channels, namely, human capital is explicitly incorporated as a factor input in the production function, by - in contrast to the augmented neo-classical model – explicitly modelling individual educational investment choices, as well as by often allowing human capital to have external effects, thus departing from the constant returns to scale assumption and the factors leading to endogenous growth are explicitly related to the stock of human capital. This may be either because human capital is assumed to directly produce new knowledge/technology or because it is an essential input into a research sector which generates new knowledge/technology. Accordingly there are two strands of thought in the new growth approaches, that respectively focus on the effects of the accumulation (or "flow") of human capital and the stock of human capital. This distinction has implications. In particular, any measure such as a subsidy to education which raises the level of human capital will have a once and-for-all effect on output in the first framework, but will increase the growth rate of the economy forever in the second one.

The new growth theory drops two central assumptions of the Solow model, that technological change is exogenous, and the same technological opportunities are available in all countries. In addition, the assumption of decreasing returns to a narrow concept of capital (including only physical capital) is replaced by the assumption of constant returns to a broad measure of capital (including also human capital and infrastructure). New growth models treat technology and knowledge as economic goods in an attempt to understand the determinants of long term growth based on learning-by-doing or investment in human capital and new technologies. Contrary to the standard neoclassical models and that by Arrow (1962), there are invention costs in the creation of new technology, and there are adoption costs associated in particular with creating the human capital required to use a new technology. Adoption costs have a direct component in the form of investment outlays for schooling, on-the-job training, etc., as well as an indirect component, such as in the form of foregone output. Endogenous growth models can be distinguished according to whether they emphasize invention costs or adoption costs.

New growth models differ as to what mechanism is employed to endogenize the impact of technical progress on growth. The mechanisms in early models (Romer, 1986; Lucas, 1988) are dynamic externalities at the aggregate level, i.e. technology is endogenously provided as a side-effect of private investment decisions. Romer (1986) assumes that the stock of knowledge of a firm increases in proportion to the firm's expenditure on research and development, while

spillovers from these private investments increase public knowledge. In the absence of an effective patent market, the stock of knowledge is like a public good. Even though Romer's model is similar to Arrow's, technological change is endogenized, since in his model long-term growth is driven primarily by the creation of new knowledge by forward-looking, profit-maximizing, private agents. The investment which creates new knowledge displays diminishing returns. But, given the knowledge spillovers due, for example, to the inadequacy of patent protection, the production of goods from new knowledge exhibits increasing returns. Since new knowledge is produced from investment with diminishing returns, each profit-maximizing private agent who invests in knowledge creation - and hence incurs invention costs - faces an optimal upper limit to his investment. Thus, technical change should be responsive, endogenously, to policy, such as tax and fiscal incentives.

The model by Lucas (1988) is also similar to Arrow's (1962). However, the spillover effects which increase the level of technology stem from investment in human capital rather than in physical capital. The model focuses on general skills and in particular those which cannot be separated from the worker who has acquired them. Knowledge grows with the time spent on education and the efficiency with which this time is translated into human capital. This efficiency is associated with different factors depending on whether education is understood as schooling or as learning-by-doing. Regarding schooling, efficiency increases with the quality of schooling which, in turn, improves with increased general knowledge. Here, the mechanism of raising long-term growth is learning or doing rather than learning-by-doing. Differences in long-term growth are the result of different rates of human capital accumulation, stemming from differences in countries' time allocation decisions. Regarding learning-by-doing, efficiency is associated with the type of process workers are engaged in: "one might think of some activities as carrying with them a high rate of skill acquisition and others, routine or traditional ones, as associated with a low rate. If so, the mix of goods a society produces will affect its overall rate of human capital accumulation and growth" Lucas, (1993). A country's initial comparative advantage determines the goods it produces, and hence its rate of human capital accumulation and growth.

Neo-Schumpeterian growth models employ temporary monopoly profits, which motivate the discovery of new technology, as the mechanism to endogenize the impact of technological progress on growth. This branch of new growth models introduces conditions of imperfect competition at the micro-level of production, emphasizing the importance of temporary

monopoly power as a motivating force for the intentional investment of resources by profit-seeking firms or entrepreneurs in the innovative process. In these models, growth depends on the incentives to invest in improving technology. It is also important to note that the appropriability of (new) knowledge is related to lead times over rival inventors and imitators rather than to effective patent protection. The models are based on the assumption that there are inventions but no adoption costs. The invention costs are fixed-cost expenditures which occur, for example, through the need to conduct research and development for the invention of new designs; the inventors sell these designs to producers of goods that are new Romer, (1990). The competitive equilibrium solution of the neoclassical model cannot be sustained where such fixed costs are important because, if this is the case, decentralized market valuations of the economic efficiency of an investment project diverge from valuations at the aggregate level. As a result, no such investment will take place if at least part of the expenditure cannot be recovered through monopoly profits.

The approach focusing on invention emphasizes ideas which can be used by many workers once they are created, i.e. disembodied human capital, through a research and development effort by a small subset of educated workers. Policies that raise the incentive of this group of workers to innovate consciously raise the question of long-term growth. Romer (1990) explains that the basic difference between ordinary tangible goods, such as capital and knowledge, is that the latter is a non rival and partially non-excludable good. The feature of non-rivalry means that knowledge can be used in more than one place at any one time; while the feature of non-excludability means that the creators or owners of knowledge can exclude others from making unauthorized use of it only with difficulty. Knowledge may be considered a partially non-excludable good because one type of knowledge, namely product-specific information, can be protected through patents, while more general technical information which may allow for subsequent inventions cannot be hidden from rival innovators and is much more difficult to appropriate. Technological spillovers associated with the latter feature maintain investment incentives endogenously and allow successive inventions to use fewer resources than their predecessors because, contrary to inputs of capital and labour, it is not necessary to replicate non-rival inputs. The resulting fall in the real cost of invention counteracts the falling marginal product of investment. "In short, the process of knowledge accumulation generates endogenously the productivity gains that sustain growth in the long run" Grossman and Helpman, (1994)

A third class of new growth models distinguishes human capital from technology as well as different types of each. They include both invention and adoption costs but focus on the latter. Young (1993a) and similarly Lucas (1993) criticize the discussed models of invention and models of learning as focusing on two extreme cases of the process of accumulation of human capital. In particular, Young (1993a) points to the unrealistic assumption in the learning approach "that the potential productivity gains from learning are essentially unbounded", since making this assumption does not allow "to explain the recurring pattern of technological improvement and stagnation apparent in pre-modern history".14 This approach also implies the assumption that, contrary to the invention approach, new technologies are not considered to attain their full production potential at the moment of their invention but that they initially are broadly inferior to the older technologies they seek to replace. This means that these models add a complementarity element of innovation to the Schumpeterian emphasis on substitution.

Young concentrates on the interaction of factors emphasized in the learning and invention approach, starting from the basic assumption that the potential of "learning in the production of any particular good, using any particular process, is in fact finite and bounded. When a new technical process is first invented, rapid learning occurs as, by virtue of experience, the productive potential of technology will be approached and learning will slow and, perhaps, ultimately stop. In the absence of the introduction of new technical processes, it is unlikely that learning-by-doing can be sustained" (Young, 1993a). This means that Young emphasizes the existence of a technology ladder in the production of goods ordered by increasing technical sophistication, with the result that countries have to combine efforts at learning by-doing and innovation in order to fully exhaust their potential in human capital accumulation.

The consideration that, in the absence of further invention, learning is bounded has important implications for diversification. If the potential for learning-induced productivity improvements in each good is finite and bounded, then the potential maximum accumulation of knowledge in an economy is determined by the number and variety of activities as well as by the level of technology mastered by the labour force, compared to that required to exhaust fully the learning potential incorporated in the production of a given set of goods. Accordingly, if an economy continues to produce the same narrow range of goods, its learning-induced productivity improvements are likely to peter out. It also means that neither the presence of state-of-the-art technology nor a highly-skilled labour force alone is sufficient for the full exhaustion of an

economy's learning potential, but that the introduction of new technologies and the commensurate up-grading of skill-related knowledge must go hand in hand.

It is important to note that in such cases the estimated increase in productivity is not simply a phenomenon in the transitional period as the increase in the flow of education leads to a gradual increase in the equilibrium human capital stock. Implicit is the claim that increasing average education in an economy will permanently increase the rate of economic growth, even after the human capital stock has adjusted to its new long-run level.

2.4 Growth accounting

As we have seen, the labour economics literature provides a wealth of evidence on the private returns to schooling. It is necessarily silent, however, on the contribution of education relative to other sources of aggregate growth. Making assumptions similar to those of labour economists, researchers in the growth accounting tradition have set about the complex task of evaluating the overall growth contribution of changing educational attainment.

Growth accounting essentially divides output growth into a component that can be explained by input growth, and a “residual” which captures efficiency change, partly reflecting changes in technology. In explaining the change in output, the change in the quantity of each input is weighted by its marginal product, proxied by its market reward. This principle can be extended to any number of inputs, and where sufficiently detailed data are available; it is possible to disaggregate the labour force into various categories, where each type of worker is weighted by the average wage of that type. For instance, in analysing the contribution of changes in educational attainment, the researcher disaggregates the labour force by level of schooling, and often by other available characteristics such as age and gender. Changes in the number of employees at each level of schooling are then weighted by their marginal products, proxied by the mean income associated with each schooling level, to give the overall change in an index of “effective” or quality-adjusted labour.

This ultimately allows the researcher to quantify the proportion of output growth that can be directly attributed to increases in educational attainment. Griliches (1997) provides a brief but useful survey of this literature, and points out the two major assumptions, both of which will have a familiar ring to readers of the previous section. First, it is assumed that differences in

observed market rewards correspond reasonably closely to differences in marginal products. Secondly, the calculations assume that differences in market rewards across schooling levels originate in schooling, and not in other factors such as native ability or family background that may be correlated with schooling.

The advantage of the first assumption, that market rewards correspond to marginal products, is that it allows the growth accountant to obtain theory consistent weights using the available data, at least under the assumptions of constant returns to scale and perfect competition. Less restrictive frameworks are possible, but will generally tend to require additional and perhaps controversial assumptions about parameters. It should also be clear that conventional growth accounting will not shed any light on the possible contribution of externalities.

This is a major limitation, and an important motivation for the cross-country empirical studies that will be considered further below. What of the second assumption, that differences in wages originate in schooling? The danger here can be seen from considering an extreme scenario, in which education has absolutely no effect on an individual's productivity, but more able individuals both spend longer in school and earn more while in employment. This scenario clearly implies that educational attainment and earnings are positively correlated. Now consider an exogenous increase in the proportion of individuals with the highest level of education: since the index of labour quality weights the numbers in each education class by the mean income of that class, the index must increase. As a result, the growth accountant will attribute some portion of growth to educational improvement, even though education plays no role in productivity gains. This implies that, as in the labour economics literature, growth accounting can give us some insight into the productivity contribution of education, but the answers are by no means complete or conclusive.

Before describing the results of growth accounting exercises in more detail, it is important to clarify the connection between changes in educational provision and the measured effects. An expansion in provision typically affects only younger cohorts, and so has long-lived effects on educational attainment in the labour force as a whole. Average attainment will continue to increase for some time as older; less educated cohorts retire from employment and are replaced by the more highly qualified. When using growth accounting methods, it is these long-lived effects that are quantified, and one should bear this in mind when interpreting specific

findings. The practical implication is that results for recent years are driven by changes in educational provision much further back in time.

Growth accounting exercises vary widely in the extent to which they disaggregate labour input. Nearly all the studies which carry out a detailed disaggregation by level of schooling are restricted to the United States; the classic study is Jorgenson, Gollop and Fraumeni (1987). For the period 1948-79, they find that growth in labour input has contributed about a third of growth in aggregate value added, where the measure of labour input takes into account both hours worked and the quality of labour. Changes in their aggregate index of labour quality are based on changes in the composition of total hours worked by age, sex, education, employment class and occupation. They find that a favorable shift in labour quality is responsible for about a tenth of the growth in value added, or about a fifth of the productivity residual that remains after accounting for the contribution of growth in physical capital.

In interpreting the results of Jorgenson, Gollop and Fraumeni, it is important to note that some of the compositional shifts within the labour force have a negative effect on the index of labour quality over the 1948-79 period, which partly offset the benefits of improvements in educational attainment. As previously noted, the calculation of the labour quality index assumes that differences in market rewards reflect genuine differences in marginal products. One consequence is that the increasing entry of women and young workers into the labour market, mainly into low-paying jobs, has a negative effect on the aggregate index of labour quality. Over the 1948-1979 periods, the negative effect on the index of labour quality is more than offset by positive changes in the composition of the labour force by educational attainment and occupation. One implication is that the latter effects are likely to be responsible for more than a fifth of the productivity residual, since the favorable shift in labour quality would have been larger in the absence of the change in composition by age and sex.

In reviewing the evidence as a whole, Griliches (1997) writes that increases in educational attainment seem to have accounted for perhaps a third of the productivity residual in the US over the post-war period. In the 1950s and 1960s, this would correspond to an effect on the annual growth rate of aggregate output of around 0.5 percentage points; during the 1970s productivity slowdown the effect of educational improvement will have been lower, perhaps raising the growth rate by 0.2 or 0.3 percentage points. As discussed above, these effects are inherently transitional ones, driven by long-standing changes in education policy that shift the

educational composition of the labour force towards a new steady state. Other OECD Member countries have also seen important changes in educational attainment in the last fifty years. Englander and Gurney (1994*a*) note that tertiary education in particular has expanded rapidly in many OECD countries since 1960.

The best known studies covering a number of developed countries for recent years are those of Maddison (1987, 1991). Maddison (1991) argues that the 20th century saw a fairly steady improvement in educational attainment for the six countries he considers (France, West Germany, Japan, the Netherlands, the UK and the US). One implication is that changing trends in educational attainment are unlikely to provide a satisfactory explanation for the transition from Europe's "Golden Age" of rapid growth (1950-1973) to the productivity slowdown after 1973. For these six countries, Maddison estimates the growth impact of changes in educational attainment by disaggregating the labour force into those with primary, secondary and higher qualifications. He then combines these three different types of labour using weights that are the same across countries and over time. In selecting the weights, he follows Denison (1967) in assuming that observed educational wage differentials overstate the contribution of education to productivity, for the reasons discussed in the previous section. Inevitably, the adjustments made are somewhat arbitrary, but they do serve to highlight the uncertainty inherent in the general approach. The other point to note is that, because of these adjustments, the estimates of Denison and Maddison are not directly comparable with those of other studies.

With all this in mind, we can turn to Maddison's results on the contribution of increases in labour quality to output growth in France, West Germany, Japan, the Netherlands, the UK and the US. His figures suggest that changes in the quality of the labour force typically added between 0.1 and 0.5 percentage points to annual growth rates between 1950 and 1984. The Maddison index of labour quality takes into account changes in the male/female composition (though not age composition) of the labour force, as well as changes in educational attainment. In countries where the proportion of women in the labour force has noticeably risen, such as the UK and the US, the contribution of education to growth will be slightly higher than the reported contribution of growth in labour quality.

More recent studies include that of Jorgenson and Yip (1999), who have recently carried out a detailed growth accounting exercise for the G & members country, and present estimates of growth in labour quality for 1960-1995. These estimates suggest that labour quality has grown

particularly quickly in Japan, and to a lesser extent, relatively quickly in France and the US. The Jorgenson-Yip disaggregation of the labour force is slightly finer than that adopted by Maddison, and this makes it harder to assess the role of education within changes in the overall index of labour quality.

A useful survey by Englander and Gurney (1994*b*) draws together the results of a number of studies for the G7, although some of this evidence is based on regressions rather than growth accounting. Their summary suggests that for the 1960s to 1980s the growth of human capital (sometimes including demographic effects, of the kind discussed above) typically accounts for a tenth to a fifth of growth in total output. For those countries, like the US, where there has been a rapid increase in employment, these figures probably slightly understate the proportion of growth in output per worker that can be attributed to rising attainment.

Another OECD country for which recent and detailed growth accounting results are available is Korea. The most influential contribution is that of Young (1995), who examines and compares the growth performance of four East Asian economies. For the purpose of the present survey, the case of Korea is particularly interesting in that the country has seen a dramatic increase in the educational attainment of the labour force. Between 1966 and 1990, the proportion of the working population with secondary level education or higher roughly trebled, from 27 per cent to 75 per cent. Yet this dramatic expansion does not translate into an equally dramatic effect on the growth rate, at least under the assumptions of growth accounting. For each of the four economies he considers, Young finds that the improving educational attainment of the workforce raised the annual growth rate of effective labour input by about 1 percentage point Young (1995).

I end this part by noting an essential qualification to the results above, and a possible extension to the conventional approach. All growth accounting results require careful interpretation, because the approach does not tell us everything we need to know about the relevant counterfactual. As an example, consider a claim that X percentage points of growth in a given country is due to a change in the quality of the labour force. This does not imply that, in the absence of the change in labour force quality, the growth rate of output would have been precisely X percentage points lower. The problem is that educational attainment may have other, indirect effects on output through labour force participation, investment, and even R&D and the growth of total factor productivity. Growth accounting does not capture these indirect

effects, and so gives only a partial picture of the overall importance to growth of variables like education.

Finally, although accounting decompositions are usually applied to growth rates, the same ideas can be applied to decompositions of output levels. We can then ask questions such as: to what extent do differences in educational attainment explain the variation in GDP per capita across South Africa or the emerging economies? Research applying such ideas is just starting to emerge, and Woessmann (2000) discusses the approach in more detail. Working on the assumption that measured private returns to schooling are capturing a genuine productivity effect of education, his analysis suggests that differences in educational attainment account for most of the output variation across OECD Member countries.

2.5 The growth effect of education

The interrelation between education and economic growth has been discussed since ancient Greece. Adam Smith and the classical economists emphasized the importance of investment in human skills. Early attempts to measure the contribution of education to economic growth were based either on the growth accounting approach or on the rate of return to human capital.

However, it was not until late in the twentieth century that researcher undertook formal and scientific analysis of this relationship. Several studies have investigated the relationship between economic growth and education such as De Meulmester *et. al., (*1995); Jorgenson and Fraumeni, (1998). Their starting point was always the root of the economic growth itself. The pioneer theorists hypothesized that economic development depended on the increase of capital and the labour factor in the productive processes. A fundamental reason for economic growth was found to be the increase of productivity in these factors of production. Whereas researchers affirmed that correlations exist across countries between economic growth rates and schooling enrolment rates including enrolment in higher education, another group of researchers such as De Meulmester *et. al.* (1995), using more sophisticated econometric techniques, found that this relationship is not always a direct one.

One of the most prominent and influential contributions is that of Lucas (1988), which is in turn related to previous work by Uzawa (1965). In these models, the level of output is a function of the stock of human capital. In the long run, sustained growth is only possible if human capital can grow without bound. This makes it difficult to interpret the Uzawa-Lucas conception of

human capital in terms of the variables traditionally used to measure educational attainment, such as years of schooling. Their use of the term “human capital” seems more closely related to knowledge, rather than to skills acquired through education. One way to relate the Uzawa-Lucas model to the data is to suggest that the quality of education could be increasing over time Bils and Klenow, (2000). In this view, the knowledge imparted to school children in the year 2000 is superior to the knowledge that would have been imparted in 1950 or 1900, and will make a greater difference to their productivity in later employment. Even if average educational attainment is constant over time, the stock of human capital could be increasing in a way that drives rising levels of output.

Yet this argument runs into difficulties, even at the level of university education. There may be some degree courses in which the knowledge imparted currently has a greater effect on productivity than before (medicine, computer science, perhaps economics) but there are other, less vocational qualifications for which this argument is less convincing. At the level of primary and secondary schooling, with their focus on basic skills such as literacy and numeracy, the idea that increases in the quality of schooling drive sustained growth seems even harder to support. Finally, note that these models are typically silent on exactly how the increase in the quality of schooling is brought about: individuals can raise the stock of human capital, or knowledge, simply by allocating some of their time to its accumulation.

An alternative class of models places more emphasis on modelling the incentives that firms have to generate new ideas. Endogenous growth models based on the analysis of research and development, notably the landmark contribution of Romer (1990), yield the result that the steady-state growth rate partly depends on the level of human capital.
The underlying assumption is that human capital is a key input in the production of new ideas. In contrast with the Uzawa-Lucas framework, this opens up the possibility that even a one-off increase in the stock of human capital will raise the growth rate indefinitely. Indeed, in many endogenous growth models, human capital must be above a threshold level for any innovation to take place at all.

In practice, the generality of these results, and the contrast with the Uzawa-Lucas models should not be overdrawn. The Uzawa-Lucas framework can be seen as a model of knowledge accumulation in a similar spirit to that of Romer, but easier to analyse; and restrictive assumptions are needed to yield the Romer result that the long-run growth rate depends on the

level of human capital Jones (1995). But even under more general assumptions, a rise in the level of human capital is likely to be associated with a potentially substantial rise in the level of output, brought about through a transitional increase in growth rates.

In most endogenous growth models based on research and development, the stock of human capital is taken to be exogenously determined. More recent papers, notably Acemoglu (1997) and Redding (1996), have relaxed this assumption, and considered what happens when individuals can choose to make investments in education or training, while firms make investments in R&D. For some parameter values, multiple equilibriums are possible, since the incentives of workers to invest in human capital, and those of firms to invest in R&D, are interdependent. This provides a way of formalising earlier ideas about the possible existence of a “low-skill, low-quality trap” in which low skill levels and slow rates of innovation reflect a co-ordination failure Finegold and Soskice, (1988). The models suggest that, at the aggregate level, greater investment in education or training might raise expenditure on R&D, and vice versa.

Another interesting aspect of recent growth models is their suggestion that individuals may under-invest in education. Rustichini and Schmitz (1991) examine this argument in some detail. They present a model in which individuals divide their time between production, original research, and the acquisition of knowledge. Each individual knows that acquiring knowledge (through education) will raise their productivity in subsequent research, but since they do not fully capture the benefits of research, they will tend to spend too little time acquiring knowledge relative to the socially optimal outcome. Rustichini and Schmitz calibrate a simple model, and find that although policy intervention has only small effects on the allocation of time to education, it can have a substantial effect on the growth rate.

More recently, Romer (2000) has pointed out that models of growth driven by R&D should potentially inform education policy. He notes that, in the models reviewed above, growth is determined by the quantity of inputs used in R&D, not simply expenditure upon it. One reason this point matters is that incentives to encourage R&D, such as tax credits, may be ineffective unless they encourage a greater number of scientists and engineers to work towards developing new ideas. To illustrate this, consider a very simple model, in which a fixed supply of scientists only work in R&D and are the only input to the research process. Then an increase in R&D

spending will simply raise the wages of scientists, with no effect on the number of researchers engaged in R&D, or the growth rate.

In a more general and realistic model, there will be some effect of greater R&D spending on total research inputs and therefore growth. To create a large effect, higher wages for scientists should encourage more individuals to train as scientists. This requires some flexibility on the part of the education system, and in the provision of relevant information to potential students. So the effectiveness of direct subsidies or tax credits for R&D may be enhanced by complementary education policies, aimed at improving or subsidising the supply of research inputs, rather than simply the demand for them.

In summary, the models of the new growth theory are important for several reasons. First, they see human capital as an important input in the creation of new ideas, and this mechanism provides a relatively appealing justification for viewing education as a central determinant of growth rates, even over long time intervals. Second, they sometimes yield the result that the *laissez-faire* outcome delivers slower growth than is socially optimal. Third, the models suggest that policymakers wishing to raise the level of output have several options: not just direct support for R&D – which may be difficult to implement and monitor – but also subsidies to certain kinds of education, perhaps especially those which could lead to later work in research and development.

As we have seen, theoretical models imply that, in searching for the determinants of growth, policy on education is one of the first places to look. In this part, I will turn to the attempts of economists to quantify education's importance with evidence supporting the above theory. It would be a mistake, however, to review this evidence without first discussing the work on education and earnings by labour economists. If education affects productivity directly, this tends to imply an observable relationship between an individual's education and their earnings. The evidence for these effects is the best established in the literature and an understanding of its strengths and weaknesses helps place the cross-country evidence in context. This will clarify the areas in which the macro approach may have something worthwhile to contribute, and also point to the areas in which micro evidence is more likely to be fruitful.

The review points out that each approach to measuring the productivity effects of education has its own important weaknesses and areas of uncertainty. Yet taken together, the various

methods tend to agree in pointing to quite substantial effects. As a result, it would be difficult to use the available evidence to construct a case that education is currently over-provided in the OECD as a whole, and perhaps even harder if one acknowledged the wider benefits discussed below.

Broadly speaking, this work might also justify an expansion of educational provision in some countries, especially those where current policies imply relatively low levels of attainment in future years. A full analysis of policy questions, however, would need both to acknowledge the potential importance of training, and to investigate how a given quantity of educational spending is best allocated; these topics are beyond the scope of the present review.

Before turning to the various strands of evidence in more detail, it may be helpful to clarify the concepts of productivity that the different approaches have in mind. At the level of individuals, output per worker hour seems the most relevant measure of productivity, not least because one benefit of an increase in hourly productivity may be that individuals choose to work fewer hours. In examining productivity differences across countries, however, there are sometimes disadvantages in using output per worker hour as the basis for comparison. This measure of productivity is affected by labour force participation rates, and other aspects of labour market institutions. Further discussion and some recent evidence can be found in Scarpetta *et al.* (2000).

It is also worth pointing out that, for some purposes, policy-makers are interested in output per worker and output per head, as well as output per worker hour. Education may also have indirect effects on these variables, not simply through hourly productivity. For example, education is often thought to affect labour force participation, particularly that of women. It may also affect the nonmonetary benefits associated with work and leisure, and so affect working hours. Since cross-country empirical work is typically based on output per capita or output per worker, it will tend to conflate these effects with the direct impact of education on labour productivity that labour economists have sought to quantify.

2.6 Human capital

There is some debate over the role of human capital in economic growth. One approach sees human capital as an ordinary input in production, where the level of output depends on the level of human capital. This implies that the growth rate of output depends on the rate at which

human capital is accumulated over time. The other approach sees human capital as the primary source of innovation, so that education levels (human capital stocks) are linked to productivity growth. If this is the case, human capital would play a more significant role in economic growth. But what is “human capital”? One widely used definition of human capital is: “The knowledge, innovation, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic wellbeing” OECD (2008).

After World War II, several economists, including Milton Friedman, Gary Becker, and Jacob Mincer, developed the “human capital” theory to examine the benefits of education for individuals and society. Friedman and his wife Rose originally suggested that there was no evidence that “higher education yields ‘social benefits’ over and above the benefits that accrue to the students themselves.” On the contrary, they hypothesized that higher education may promote “social unrest and political instability”. Higher education may create greater tax revenue, increase savings and investment, and lead to a more entrepreneurial and civic society. It can also improve a nation’s health, contribute to reduced population growth, improve technology, and strengthen governance. With regard to the benefits of higher education for a country's economy, many observers attribute India's leap onto the world economic stage as stemming from its decades long successful efforts to provide high-quality, technically oriented tertiary education to a significant number of its citizens, Milton and Rose, (1980).

In the expanded Solow framework education is treated as a separate factor of production. The “stock” of human capital is measured in a way similar to the stock of physical capital. A person year of education is valued at the cost of producing it and all the person years are added up to get the stock. Increases in the stock of human capital, or in any other specific factor of production, are assumed to produce less than proportional increases in output since the various factors must be combined to obtain an increase in output. Specifically, a one percent increase in the stock of human capital is assumed to cause somewhat less than a half a percent increase in national income. In the Solow framework the impact of a one percent change in the stock of a factor of production is equal to its share in national income. A one percentage point increase in the capital stock causes only about a third of a percentage point increase in output because capital’s share of national income is only about a third. Labour gets most of the other two-thirds, and typical studies attribute two-thirds of that to human capital as opposed to raw labour. Thus increases in the number of workers, with no change in the total number of years of education, would have an impact smaller than an equal proportional increase in the stock of physical

capital. But an equal proportional increase in the stock of human capital (person years of education) would have an effect twice that size. Some other theories of how education affects output suggest the gain could be even larger than this.

An alternative to treating human capital as a separate factor of production is to take account of the effects of education by assuming that it is not a separate factor of production but instead simply increases the productivity of labour. In this framework an economy with twice as much human capital per worker could produce the same amount with half as many workers. Uzawa (1965) was the first to propose a model of economic growth with human capital impacts of this sort. In his model a one percent increase in the amount of human capital per worker causes an increase in national income of about two-thirds of a percent. This is because one percentage points increase in the stock of human capital per worker causes a full percent increase in the effective supply of labour, which produces an effect on output equal to labour's share of income.

As part of the theoretical development, Mankiw *et. al.* (1992) stressed the importance of human capital accumulation in the economic growth literature; they constructed an augmented Solow model that includes both human capital accumulation and physical capital accumulation. They have two important reasons of including human capital in the model, Firstly, for any given rate of human capital accumulation, higher saving or lower population growth leads to a higher level of income and thus a higher level of human capital; hence accumulation of physical capital and population growth have greater impacts on income when accumulation of human capital is taken into account. Second, human capital accumulation may be correlated with saving rates and population growth rates; this would imply that omitting human-capital accumulation biases the estimated coefficients on saving and population growth, Mankiw *et. al*. (1992).Hence, to test this augmented Solow model, they include a proxy for human-capital accumulation as an explanatory variable. Their results confirmed that accumulation of human capital is correlated with saving and population growth. Thus, as they expected, including a human capital accumulation lowers the estimated effects of saving and population growth. In this model, the proxy for the human capital is the percentage of the population in secondary school. The model is performed for three different samples and human capital enters significantly in all these three samples.

But Uzawa's model may still understate the role of education in determining the level of output and growth. Uzawa model assume that if we double the amount physical capital and human

capital per worker we will at most double the amount of output and that each factor will get a fixed share of the increase equal to its average share of existing output. However, many economists have argued that doubling capital inputs more than doubles output and that this accounts for some of the unexplained residual in a Solow-type analysis of the sources of growth. When doubling inputs resulting in more than a doubling of outputs there it said to be increasing returns to scales.

According to Blundell et al, (1999) in the UK, the main components of human capital are early ability (acquired or innate), qualifications and knowledge acquired through formal education skills, competencies and expertise acquired through training on the job.
Often these features go hand-in-hand, so that someone who goes on to higher education, for example, would have been successful anyway (the “selection” effect or “selection bias”). Further research is needed to better isolate the influence of one component on an individual’s income or life outcomes.

One of the most notable strands of this literature is initiated by Romer who asserted that human capital determines growth rates driven by technological change and thereby capital accumulation. In his first paper on growth, Romer (1990) proposes that human capital and or knowledge accepted as capital goods with increasing marginal product are not subject to diminishing returns since productive spillovers can be generated by this kind of stock of capital for the other fields of the economy. Rather, endogenous growth model relies on increasing returns to technological change and human capital inducing investors which respond intentionally to the market incentives to invest heavily in human capital resources which yield greater profits Romer, (1990). Therefore, new growth models attribute to human resources a central role as investment in human capital stock has a function of compensating diminishing returns to investment in physical capital Mcmahon, (1998). The other attractive implication of this model is that countries which grow faster are those with higher stocks of human capital by which the ratio of physical investment to GDP can profitably be increased guaranteeing the long-run growth.

2.7 Uses of Human Capital

The standard approach in labour economics views human capital as a set of skills/characteristics that increase a worker’s productivity. This is a useful starting place, and for most practical purposes quite sufficient. Nevertheless, it may be useful to distinguish between

some complementary/alternative ways of thinking of human capital. Here is a possible classification:

The Becker view: human capital is directly useful in the production process. More explicitly, human capital increases a worker's productivity in all tasks, though possibly differentially in different tasks, organizations, and situations. In this view, although the role of human capital in the production process may be quite complex, there is a sense in which we can think of it as represented by a un-dimensional object, such as the stock of knowledge or skills, *h*, and this stock is directly part of the production function.

The Gardener view: according to this view, we should not think of human capital as un-dimensional, since there are many dimensions or types of skills. A simple version of this approach would emphasize mental vs. physical abilities as different skills. Let us dub this the Gardener view after the work by the social psychologist Howard Gardener, who contributed to the development of multiple-intelligences theory, in particular emphasizing how many geniuses/famous personalities were very "unskilled" in some other dimensions.

The Schultz/Nelson-Phelps view: human capital is viewed mostly as the capacity to adapt. According to this approach, human capital is especially useful in dealing with "disequilibrium" situations, or more generally, with situations in which there is a changing environment, and workers have to adapt to this.

The Bowles-Gintis view: "human capital" is the capacity to work in organizations, obey orders, in short, adapt to life in a hierarchical/capitalist society. According to this view, the main role of schools is to instill in individuals the "correct" ideology and approach towards life.

The Spence view: observable measures of human capital are more a signal of ability than characteristics independently useful in the production process. Despite their differences, the first three views are quite similar, in that "human capital" will be valued in the market because it increases firms' profits. This is straightforward in the Becker and Schultz views, but also similar in the Gardener view. In fact, in many applications, labour economists' view of human capital would be a mixture of these three approaches. Even the Bowles-Gintis view has very similar implications. Here, firms would pay higher wages to educated workers because these workers will be more useful to the firm as they will obey orders better and will be more reliable members

of the firm's hierarchy. The Spence view is different from the others, however, in that observable measures of human capital may be rewarded because they are signals about some other characteristics of workers.

2.8 Sources of Human Capital Differences

It is useful to think of the possible sources of human capital differences before discussing the incentives to invest in human capital: Innate ability: workers can have different amounts of skills/human capital because of innate differences. Research in biology/social biology has documented that there is some component of IQ which is genetic in origin (there is a heated debate about the exact importance of this component, and some economists have also taken part in this). The relevance of this observation for labour economics is twofold: there is likely to be heterogeneity in human capital even when individuals have access to the same investment opportunities and the same economic constraints and in empirical applications, we have to find a way of dealing with this source of differences in human capital, especially when it's likely to be correlated with other variables of interest.

Schooling: this has been the focus of much research, since it is the most easily observable component of human capital investments. It has to be borne in mind, however, that the R2 of earnings regressions that control for schooling is relatively small, suggesting that schooling differences account for a relatively small fraction of the differences in earnings. Therefore, there is much more to human capital than schooling. Nevertheless, the analysis of schooling is likely to be very informative if we presume that the same forces that affect schooling investments are also likely to affect non-schooling investments. So we can infer from the patterns of schooling investments what may be happening to non-schooling investments, which are more difficult to observe.

School quality and non-schooling investments: a pair of identical twins who grew up in the same environment until the age of 6, and then completed the same years of schooling may nevertheless have different amounts of human capital. This could be because they attended different schools with varying qualities, but it could also be the case even if they went to the same school. In this latter case, for one reason or another, they may have chosen to make different investments in other components of their human capital (one may have worked harder, or studied especially for some subjects, or because of a variety of choices/circumstances, one may have become more assertive, better at communicating, etc.). Many economists believe that

these “unobserved” skills are very important in understanding the structure of wages (and the changes in the structure of wages). The problem is that we do not have good data on these components of human capital. Nevertheless, we will see different ways of inferring what’s happening to these dimensions of human capital below.

Training: this is the component of human capital that workers acquire after schooling, often associated with some set of skills useful for a particular industry or useful with a particular set of technologies. At some level, training is very similar to schooling in that the worker, at least to some degree, controls how much to invest. But it is also much more complex, since it is difficult for a worker to make training investments by himself. The firm also needs to invest in the training of the workers, and often ends up bearing a large fraction of the costs of these training investments. The role of the firm is even greater once we take into account that training has a significant “matching” component in the sense that it is most useful for the worker to invest in a set of specific technologies that the firm will be using in the future. So training is often a joint investment by firms and workers, complicating the analysis.

Pre-labour market influences: there is increasing recognition among economists that peer group effects to which individuals are exposed before they join the labour market may also affect their human capital significantly. At some level, the analysis of these pre-labour market influences may be “sociological”. But it also has an element of investment. For example, an altruistic parent deciding where to live is also deciding whether her offspring will be exposed to good or less good pre-labour market influences. Therefore, some of the same issues that arise in thinking about the theory of schooling and training will apply in this context too.

2.9 Human capital externalities

Economists have long argued that the benefits of human capital accumulation may not be restricted to the direct recipient but might spillover to others as well. Some of the new growth theories have distinguished themselves from the traditional neo-classical approach by clearly proposing a role for education externalities in economic growth: educated workers may raise the productivity of their less educated co-workers, or there may be spill-over effects from technical progress/knowledge accumulation which in turn arise from investments in human capital or an environment with a higher average level of human capital may entail a higher incidence of learning from others. Another assumption as to the existence of such externalities derives from the observation that human capital often flows to countries already endowed with a high stock of

such capital ('brain drain'), suggesting that the return to this 'unconventional' input is negatively related to its scarcity, Babatunde and Babatunde (2005).

The existence of positive economy-wide educational spillovers is an important economic justification for the public support of education, although the difficulties of actually verifying their size and thus calculating true social returns are formidable. While there is a large amount of evidence arising from micro econometric studies on the returns to education to the individual, macro studies are especially relevant in terms of assessing the empirical importance of educational externalities, which are often assumed a priority theorists and policymakers alike Sianesi and Van Reenen, (2000). In fact, external social impacts of investments in human capital can in turn have indirect economic effects. More education has been found to be associated with better public health and parenting, lower crime, better environment, wider political and community participation and greater social cohesion, all of which are in turn likely to feed back into economic growth Arakeji and Osunmaf, (2011).

Investigating the existence and size of these interactions is a highly complicated even though crucial exercise towards determining the optimal extent of public involvement in subsidizing and promoting further human capital attainment in a society. In an influential paper, Lucas (1988) argued that human capital externalities in the form of learning spillovers might be large enough to explain long-run income differences between rich and poor countries. In his model, in addition to the private return from investing in human capital, a firm's productivity depends on the stock of human capital in the economy. At the time of investing, firms or workers do not take into account this spillover effect because the benefits of their particular investment are lightly spread across the distribution of firms and are therefore insignificant from the firm's point of view, relative to the more certain costs. This implies that individual agents will under invest in human capital from the social point of view but the total magnitude of the spillover effect can be economically significant and contribute to explaining productivity differences across areas.

In more recent work, Acemoglu and Zilibotti (2003) has provided an ingenious justification for the presence of externalities. His theory is based on microeconomic foundations, and so is particularly worthy of attention. In his model, firms and workers make investments in physical capital and human capital respectively, before production begins. Production requires a partnership between a firm and a worker, but when firms or workers make their respective investments, they do not know the identity of their future partner. A key assumption of the model

is that firms and workers are then brought together via a matching process that is imperfect, perhaps because searching for partners is costly. Acemoglu shows how the structure of the model yields an important result: an increase in the average level of human capital can have a positive effect on the private return to human capital, at least over some regions. The intuition is as follows: say that a subset of workers decides to acquire more human capital. This will raise average human capital, and anticipation of this encourages firms to make greater investments in physical capital. Since the matching process is inefficient, the firms that have invested more are not necessarily matched with the workers who have invested more in human capital. As a result, some of the other workers will gain from the increase in average human capital, since they are matched with firms using more physical capital than before; and in this sense the average level of human capital has an external benefit. Work of this kind has helped to motivate the recent search for externalities, using survey data sets that include individuals who live in different cities or regions. The idea is to estimate human capital earnings functions in the normal way, but including a new variable, the average level of schooling in each individual's city or region. The central idea is that, if there are significant externalities to human capital, individuals should earn more when they work in those cities with a higher average level of schooling. The exercise will miss externalities that work at the national level, perhaps through social structures or institutions, but it remains of considerable interest.

The analysis in Lucas (1988) is largely motivated by welfare differences across countries. However, one would not expect interactions-based human capital spillovers to be homogeneous and uniform within a country. Instead, one would presume that the extent of interactions should decline as a relevant concept of distance between firms and workers increases. The volume of economic transactions and geographical or commuting distance between different units could be considered as determinants of the degree of technological spillovers considered by Marshall (1890) and Lucas (1988) summarized by Fernando (2004). Moreover, one can also think of a spatial distribution of a human capital semi-public good arising from such model of interactions and spillovers. Without considerable constraints in the mobility of capital and labour, economic agents will make location and investment decisions taking into account the distribution of the human capital semipublic goods. According to Lucas (1988), social interactions among workers create learning opportunities and increased communication with more qualified, better educated customers, suppliers, neighbors, etc. may contribute to enhancing productivity and productivity is significant on economic growth. These reasons are also commonly accepted as a reasonable justification for the existence of urban agglomerations. Certainly, cities have often been

associated with centre of knowledge, and their growth has been in par with the establishment and progress of academes and universities.

The nature of human capital spillovers is a subject not exempt of argument. Despite authoritative figures such as Marshall (1890) supporting the idea of human capital externalities from outside the firm, it is natural to feel doubtful about productivity effects from the human capital of workers in other firms or industries, arguing that most spillovers would naturally take place between workers within the same firm, leaving interactions such as those identified by Moretti (2002) summarized by Fernando (2004) as merely of interest from an academic point of view. Besides, there is limited plausibility for the notion of, say, manufacturing workers from different firms meeting in their spare time and exchanging productive ideas in the way that scientists would meet in conferences or artists would discuss their work in a café. Nonetheless, even accounting for these criticisms, one should not underestimate the potential of market based relationships for the flow of human capital-related ideas. A particular firm may well benefit from being exposed to market-based relationships with other firms that have a better educated workforce. Better educated suppliers may be faster and better at pointing out a particular firm's needs, or more educated customers may find it easier to highlight which higher value added products the firm could supply. As the degree of economic transactions between different units declines, one would therefore expect a reduction in the extent of such positive impacts. Whether these are genuine external effects or are properly accounted for in prices is worth discussing. More educated suppliers (customers) may also command higher prices (impose lower prices) for the transactions but may fail to capture all rents from the accompanying information flows. Besides, by exerting mutual pressures, a selection, Darwinian-like mechanism may be at work. Areas where the competition for resources and customers is more intense as a result of a higher quality workforce may be in a better global competing position *vis a vis* firms in less educated areas that lack these competitive pressures. In a process of nationwide increasing competition, firms in the former areas will be better equipped to deal with the new pressures.

2.10 Innovation

A theoretical link between innovation and economic growth has been contemplated since at least as early as Smith (1776). Not only did he articulate the productivity gains from specialization through the division of labour as well as from technological improvements to capital equipment and processes, he even recognized an early version of technology transfer from suppliers to users and the role of a distinct R&D function operating in the economy:

All the improvements in machinery, however, have by no means been the inventions of those who had occasion to use the machines. Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of a peculiar trade; and some by that of those who are called philosophers or men of speculation, whose trade it is not to do anything, but to observe everything; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects. In the progress of society, philosophy or speculation becomes, like every other employment, the principal or sole trade and occupation of a particular class of citizens… and the quantity of science is considerably increased by it, Smith, (1776).

The importance of technical progress was recognized in the neoclassical growth models (Solow 1956, 1957), but the determinants of the level of technology were not discussed in detail: instead, technology was seen as an exogenous factor. Yet, it was clear that convergence in per capita income levels could not occur unless technologies converged. From the 1980s and onwards, growth research has therefore increasingly focused on understanding and endogenizing technical progress. Modern growth theory is largely built on models with constant or increasing returns to reproducible factors as a result of the accumulation of knowledge. Knowledge is to some extent a public good, and R&D, education, training, and other investments in knowledge creation may generate externalities that prevent diminishing returns to scale for labour and physical capital. Taking these externalities into account, an economy with a continuous expansion of the knowledge base may experience positive long run growth instead of the neoclassical steady state where per capita incomes remain unchanged. This insight is one reason why the most successful modern economies are often referred to as .knowledge economies. Another reason is, of course, the increasing complexity of modern technology, where competitiveness is based more on institutional and organizational capacity and human capital than on abundance of natural resources or physical capital.

Depending on the economy's starting point, technical progress and growth can be based on creation of entirely new knowledge, adaptation and transfer of existing foreign technology, or a mix of the two. Since it is typically less costly to learn how to use existing technology than to generating new technology. Developing countries have the potential to grow faster than developed economies for any given level of investment or R&D spending. However, this potential for convergence is conditional on the economy's level of human capital.

In addition to a well functioning educational and research system, success in the knowledge economy also requires a business environment that facilitates growth and entrepreneurship. Elements such as competition, openness to international trade and foreign direct investment, well functioning factor markets, secure property rights, and appropriate incentives are necessary to transform knowledge and skills into growth and competitiveness. Most countries are struggling to create such an economic environment to promote growth, innovation and technical progress and to attract foreign direct investment.

Although the relationship between innovation and growth had been articulated at an intuitive level for some time, innovation was not introduced into formal economic growth models until 1957 Solow, (1957). Robert Solow, a professor at MIT, was awarded a 1987 Nobel Prize in Economics for this and related work. Like scholars before him, he defined growth as the increase in GDP per hour of labour per unit time. He carefully measured the fraction of this growth that was actually attributable to increases in capital, such as investments in machinery and related equipment, since the theory of the day was that capital accumulation was the primary determinant of growth. However, capital accumulation accounted for less than a quarter of the measured growth. Solow's insight was in attributing the remainder of the growth, the majority share, to "technical change." The magnitude of the residual calculated in this empirical study placed the role of innovation in economic growth squarely on centre stage, where it has remained for the past half century. Since Solow's contributions, the relationship between innovation and growth has been modelled in increasingly sophisticated ways. Perhaps the most notable recent advances came from Lucas (1988) and Romer (1986, 1990), who emphasized the concepts of human capital and knowledge spillovers, respectively. Following the recent idea of distinguishing human capital, which is developed by investments in education and training, from physical capital, Lucas modelled human capital with constant rather than diminishing returns, thus offering useful insights into the critical role of a highly skilled workforce for long-term growth. Romer endogenized innovation in the growth model by introducing knowledge spillovers, which resulted in deep implications for how scholars think about growth.

In the evolutionary economics stream of literature, heterogeneity in firms' managerial, organizational and technological capabilities is recognized and presented as a factor explaining differences in firms' profitability, performance, and growth Nelson and Winter, (1982). This "revolutionary" view of economics led to the development of the resource-based view of the firm

(RBV) that posits that the possession of valuable, rare and costly to imitate resources with no close substitute provides firms a competitive advantage.

Capabilities can be viewed as bundles of routines or more generally practices, that enable firms to combine their resources to efficiently achieve a particular activity Because firms' resources and capabilities are difficult to measure, this area of research remained to a large extent conceptual. But still, the few empirical studies that exist demonstrate a positive effect on firm performance Grant, (1991)..

An interesting contribution to this field of research comes from Rothwell (1992) who identifies a set of innovation success factors, such as: a good external and internal communication; treating innovation as a corporate-wide task; carefully planning and controlling innovation projects; maintaining a high quality of production; having a strong market orientation; providing good technical service to customers; the presence of champions and gatekeepers; the dynamism, commitment, and openness of the management team; attracting talented people; the visibility of support to innovation; having a long term strategy to which innovation plays a key role; insuring corporate flexibility, responsiveness, and acceptance of risk; and developing a culture of innovation.

Baldwin and Johnson (1996) also show that more innovative firms place "greater emphasis on management, human resources, marketing, financing, government programs and services, and production efficiencies", and are more successful than less innovative firms. Another study by Kremp and Mairesse (2004) finds that particular knowledge management policies translate into significantly better innovation performance and productivity. These policies are a culture that encourages information and knowledge sharing, employee retention policies, partnering for knowledge acquisition, and implementing written knowledge management rules.

2.11 Public expenditure and economic growth

Prior to the endogenous growth theory as proposed by Barro (1990), no significant relationship was predicted to exist between economic growth and public expenditure. In fact in Solow growth model (1956) public expenditure is only related to the equilibrium factor ratios and it is assumed that public investment is not related to long run economic growth in the neoclassical perspective. However, the recent argument in favour of the significant relationship between long run economic growth and public expenditure rests on the inclusion of fiscal policies into the

endogenous growth model with the conclusion that public spending can affect the long run economic growth Barro and Sala, (2004).

Theoretical propositions on the relationship between composition of public expenditure and economic growth unlike many other theories originated from empirical findings. The explosion of empirical studies on the endogenous models led to the separation of public expenditure into productive and consumption items. The productive expenditure is assumed to be positively correlated with economic growth while the consumption expenditure is assumed to be negatively related to growth. The most comprehensive theoretical model known to the author is that of Devarajan, Swaroop and Heng-fu-Zou (1996) in which the conditions under which a change in the composition of public expenditure could enhance higher steady-state growth rate of the economy was derived. They concluded that the generally assumed productive expenditure could become unproductive if the amount allocated to them is excessive.

Prior to the endogenous growth theory as proposed by Barrow (1990), no significant relationship was predicted to exist between economic growth and public expenditure. In fact in Solow growth model (1956) public expenditure is only related to the equilibrium factor ratios and it is assumed that public investment is not related to long run economic growth in the neoclassical perspective. However, the recent argument in favour of the significant relationship between long run economic growth and public expenditure rests on the inclusion of fiscal policies into the endogenous growth model with the conclusion that public spending can affect the long run economic growth Barro and Sala-i-Martin, (1992). Government consumption expenditure is assumed to be negatively related to long run growth while public investment expenditure is predicted to be positively related to long run growth.

Barro (1990) further argued that government consumption expenditure connotes leakages in the production process due to its non entrance into the private production functions as well as its negative relationship with returns on private investment whichever poses discouragement to investors. However, public policies can be used to enhance efficient allocation of resources by correcting market failures and thus encourage higher human and physical capital productivity. Productive public expenditure is expected to boost the steady state growth rate but this argument depends on the composition of the public expenditure. Consequently, trade-off between consumption and productive public expenditure will ultimately determine the effects of government expenditure on the long run economic growth, (Kneller, Bleaney, and Gemmell,

1999).Therefore, while the neoclassical models assumed a transitory public expenditure effects on economic growth the endogenous model predicts permanent steady state growth effects of public expenditure.

Empirical studies on the relationship between the composition of public expenditure and economic growth can be broadly divided into categorical and non categorical studies. The categorical studies group public expenditure components into “productive” and “unproductive” prior to their analysis while the non categorical studies permits the data and the results to determine which component to be regarded as productive and those that are unproductive. Public consumption that enhance the utility function of the households are regarded as unproductive and are expected to reduce economic growth since it requires higher taxes to be implemented which will not only reduce investment returns but will also lower incentive to invest. On the other hand, public consumptions that complement private sector productive activities such as infrastructure are assumed to be productive Barro, (1990).

2.12 Education investment and Social rates of return

Most countries regard education as investment that can induce economic growth. In the most developed economies the rate of return of this investment is high compared to developing economies. This is for several reasons. First, a state's education investments are non-random. States that are richer and faster growing, or have better institutions probably find it easier to increase their education spending. Thus, there is a distinct possibility that correlations between education investments and growth are due to reverse causality. Second, owing to the poor availability of direct information or data on education investments, researchers are often forced to use crude proxies, such as average years of educational attainment in a state. Average years of education are an outcome that people choose, given their state's investments in education. Furthermore, because the average year of education counts an extra year of primary school just the same as a year in a doctoral (PhD) program, average years of education cannot inform us much about the mechanisms that link education investments to growth. This study will attempt to deal with this weakness by using both school enrolment and tertiary education proxies to ascertain which variable provides better results.

The internal rate of return method is a purely accounting approach which evaluates the profitability – private or social – of any given investment by looking at the properly discounted

flow of benefits and costs arising from that investment. The internal rate of return, which is given by that discount rate for which the discounted present value of the benefits arising from the investment net of its costs equals zero, can then be compared to the reference discount rate of the decision-maker. When applied to the assessment of the social profitability of an investment in human capital, the 'social rate of return' is the internal rate of return of such an investment, evaluated from a social point of view. In other words, it is given by that discount rate for which the present discounted value of all social benefits equals the present discounted value of all social costs. A correctly calculated social rate of return should be the one guiding the decisions societies make to collectively finance education. Compared to private rates of returns, these 'social' rates of return include all of the direct costs of schooling (and not just those borne by the individual) and use pre-tax (instead of post-tax) earnings. By contrast, the private rates of return estimates assume that the only cost of education is foregone earnings (because of public subsidy of direct schooling costs) and that earnings are net of taxes.

Thus, in practice, the calculations performed are accounting exercises, which provide estimates of the returns to education that include net transfers (*i.e.* subsidies to education and income taxes). These 'social' rate estimates should however be regarded as a lower bound of the full returns to education. All the costs of education are included while broader non-employment personal benefits are excluded (*e.g.* externalities in the form of macroeconomic and social gains, and the lower risk of unemployment faced by individuals with more education). 'Social' rates are consistently found to be *lower* than private ones. In general, almost all the difference between the social and private rates of return appears to be due to the direct cost of schooling.

2.13 Conclusion

In summary, the models of the new growth theory are important for several reasons. First, they see human capital as an important input in the creation of new ideas, and this mechanism provides a relatively appealing justification for viewing education as a central determinant of growth rates, even over long time intervals. Second, they sometimes yield the result that the laissez-faire outcome delivers slower growth than is socially optimal. Third, the models suggest that policymakers wishing to raise the level of output have several options: not just direct support for R&D – which may be difficult to implement and monitor – but also subsidies to certain kinds of education, perhaps especially those which could lead to later work in research and development.

Chapter 3: Empirical Literature Review

3.0 Empirical Literature

This section reviews evidence from labour economics, it also attempts to provide a summary of a vast empirical literature, the emphasis will be on how the conventional findings should be interpreted, and to what extent we can infer actual effects of education enrolment (tertiary enrolment), innovation, education expenditure on productivity and other variables that contribute to economic growth. The rest of this chapter is as follows, the first part covers the empirical work, micro studies. The micro-level approach aims to explain the variation in individual earnings by regressions, where the independent variables are usually years of schooling and a proxy for experience – such as years of experience or age. The second part elaborates on macro studies and the last part deals with South African literature. South Africa has set itself the goals of eradicating poverty, reducing inequality, growing the economy by an average of 5.4 percent, and cutting the unemployment rate to 6 percent by 2030. Education, training and innovation are critical to the attainment of these goals NDP (2012).

3.1 Empirical work

The empirical work on the relationship between education, innovation and economic growth can be divided into three main approaches: wage equations undertaken in labour economics that consider the rate of return to education using individual level data, growth accounting where the attempt is to split the growth of an economy into the contributions of various inputs such as labour, capital, quality adjusted labour, etc.; and growth regressions which use cross-country data to estimate the relationship between education and growth Temple (2001). Regardless of the approach taken, the empirical evidence is mixed on the importance of education and skills in explaining economic growth – and this leads to an often unclear picture for evidence-based policy-making and implementation Krueger and Lindahl (2001), Patrinos and Psacharopoulos (2002), Pritchett (2001). This lack of clarity in the literature further justifies the need to conduct research on relationship between education and economic growth.

In addition to the above mentioned empirical evidence, according to Jackson, (2005), if the labour force is more educated this will lead to higher productivity and educated labour force can lead to the higher rate of innovation which implies the higher technology. The higher technology in the country can lead to the economic growth considering how the country utilised it in such a way that it becomes productive resource for the nation. The paper was based on the data that

was collected in Cameroon, the VAR/VECM methodology was employed and the result shows that one percent increase in human capital and innovation course approximately 28.5 % increase in productivity.

Benhabib Spiegel (1994) suggested that the change in schooling has an insignificant effect if it is included in a GDP growth model. They used cross-country estimates of physical and human capital by estimating a growth accounting model. Their results indicate that human capital enters insignificantly in the model. However, they specified an alternative model in which the growth rate of total factor productivity depends on a nation's human capital stock level. In this specification, human capital affects aggregate productivity through two different channels. First, they thought that it directly influences productivity by determining the capacity of nations to innovate new technologies that are suitable to domestic production. Second, they assumed that human capital level affects the speed of technological catch up and diffusion. Hence, they further assumed that the ability of a nation to adopt and implement new technology from abroad is a function of its domestic human capital stock. In this second specification, human capital has a positive role in determining the growth of per capita income and it attracts physical capital.

The findings of education and development have two different views (technology). For instance, if one favours the education-innovation link, then one might compare Europe and the U.S. in recent years, when Europe has grown more slowly. Ramirez and Weber (2003) and Singh, (2004) argue that the slower growth may have been caused by the European Union's relatively meagre investment of 1.1 percent of its gross domestic product in higher education, compared to 3 percent in the U.S. One might also look at studies such as Olorunfemi (2008), which used data on 221 enterprises from 1970 to 1985 employing a Schumpeterian growth model show that enterprises whose executives have a high level of technical education spend more money on research and development that lead to innovations. If one favours imitation or other channels through which education affects growth, one might note that, in the thirty years after World War II, Europe grew faster than the U.S. even though it invested mainly in primary and secondary education. Similarly, the "Asian miracle" (high productivity growth in Asian countries like South Korea) is associated more with investments in primary and secondary education than with investments in higher education.

3.2 Micro studies: labour economics literature

Researchers in this field typically study the link between education and productivity using survey data on the earnings and characteristics of large numbers of individuals. The techniques used to analyse this data have become increasingly sophisticated, and we will see that evidence from "natural experiments" provide measures of the private return to education that are probably quite accurate. There is much greater disagreement on the extent to which labour economists have identified the social return to education. For example, educational qualifications may be valued in the labour market because they act as a signal of ability. As a result, private returns to schooling may be high even if education has no effect on productivity. This argument will be discussed further below.

In analysing the private return, the standard empirical approach is to explain the variation in earnings across individuals using regressions, where the explanatory variables include years of schooling, either age or a simple proxy for labour market experience, and other characteristics. The most popular specification draws heavily on the work of Mincer (1996), and earlier contributions on "human capital earnings functions". The starting point is typically a specification that looks something like this:

$$\ln w = \alpha + \beta_0 s + \beta_1 E + \beta_2 E^2 \quad \text{.....(2)}$$

Which relates the natural logarithm of wages (w) to years of schooling (S) and a proxy for labour market experience (E). Under some assumptions, and given the semi-logarithmic formulation, the coefficient on schooling can be interpreted as the private return to education. Empirical estimates of the private return typically have a relatively small standard error and lie somewhere between 5 per cent and 15 per cent, depending on the time and country. If workers are paid their marginal product, these educational wage differentials may also tell us something useful about the effect of education on productivity.

There is a strong weight of evidence relating to the positive impact of education on future earnings. For the African countries and western economies, the gross rate of return to an individual of a year's additional education ranges between 5-10%: A South Africa there is a paper by Burger and Teal (2013), it was found that more education means better salaries and the higher mobility in the labour market, high mobility give you option to negotiate for the better package. In New Zealand, Norton *et al,* (2000) found that the effect on earnings of an additional

year of education is probably around 6-8% and certainly less than 10%. In the US, Kruger and Lindahl (2001) found that an additional year's schooling appears to raise an individual's earnings by about 10%. Many studies, including Blundell *et al,* (1999) in the UK, point out that there are diminishing returns to successive investments in human capital: the rate of return declines with the level of schooling.

Several studies based on Acemogol's firm-worker partnership microeconomic model discussed in the previous chapter have been carried out for the US. The initial results of Rauch (1993) appeared promising where he applied the simulation analysis. He considers two otherwise similar individuals living in two different cities, the second city with a population that has an extra year of average schooling. His estimates suggested that an individual living in the second city could expect to gain a wage premium of around 3 per cent, an effect large enough to be worthy of further investigation.

However Matt (2009) point out; there is an important argument against interpreting the observed wage premium as solely driven by externalities. Differences in average years of schooling across cities are likely to be associated with differences in the relative supplies of skilled and unskilled labour. They empirically demonstrated using the basic semi log linear wage regression technique that these relative supply effects may give rise to an apparent wage premium for average schooling even in the absence of externalities. When they follow relative supply effects, they are able to obtain a high and precise estimate of the social return to education. In a more general approach, which builds in a role for supply effects, the measured externalities are greatly reduced; indeed it is not possible to reject the hypothesis that externalities are absent altogether. He also indicates that the overall social returns to education may be close to the private returns, this time using the variation in average schooling across US states to capture the effects of externalities.

The evidence that earnings are positively associated with schooling is robust and uncontroversial; the obvious difficulty lies in giving this association a causal interpretation. One of the most easily understood problems is that, through lack of suitable data, the regressions inevitably omit some important variables that are likely to be correlated with both schooling and earnings. Family background and traits such as innate ability or determination are notable examples. The basic problem, from the econometrician's point of view, is that the group of people with a relatively advanced level of educational attainment is not a random selection from

the population as a whole. For example, if more able individuals have relatively high earnings regardless of extra education, and also choose to spend more time in school, then the estimated return to schooling overstates the effect of education on productivity. If ability is not observed by employers, then the regression estimate may still capture the private return to schooling, but it will not capture the social return that is ultimately our main interest, Branson and Leibbrandt (2013).

However the problems do not stop there. It seems probable that the costs and benefits of education vary across individuals, perhaps substantially. Indeed, this is likely to be the principal cause of the variation in completed schooling that the econometrician uses to identify the effects of education. The heterogeneity will typically mean that the private returns to education vary across individuals. In the unlikely case where the returns vary independently of the explanatory variables, the regressions should still recover an unbiased estimate of the average return. More generally, however, the heterogeneity problem will lead to biased estimates.

The recent focus of the literature on education has been on identifying natural experiments, in the hope that these will allow stronger claims about causality to be made. Researchers look for situations in which the level of schooling varies across individuals for reasons that are likely to be independent of the unobserved characteristics of those individuals (ability, determination, and so on), Branson and Leibbrandt (2013).

The idea is best explained by means of an example. A good starting point is one of the most influential papers, by Angrist and Krueger (1991). The paper starts from the observation that, when it is compulsory to stay in school until a certain age, individuals born earlier in the calendar year will reach the legal minimum age for school-leavers at an earlier stage in their education. As a direct result, there is likely to be a correlation between an individual's quarter of birth and their length of schooling. The correlation means that quarter of birth can potentially be used to identify exogenous variation in schooling – that is, variation independent of unobserved characteristics like ability or determination. In econometric terms, quarter of birth can be used as an instrument for schooling, under the maintained assumption that personal characteristics other than schooling are independent of quarter of birth. Somewhat surprisingly, Angrist and Krueger find that the instrumental variable estimates of the return to schooling are similar to the least squares estimates, supporting the idea that conventional estimates are reasonably accurate.

Another much-discussed natural experiment is provided by identical twins who have different levels of schooling. Given that such twins have the same genes, and will usually share the same family background, the wage differential between twins with different years of schooling may provide useful information on the productivity effect of education. Finally, other natural experiments are provided by the possible connection between the geographical proximity of colleges to individuals, and their choice of schooling, by applying the simple techniques of the OLS model, Card (1999). Research of this kind has considerably strengthened the case for productivity effects of education, but even these studies retain an important weakness. It has long been understood that the private return to education may be a poor guide to the social return.

Models of signalling start from the observation that individuals have traits which employers value but do not fully observe at the time of hiring (ability, determination, and so on). If there is a systematic association between these traits and the costs and benefits of education, this may lead to an equilibrium in which high-ability individuals stay in school for longer because this decision signals their ability to employers. This argument provides a plausible reason for a correlation between ability and years of schooling, and suggests that earnings may be correlated with schooling even if schooling has no effect on productivity, Branson and Leibbrandt (2013).

Few doubt that signalling plays some role in explaining educational wage differentials, but its overall importance remains controversial. Weiss (1995) and Quiggin (1999) provide very different perspectives on the theoretical generality and empirical validity of signalling models. There are two main arguments against such models, which note the implications of the assumption that education has no effect on productivity. First, given the wage premium earned by those with more years of schooling, employers would probably have strong incentives to conduct their own tests of ability and other characteristics, and use this direct information rather than the somewhat indirect signal provided by the schooling decision. This research paper is supported by evidence that measured performance in school and universities is correlated quite strongly with the outcomes of tests carried out at an earlier stage by Quiggin. Yet the argument is not conclusive, mainly because employers may not be able to appropriate the returns to acquiring more information about their employees; other firms could bid away those workers found to have higher ability (Stiglitz, 1975). The second argument is that, if education does not

affect productivity, one would expect to see the educational wage differential decline with job tenure, as employers acquire direct knowledge of the characteristics of their employees. This does not seem to be observed in the data, although this question has not received the sustained attention it probably deserves.

More generally, there is clearly room to develop and test signalling arguments in more detail. This is important not least because, as Weiss (1995) has pointed out, even the results of natural experiments are not necessarily inconsistent with the signalling view of education. To see this, recall that employers may use years of schooling to gain information about characteristics that are not observed at the time of hiring. The results from the Angrist and Krueger quarter-of-birth study and the work on twins can easily be interpreted in terms of these signalling effects, and so one could still defend even the extreme view that productivity is entirely independent of education.

For now, let us assume that employers fully observe all relevant characteristics, and hence do not infer any information about them from schooling decisions. Even in this case, as Card notes, not much is presently known about the mechanisms by which education might contribute to higher wages. The simplest interpretation of the evidence from earnings functions is that more educated individuals are more productive, whatever their chosen occupation. In practice, a college degree is unlikely to make one a noticeably better postman or road sweeper, Spence, (1973).

Education's role may be to equip workers for the task of working with more advanced technologies, for providing a higher quality of service, or for "learning by doing" in the course of employment. Understanding the mechanisms could be important, and will have implications for the interpretation of earnings functions. For instance, more educated workers may have better access to those jobs in which workers share some of the rents earned by imperfectly competitive firms. If mechanisms like this are at work, there would again be less reason to believe that the observed correlation between schooling and earnings represents solely a direct productivity effect.

3.3 Macro Studies literature review

Following the release of the Summers-Heston cross-country dataset, there has been an outpouring of cross-country empirical work carried out by macroeconomists trying to explain

post-1960 cross-country growth performances. this ‘new growth evidence’ exploits cross-country variation in the data to estimate, rather than impose the parameters (output elasticity) of the aggregate production function. It is tries to explain cross-country variation - the unexplained total factor productivity growth from growth accounting exercises. Most of these analyses group developing and developed countries together and there is considerable overlap in the data sets and specifications used by the different studies. These regression, sometimes termed ‘Barro regressions’, are informal ad hoc regressions, in which the choice of explanatory variables is largely driven by previous results in the literature and a priori considerations. The measure of productivity is often aggregate real GDP per capita (or per worker or per working-age person). Regressors typically include proxies of human capital, initial level of GDP, physical investment ratios, geographical dummies, and a number of variables that capture the role of governments, such as real government consumption ratios, political stability indicators, measures of market distortions and economic system indicators. The aim of such macro regressions is to investigate the respective role of the various ‘inputs’ in contributing to economic growth.

If we turn to the link between education and productivity at a macro level, Fernando (2004) estimate that increasing average education by one year would raise aggregate productivity by at least 5%, with possibly a stronger effect in the long-run. In Canada, Colombe *et al*, (2004) found that a rise of 1% in adult literacy scores relative to the international average are associated with an eventual 2.5% relative rise in labour productivity. However, Barnes and Kennard (2002) in Australia suggest that factors other than increased skill have mainly contributed to Australia’s recent productivity surge. They also comment that there does not appear to be a strong correlation across countries between labour productivity growth and movements in skill composition towards skilled workers. Some countries with large contributions of skill change, such as France and the UK, do not have very high labour productivity growth. Having said this, they believe that education and skills remain important for long-run growth.

The larger the sum of the impact coefficients of physical capital and human capital, the longer will be the effect of an increase in investment on growth, last If their sum of them is one or greater (as it is in the Uzawa and Lucas models) an increase in the rate of investment produces a permanent self-sustaining increase in the rate of growth. The reason is that new physical and human capital are produced in fixed proportions to national income with the investment rates for the two types of capital determining the ratios of the value of new capital to output. Then an increase in either form investment rate causes an initial increase in the rate of growth as output

increases in response to the increase in capital. This increase in output will cause a further increase in the amount of physical and human capital that will cause yet another increase in output. If the sum of the impacts of physical and human capital on output is less than one then the second round increase in output will be less than proportional to the increase in human and physical capital induced by the first round increase in output. Thus the next round of increases in physical and human capital will be smaller than the last. As the process continues each round of increases will be smaller than the last until after a long time almost no effect remains. However, if the sum of the impacts is greater than or equal to one, the increases are self-perpetuating and a one-time increase in the investment rate for either physical or human capital will cause a permanent increase in the rate of growth of output. Thus long-lasting correlations between savings rates and the rate of growth are indicative of models where the impact of education and physical capital are large, Uzawa, (1965).

There are other ways in which private and social returns could differ. In some countries, especially poorer ones, the public sector is a major employer of the well-educated. As Pritchett (1996) emphasises by employing the semi log linear wage regression, the assumption that wage differentials reflect differences in marginal products is much harder to sustain in this context. If educational credentials are used as a means of determining access to rationed high-paying jobs in the public sector, estimated earnings functions may detect an effect of education even when it has little or no effect on productivity.

The general problem is that estimates of earnings functions capture, at best, the private return to education, yet it is the social return which is of most interest to policy-makers. The two may diverge for a number of reasons, including the possibility that education acts mainly as a signalling device. The arguments discussed above imply that the social return to education is less than the private return, and as we have seen, even just a lower bound on the social returns is difficult to establish, Branson and Leibbrandt (2013).

There are also some reasons to believe that the social return to education could exceed the private return. It is plausible that individuals do not fully capture some of the benefits to society of their schooling, and I will review some of the empirical evidence on externalities and wider benefits below. Another important argument is that educational provision may play a valuable role in allowing a more efficient matching between workers and jobs than would otherwise be

possible (Arrow, 1973, Stiglitz, 1975). In other words, even if education does act mainly as a signal, there should not be a presumption that education is therefore socially wasteful.

In summary, there is an ingenious and persuasive body of work which supports the view that private returns to schooling are quite high. Card (1999) concludes that the average marginal return to education is unlikely to be far below the standard regression estimates. The view that this private return originates in a genuine productivity effect is far from universally accepted, however. As Weiss (1995) has argued, even the most recent results can be interpreted as the outcome of signalling effects. This suggests two lines of enquiry that might be particularly fruitful. The first is further theoretical examination (and perhaps calibration) of signalling models, with a particular focus on the extent to which they can incorporate the direct productivity effects envisaged in the traditional theory of human capital. Second, more evidence on the extent to which educational wage differentials evolves with job tenure could be of great interest in advancing the debate.

3.4 Evidence from growth regressions

The labour economics literature provides a wealth of evidence on the private returns to schooling. As we have seen, the contribution made to productivity by education is uncertain but may be worthwhile, even before we start to think about possible externalities. Making similar assumptions to those of labour economists, the 'growth accountants' have set about the complex task of evaluating this contribution relative to other sources of growth. Again, we will see that the degree of uncertainty is considerable. Even the most careful and accurate studies may substantially mis-measure the overall contribution of education.

Although growth accounting exercises are informative and often useful, it is clear that they are not a complete substitute for other forms of investigation, given the necessary assumptions. Griliches (1997), writes that the main, and possibly only, approach to testing the productivity of schooling directly is to include it as a separate variable in an estimated production function. Such estimates could be at the level of firms or regions, but much of the evidence uses the variation in education across countries, and it is to such estimates that I turn next.

The key attraction of growth regressions is that they provide a way of testing directly for productivity effects of education. This has sometimes been noted in the theoretical literature: Arrow (1973) pointed out that the use of macroeconomic evidence would be one way of testing

the signalling arguments, although he also expressed doubts about the likely reliability of such an approach. The growth regression model is as follow:

$$\Delta Y_{i,t} = \gamma\, Y_{i,t-1} + \sum_{j=1}^{k} \beta\ \beta_j, x, it + a_t + u_{it} \text{.....(3)}$$

Here $\Delta Y_{i,t}$ is the average growth rate, $Y_{i,t-1}$ is the log of the initial level of per capita GDP, j, x, it are *k* additional regressors, and a_t is a constant term that may change over time. The errors u_{it} are decomposed into time invariant country specific effects, u_i and random noise e_{it} so u_{it}=$u_i + e_{it}$.

This model formulation shows that the presence of a country specific effects in the growth model .Recent work has led to a better understanding of precisely when and where skepticism might be justified. In what follows, I will review the most important problems associated with measuring growth effects of education at the macroeconomic level.

This may seem surprising, given that several well-known papers in this field take very different views on the importance of education. The argument presented below is that a more coherent story is gradually starting to appear, in which the results of cross-country studies increasingly look consistent with the effects identified by labour economists, and which can also explain why some earlier studies failed to detect any significant effect of education using aggregate data. In the early work in this field, some of the estimated effects looked too large to be credible, as will be discussed further below. One of the best known and most influential contributions to the empirical growth literature is that of Mankiw, Romer and Weil (1992). If taken at face value, their parameter estimates for an OECD sample imply that if human capital investment (as a share of GDP) is increased by a tenth, output per worker will rise by 6 per cent; if investment in human capital is doubled, output per worker will eventually rise by about 50 percent. Results of this kind are often perceived as rather dubious, since all growth regressions share a number of important statistical problems Temple (1999*a*). In the present context, one drawback of most regression studies is their focus on a large sample that includes less developed countries as well as OECD member countries. One should clearly be rather wary about drawing conclusions for OECD policy based on samples that are often dominated by developing countries.

Researchers have generally used one of two specifications in modelling growth and education. In the first and most common specification, the researcher chooses to regress growth on control variables and the initial level of an education measure, such as the secondary school enrolment rate or (preferably) average years of schooling. The underlying idea is that the stock of human

capital could affect subsequent growth in a variety of ways, notably by influencing a country's ability to adopt technology from abroad.

The second specification uses the change in educational attainment, not its level, to explain output growth; this approach will be discussed further below. It has sometimes been argued that in practice, one might expect a negative effect to emerge from regressions based on the level of education, and this potential ambiguity could make the results hard to interpret Topel, (1999). For example, countries with a low level of education may also be relatively far behind technological leaders like the US, and therefore have more opportunities to catch up and grow quickly. Arguments of this kind are not yet altogether convincing. In this specific case, one should note that growth regressions usually control for initial output per worker, and this will incorporate a large part of the catch-up effects associated with technological backwardness. When researchers relate growth to the initial level of education, they typically find an effect of schooling that is both large and precisely estimated, at least when initial output per worker is also included as an explanatory variable, Barro, (1991). Yet it is not clear that these results are applicable to developing countries such as South Africa.

In an interesting exercise, Englander and Gurney (1994*a*) re-estimate growth regressions based on four influential papers, including Barro (1991), but restricting the sample to the OECD. Three of the four sets of regressions include human capital variables, typically primary and secondary school enrolment rates. These variables turn out to perform relatively well, but are still far from strong. In further work, it may be valuable to repeat this exercise, drawing on more recent data sets that allow one to use average years of schooling rather than enrolment rates. A more recent paper that includes results specific to OECD samples is Gemmell (1996). He emphasises the problems of using enrolment rates, and constructs alternative measures of human capital based on attainment at the primary, secondary and tertiary levels. For a sample of 21 OECD countries, he finds a correlation between the number of people with tertiary qualifications and subsequent growth. He also finds some evidence that investment in OECD countries is positively correlated with the extent of secondary schooling in the labour force. One drawback of most cross-country work is the likelihood of important differences in the nature and quality of schooling across countries, which could undermine the usefulness of international comparisons. Even such things as the length of the school year can show a surprising degree of variation across countries. An alternative data set, which may overcome these problems to some extent, has been introduced by Hanushek and Kimko (2000). They measure educational attainment

using scores in international tests of cognitive skills in mathematics and science. Their results support the idea that education has a substantial effect on growth rates, although the applicability to OECD countries is not clear.

The lack of studies with direct relevance to the OECD is not the only dilemma for those who wish to draw policy conclusions for developed countries. The rather a theoretic approach of the macroeconomic literature on education and growth has attracted a certain amount of criticism. One argument, used by Topel (1999), is that the measured effect of the initial level of human capital is often too large to be credible. The underlying assumption here is that education's effects are mostly accounted for by examining the correlation between education and earnings at the individual level. The models of the new growth theory, reviewed above, indicate that this view of education's role is perhaps too narrow. Nevertheless, the perspective of labour economics remains of interest. Starting with Pritchett (1996), researchers have noted the implications of traditional earnings functions for analyses at the cross-country level. If an individual's education contributes directly to their productivity, in the manner envisaged by labour economists, we should expect to observe a correlation between the change in output per worker and the *change* in average educational attainment, at least after controlling for other variables. Furthermore, it should be possible to detect this effect regardless of whether or not the initial level of educational attainment determines growth. This argument has shifted the focus of research towards regressions that relate growth to the change in educational attainment, rather than its level. Several well-known studies have found the correlation to be surprisingly weak; Benhabib and Spiegel (1994) and Pritchett (1996) both come to this conclusion for a large sample of countries. Benhabib and Spiegel do find a statistically significant correlation between the level of educational attainment and growth for the wealthiest third of the sample but no connection between the change in attainment and growth in a larger sample.

There are a number of other problems that dictate caution in reading these papers. One is the specification chosen for the relation between years of schooling and output. The specification adopted by Benhabib and Spiegel implicitly assumes that the returns to an extra year of schooling are much higher at low levels of schooling than high levels. As Topel (1999) points out, this runs contrary to the standard semi-logarithmic formulation for earnings functions, which in its simplest form assumes that the returns to an extra year of schooling are independent of

the level of schooling. When growth regressions are specified in a way that is more consistent with this idea, the evidence for an effect of education is rather stronger.

Krueger and Lindahl (1999) have argued convincingly that another important problem is likely to be measurement error. The difficulty is that a specification based on an aggregate production function (as in Benhabib and Spiegel) typically seeks to explain growth using the change in educational attainment, but first differencing the education variable in this way will usually exacerbate the effect of any measurement errors in the data. To support this argument, Krueger and Lindahl examine the correlation between two different measures of the change in average years of schooling that have been used in the literature. The correlation is low enough to suggest that a substantial component of the measured change in educational attainment is uninformative noise. As a consequence, regressions that use the change in education to explain growth will tend to understate its importance. The case for seeing measurement error as an important part of the story has been considerably strengthened by the impressively careful and detailed work of De la Fuente and Domenech (2000). Unusually, they restrict attention throughout to OECD Member countries. Their close examination of standard data sets reveals that schooling levels for some countries appear implausible; some of the figures for average years of schooling display surprising short-run volatility; and others appear to give a misleading view of trends. Other writers, notably Steedman (1996), have also noted inconsistencies in the way data on human capital are collected and compared. By drawing on national sources and more recent figures compiled by the OECD, De la Fuente and Domenech compile a new and more reliable data set for years of schooling in OECD Member countries. In their empirical work, they find that changes in output and educational attainment are positively correlated, even in panel estimates that include country and time fixed effects. This supports the idea that, where previous researchers have failed to detect an effect, this may be due to measurement error.

More recently, Bassanini and Scarpetta (2001) have extended the De la Fuente and Domenech database forward in time, and estimated the effect of education over 1971-1998 for 21 OECD Member countries using the Pooled Mean Group (PMG) estimator. The key advantage of this approach is that, compared with traditional methods of estimating panel data models, it allows greater flexibility in the short-run dynamics. Using the PMG estimator, Bassanini and Scarpetta's preferred estimate is an elasticity of 0.6 for output per capita in response to additional years of schooling. This implies that, at the sample mean of average schooling of about ten years, an extra year of average schooling would raise output per capita by 6 per cent.

3.5 Impact of education on economic growth

The large majority of the empirical studies on the relationship between growth and education/skills (or human capital in general) estimate the latter's direct effect on growth, i.e. the effect represented by the wide arrow in Figure 1.1. In these studies, human capital is considered as an input into the production process and this specification is in accordance with both exogenous and endogenous models of growth. However, the theoretical/analytical studies on growth and studies that examine the cross-country or time-dependent determinants of the change in inputs such as labour, capital or technology tend to point out the indirect effects of human capital on growth. The indirect effects are due to either externalities of education/skills or the process by which human capital filters into the production process by the interaction of the latter with inputs such as labour, innovation, capital and technology. Figure 1.1 takes account of such interactions explicitly. Brief elaboration on the indirect effects of education/skills on growth and references to the relevant literature are given below.

The first key pathway to consider is the interaction between human capital and labour productivity, Temple (2001). This pathway grows from the rate of return literature in labour economics. The idea is that a worker is paid a wage equal to his/her marginal revenue product of labour. If this is the case, standard wage equations should establish a positive relationship between the level of education however it is measured and the level of earnings. This positive relationship between education and earnings implies that educated workers have a higher marginal revenue product of labour as they are more productive. When aggregated at the macroeconomic level, it can be established that higher levels of education and skills (however they are measured) are conducive to higher productivity and the latter is conducive to higher output in the economy. Clearly the strength and weakness of this proposed pathway is whether education and skills actually do lead to a more productive workforce, or whether they are just a means of signalling prior ability. This is the old-standing debate in the theory of human capital. If education merely serves as a signalling device then the positive relationship between the level of education and skills and output growth will not hold. Therefore, theoretically, there is no a priori reason to assume that higher levels of education and skills are conducive to higher levels of growth: this relationship must be established empirically.

The second link is between human capital and labour market participation Glewwe (2002), Klasen (2002) where they apply the simple OLS model and VAR model to the data. In this case, investment in human capital may increase the probability of the person actually finding a job and

entering the labour market. Therefore an increase in the amount of the labour input will increase the output of the economy and therefore the economic growth. This link is likely to be especially important for females as a higher level of education may be associated with lower fertility rates that, in turn, may be conducive to higher levels of female participation in the labour market. Several econometric studies referred to by Barro (1991) report evidence that education is associated with lower fertility rates. In addition, more recent studies by Guisan *et al*. (2001) using the same model is one employed by Barro have also reported evidence on a negative association between education and fertility rates.

The third link relates to the interaction of human capital with domestic and foreign investment Engelbrecht (2003), Oketch (2006). It can be argued that a more skilled workforce is better able to make effective use of the capital stock due to domestic and foreign investment. This interaction with physical capital may have a potentially powerful effect on the rate of growth of the economy.

The fourth link is through the income effect of human capital that fosters higher levels of product variety and product innovation. That higher-income countries tend to produce a wider set of products is a well-established correlation in the development literature (Bils and Klenow 2001). However, there is also a reverse relationship that runs from higher product variety to higher levels of growth – the so-called supply-side effect of higher personal income levels on growth. In this approach, as higher income levels lead to higher levels of product variety, the latter leads to higher levels of growth because product variety is embedded within product and process innovation. Product and process innovation, in turn, is a reflection of technological progress, which is an essential but largely unobserved component of the growth functions

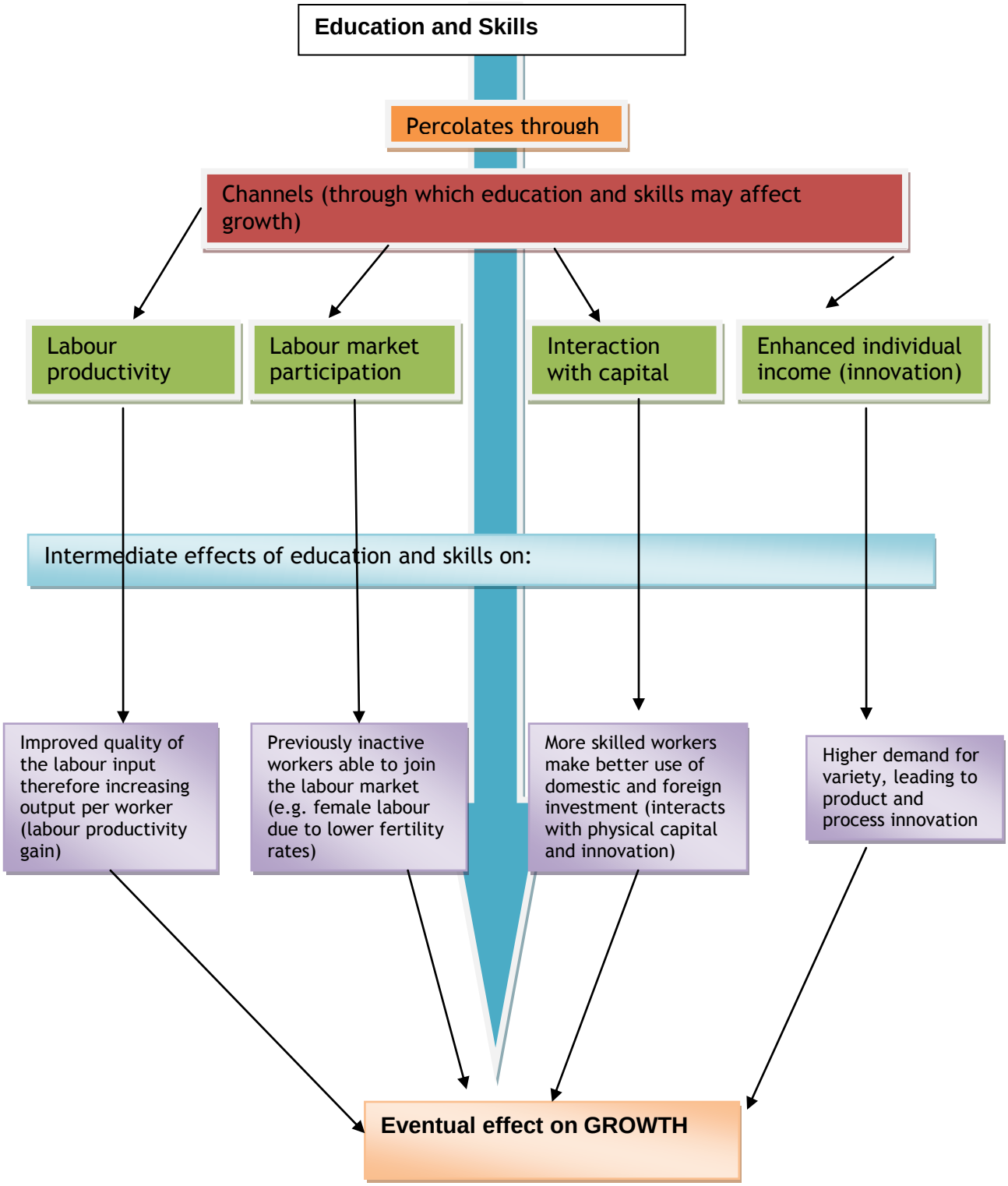
As stated below, and despite well-established theoretical foundations to the indirect effects of human capital on growth, empirical papers tend to focus largely on the direct effect of human capital on economic growth (large background arrow). The only exception in this context is the 'labour productivity' channel, the effect of which may be captured partly in the estimates of direct effects of human capital on growth. This tendency, in our opinion, is due to an accepted adherence (in both exogenous and endogenous growth models) to the original Solow-Swan models of growth. In both varieties of growth modelling, the standard assumptions are that there are constant returns to scale and the contributions of the individual inputs (capital, labour and technology) to growth add up to one, i.e. these contributions exhaust the sources of growth. I

think this restriction may be necessary to remain embedded within the theory of growth, but it is costly in terms of empirical innovation and capturing other sources of growth that are clearly identified in theoretical/analytical literature. In addition, I must also indicate here that the estimates of the direct effects of human capital on growth in growth regressions will tend to be biased downward in the absence of interaction terms that capture the indirect effects.

There is the possibility that part of the estimated effects of investment or technology on growth may be imitating direct effects of these inputs on growth even though they may actually be due to the interaction of these inputs with human capital input. This is a clear limitation in the human capital– growth regression literature and an avenue for research in future work. To give clarity on the relative merits of micro- and macro-level approaches to the economic consequences of education/skills. As Temple (2001) indicates, earnings are usually associated positively with schooling and this association is robust, but there are various difficulties faced by the micro-level approach. First, the association between education and private returns may reflect endogeneity between ability, earnings and education, such that more able people may secure higher earnings and invest more in their education. If this is the case, the estimated return on schooling overstates the contribution of education to productivity and ignores innate ability with which employees are endowed. Second, the regression may capture the private returns to schooling in terms of wages or earning potential, but it will not capture the social returns of education – either because of the so-called signalling problem or because of the externality problem that drives a wedge between private and social returns. This feature of the micro level studies is also noted by Krueger and Lindahl (2001), who report that although the wage equation approach provides good evidence on the private benefits of education, it is less clear when looking at the social returns to education or the impact of education on economic growth.

Given that this research paper aims to discover the effect of education investment, innovation and tertiary enrolment on economic growth, social returns on education and educational externalities are core issues. In addition, the micro-level approach is silent on the contribution of education relative to other sources of growth – such as investment or initial levels of income. Therefore, this review does not analyse the findings of micro-level studies on the private returns to education.

Figure 1.1 Channels through which education and skills may affect economic



Source: *Hanushek and Zhang (2006).*

3.6 Innovation and economic growth

The first one to empirically address the role of innovation for economic growth is Solow (1957). Solow uses a Cobb-Douglas production function and concludes that the traditional inputs of the production function, i.e. labor and physical capital, only explain a fraction of economic growth. The remaining fraction would result from technological progress. This residual part is the so-called “Solow’s residual”. In the decades that followed, many authors worked at decomposing this residual and finding a way to express technological progress as an explicit explicative variable of economic growth, and not only as a residual. A major contribution in this literature stream came from Minasian (1969) who first proposed to proxy technological progress by and R&D indicator and introduce it directly into the production function applying the same model of Cobb-Douglas.

Cohen and Levinthal (1989) argue that the key role played by R&D results from two effects. The first one is the development of innovations that R&D investments enable. The second one is the learning effect associated with the progressive development of a stock of knowledge at the origin of a firm’s absorptive capacity. This ability to recognize, assimilate and exploit external information and knowledge would be a crucial aspect of a firm’s capacity to innovate. Another interesting contribution to the firm-level literature on the relationship between innovation and performance comes from Crépon *et al.* (1998). Conceptually, the authors present innovation as a process that starts with R&D and continues with the application of patents and the sale of new products. Empirically, they build a model that explains productivity by innovation output and innovation output by research investments. Their results demonstrate that it is in fact innovation output (patent applications and sales from new products) that drives firm productivity, and not innovation input (R&D investments).

Many other studies validate the positive effect of innovation on various indicators of firm performance. A review of 30 empirical studies by Walker (2004) shows indeed that in about 60% of cases the empirical tests validate the positive relationship between innovation and organizational performance. This percentage appears to be slightly higher for services than for manufacturing sectors, in studies using samples smaller than the median of 141 firms, and in studies using effectiveness measures of performance like market share, as opposed to efficiency measures like return on assets.

To function effectively in a knowledge economy, organisations have to be knowledge-centred in their approach to business activities. As advanced technologies proliferate and new products become obsolete faster than before, organisations that are able to capitalise on opportunities arising from the availability of knowledge assets and derive the most value from them will be the industry winners, while those who cannot will be left behind as industry losers. Given that today's products and services constitute the embodiment of knowledge assets which are being introduced incessantly, organisations are challenged on how they leverage the value of knowledge to improve corporate performance. Corporate leaders are thus taking a keen interest on identifying "effective means" of harvesting all sorts of knowledge assets and are differentiating themselves from competitors based on new management initiatives Malhotra, (2001). This has become so pervasive in knowledge-intensive enterprises that it will soon be mandatory for organisational survival.

Before the 1980s, the acquisition of data management tools was the raison d'être for business growth. Then, from 1980s to 1990s, the focus shifted from data management to information management. Now, the use of knowledge and its management, termed "knowledge management (KM)" and defined as the systematic leveraging of data, information, skills, expertise, and various forms of assets to improve organisational innovation, productivity and competence, has emerged as a critical area of management (Barth, 2000). Increasingly, a crucial aspect of corporate strategy is the use of knowledge management practices to speed up the innovation process; and its centrality in corporate strategies bears testimony that adopting the best KM practices would result in better, higher quality and costeffective innovations. It is thus not surprising that managers are employing KM techniques in innovation programmes; and it seems that failure to do so may impede innovation performance and thus undermine corporate competitiveness Lindgren & Henfridsson, (2002). However, the importance of managing knowledge is still far from being fully understood. For instance, the "apparent confusion" between what constitutes "knowledge" and "information" has caused some organisations to sink huge investments in information technology (IT) infrastructure that yielded marginal corporate performance Malhotra, (2000). This is because IT expenditures are not directly related to corporate performance and this noticeable lack of understanding is attributed to the transition from an economic era based primarily on information to one dependent on knowledge.

In summary, industry policy-makers must realise that the solutions of past decades based on the old economy paradigm of efficient resource accumulation only will not suffice and may even fail miserably. Instead, intangible assets like intellectual capital and knowledge assets are far outstripping traditional assets such as land and labour as the main drivers of industrial growth. Put simply, industrial development must support the transition into a knowledge economy. Given this scenario, the commercialisation of knowledge, which concerns the utilisation and application of scientific, technical, organisational and managerial assets and skills, becomes the dominant force behind maximising entrepreneurial opportunities and fuelling economic growth.

3.7 Government Intervention

Higher education is a major driver of the information or knowledge system, linking it with economic development. However, higher education is much more than a simple instrument of economic development. Education is important for good citizenship and enriching and diversifying life. Quality higher education needs excellence in science and technology, just as quality science and technology need excellent higher education system. Good science and technology education is a crucial for South Africa's future innovation. The South African state has various category of intervention in improving the countries innovation by funding the students who are will to peruse their career in the post graduate studies; this includes National Researchers Funds (NRF), Human Science Researchers Council (HSRC) and National Students Financial Aid Scheme (NSFAS) ect, NSA (2013).

NSFAS has been remarkably successful in terms of student graduation (degrees, diplomas and certificates), even if one does not consider student home background. As NSFAS serves largely students from poorer backgrounds who are usually first generation university students, the success of these students in progressing through the higher education system is even more remarkable. The success of the NSFAS performance can be gauged from the fact that NSFAS students outperform non-NSFAS students, according to an analysis of HEMIS datasets for 10 years that were analysed. The better NSFAS performance compared to non-NSFAS students may perhaps be because of smaller dropout among the former. This appears to be related to the financial support by NSFAS that allows these students to continue their studies even when not fully successful, whereas non-supported students tend to drop out more easily, De Villiers,Van Wyk and Van Der Berg (2013).

3.8 Enrolment trends and policy affecting education

South Africa has made sustained education progress over the two past decades. The South African school act of 1996 made schooling mandatory until age of 15 or grade 9, and the goal of full enrolment at primary and lower secondary level has been nearly achieved. In 2004 about 89% of the population aged over 15 years and 98% of those aged 15-24 were literate, OECD (2012a).The spending in education by South African government is estimated to be about 5.8% of GDP, this amount is two times if it compared with the amount that spent in Brazil and other developing countries.

In most countries, government plays an important role in human capital formation by providing funds for formal schooling and research. The existence of social benefits of education that are not captured by private agents supports the role for government education policy. Moreover, the empirical evidence supporting the hypothesis that investments in higher education and skills are more growth-enhancing strengthens the case for additional public expenditures on education. But the issue of expanding public investment in human capital and skills cannot be addressed separately from questions about how spending is funded because how taxes are raised has powerful impacts on the targeted outcomes.

After South Africa's transition to democracy, the rapid rise in school enrolment that had already been a feature of the education landscape from the 1960s continued unabated. This worsened the pressure on educational and fiscal resources that came at a time when the new government was confronted with a number of fiscal challenges. Such pressure made it more difficult to improve the resource situation in schools and particularly to reduce the extremely high pupil-teacher ratios in many schools that had formed part of the black school system (the Department of Education and Training or DET and the former homelands) in the apartheid era.

Education is compulsory in South Africa from age seven (grade 1) to age 15 or the completion of grade 9 and enrolment in these grades is almost universal. Grades 10 through 12 are referred to as further education and training (FET) since learners can choose between a vocational training route or to continue their education in the basic education system. Those who choose the vocational route complete it with a National Certificate Vocational (NCV). The nationally administered National Senior Certificate (NSC) taken in grade 12 represents the completion of basic education and continues to be the preferred choice. Enrolment rates are high, but levels of grade repetition are also high in most grades and the majority of learners still

leave the schooling system without completing a National Leaving Certificate (NCV or NSC) commonly known as matric, about 58.4% of the learners. This reflects the poor quality of schooling in most South African schools despite educational attainment have increased over the past decades, completion of matric continues to represent a large and important hurdle to cross. South African government was trying to rectify the situation of over aged learners in the South African schools. The introduction of these educational policies coincided with some important changes in aggregate labour market outcomes. They occurred in the same period an inexplicably large and sudden increase in labour force participation, which increased the already high unemployment rate Burger , Van Der Berg And Von Fintel (2012).

A strategic priority of the HRDSA is to address the demand for quality further and higher education, which is to be accessible in all provinces and at all locales. It is clear that the capacity of the system must be substantially increased to provide greater access to post-school youth between the ages of 16 and 24, and more in particular those who have left the schooling system. Estimates are that currently 2.8 million or more of the 18-24 year-olds are not in employment, education or training DHET Strategic Plan (2010). The National Plan for Higher Education set a target of 20% participation in the higher education rate by 2016. The National Plan for FET commits government to increasing participation by the youth and adults in FET colleges, to reach one million by 2014. There are huge social expectations that the post-school system will promote a more equitable and socially inclusive society. This goal is consistent with social justice. If the Department of Basic Education succeeds in raising the number of school graduates ready to meet the challenges of further education and training, this will create additional pressure for access, and capacity will have to be increased incrementally to meet the anticipated needs of the country and the aspirations of its citizens.

The labour market trends indicate the need for higher education system to produce more graduates. However, an assessment of enrolment trends suggests that both in terms of size (numbers of student enrolled) and shape (enrolments in different field of study), the higher education is not meeting this need. The National Commission on Higher Education (NCHE) project in 1996 that the higher education system would be transformed from an elite to a mass system by 2005, with the participation rate increasing from 20% in 1996 to some 30% in 2005. In terms of the head counts, the NCHE projected that enrolments (including private higher education would double, from just under 600 000 in 1996 to nearly 1 500 000 in 2005. This projected growth has, however, not been borne out in practice. In 2009 the enrolment rate

increased dramatically from 30% in 2008 to 43% in 2009, this increase was the result of government intervention by allowing to get registered for free in use of NSFAS. Most of disadvantaged student get the access to the higher education, NCHE (2011).

3.9 South Africans reflect on international experience

South Africa had made sustainable improvement in offering education and making education easily accessible. The Brazilian experience should provide hope for South Africa. In a society characterised by great inequality, and a population four times the size of ours, political leadership made a major difference to education. Former president Fernando Cardoso mobilised public sentiment and political will throughout the country. As a result of introducing incentives for teachers, consequences for delivery failures, and a focus on student performance, the country has moved from being "bottom of world class" to "the world's fastest reforming schooling system", Coughlan, (2012)..

The evidence reported from Denver is instructive. This city is only one of the many and diverse city and state experiments in schooling reform taking place throughout the United States. The Denver presentation shows decisively that improvement in outcomes is not correlated with aggregate expenditure, but rather with how resources are managed. The first major city to introduce a significant merit pay programme for teachers, it has led national thinking on how to make public, private, and charter schools more competitive, and teachers much more effective.

The Ghanaian experience shows that achieving education reforms requires administrative and leadership continuity, together with a sense of urgency and political commitment from the very top. An overview of African and other developing country experience summarised new evidence on why education systems in developing countries are performing poorly. Funding is generally available but is inequitably allocated, both geographically and across income and ethnic groups. In addition, the funding ‘leaks’, with only 20 to 50 per cent of the money reaching schools. Teacher absence and significant loss of instructional time are key impediments to learner performance. Spending is poorly correlated with results, with evidence showing very large disparities between test scores and public education spend in a range of countries. South Africa is an infamous example–performing poorly in international tests, and yet spending 5-6 per cent of GDP on education, OECD (2011).

The key to improving education in Africa is to strengthen accountability. In the case of schools, three levels of interventions are needed to achieve this: information, school-based management, and teacher incentives. Schooling reform in Africa is most effective when it starts from the ground up, and empowers those who are closest to learners, namely parents and communities, OECD (2012a).

The lesson about the importance of teachers – underlined by the reports from different international counties, especially those on Brazil, Denver, and Ghana – was strong and clear. It is now well known that no system can transcend the capacity and performance of its teachers. The importance of the school as a 'vital unit of performance and change' was also underlined. President Jacob Zuma is right, when he said we need teachers in class, on time and teaching. But intentions are not enough. South Africa needs bold political leadership and a new social compact on quality schooling. We need firm resolve, and we need much better outcomes. South Africans – in the view of the Director-General of Basic Education – need to understand that the school is the point at which we convert inputs into outputs. If we don't do that, we are not going to succeed, DoE (2013).

3.10 School reform system in South Africa

South Africans are too complacent about South Africa's crisis in education. Despite one of the highest levels of government expenditure for any country 5%-6% of GDP and very poor outcomes in terms of student performance, the severity of the situation is sufficiently recognised as South African government is in the process of reforming the system.

Far too often the imperative of systemic schooling reform is reduced to a discussion about ad hoc or isolated individual projects. This is totally inadequate. The South African education system is large and complex, comprising more than 12-million pupils, more than 350000 teachers and more than 30000 schools in 70 districts in nine provinces. It is also very diverse, with huge differences within and among provinces, districts and schools. Turning this "gigantic ship" around is probably SA's most challenging management and leadership task, CDE (2011).

For the past two years the Centre for Development and Enterprise (CDE) has been looking at the international experience of schooling reform. In a new publication they summarise key findings from a major workshop, held in Johannesburg earlier 2011, involving the minister and director-general of basic education, international and local education experts and business

leaders. The publication explores what could be done to reform the South African school system and what can be learnt from successful reform in other countries. The experience of four countries (Brazil, Ghana, India and the US) was examined, and then supplemented by a review of school systems that are improving in more than 20 countries; and an assessment of the African experience of schooling reform.

South Africa has its own circumstances and the result from the above mentioned countries must not be taken as the one that can solve our problem. Reflecting on other places and what they have done can help South Africa look at its challenges in new ways, and ask different questions. The international evidence is clear. Schooling reform is possible, even when dealing with very large numbers. Education systems can make significant gains from almost any starting point with measurable improvement achievable in as little as six years. However, it is also clear that doing this requires determined leadership and commitment OECD (2012a).

Minimum levels of funding and resources are necessary but insufficient to transform a schooling system. Many countries spend more money but achieve far too little; other countries have less to spend and outperform those with bigger budgets. The experience of Denver, Colorado, for example, shows improvement in outcomes is not correlated with aggregate expenditure, but rather with how resources are managed. The first major city to introduce a significant merit pay programme for teachers, it has led national thinking on how to make schools more competitive and teachers much more effective CDE (2011).

The quality of teaching is a central determinant of student performance. However, teacher quality cannot be reduced to formal qualifications, which often have little effect on student results. How teachers are trained is key to success - less theory, much more classroom practice and collegial learning from experienced, good teachers.

The report by DHET reviles that principals play a key role, especially in motivating teachers and creating an institutional culture of learning. Principals need management training, more power to decide on budget priorities for their schools, and the ability to hire and fire teachers. Successful schooling reform requires a new approach to teaching. Society needs to value the importance of teachers more highly; teachers need to see themselves as professionals and behave accordingly. Pay based on incentives and regular performance assessments are essential. The

key assessment criterion should be improved pupil performance, with severe consequences for failure.

Success is not about having some grand plan at the beginning, but having a notion of what should be done first, that will then unleash a whole lot of other productive forces. No reformer can do it all. Tough choices are required. For example, South Africa will not succeed in reforming its public schooling system if it continues to have teachers throughout the system who are present only three to four days a week, but who remain employed and receive the same pay as everyone else DoE (2011).

South Africa needs a new social compact to improve public education. The national interest in dramatically improved schooling for the poor majority must trump sectional interests. This will require bold and sustained political leadership. It will also need a more fundamental approach to schooling reform. It is not only key officials and the department who need to be committed to a new plan. A much wider set of social groupings is needed to mobilise, speak out and support reform with the department and politicians willing to lead DHET (2013).

The unions should form part of this compact. Many countries have experienced similar challenges to those in South Africa's involving the unions, but local and national leaders were able to move forward despite this. Teachers should not be made the scapegoats for a system that is badly managed and the wrong incentives, DHET (2010).

3.11 Work Integrated Learning (WIL)

Government and private stakeholder aims to improve the amount and quality of workplace training in South Africa. Places of employment as training spaces in both the public and private sectors do not and cannot come under the direct auspices of the DHET. However, our policies and systems can and must impact on the nature, type and quality of training that is made available in workplaces. Workplace training and work-integrated learning (WIL) must be a central part of our training system. This is an understanding that the DHET and other stakeholders (including employers, the labour movement and community organisations) are coming to share. It is demonstrated by the National Skills Accord, signed in July 2011 by all the partners in the National Economic Development and Labour Council (NEDLAC). All signatories agreed to promote expanded access to training opportunities in both educational institutions and workplaces, DHET (2013).

In many areas of study, useful practical experience can be obtained in an institutional workshop where learning can be easily controlled in line with a curriculum. However, institutional workshops often cannot afford to keep up with the most recent equipment available. Even where workshop training is available, it is always beneficial to augment this with practice in an actual workplace where real-life experiences such as working under pressure, dealing with customers, and working as part of a team may be more easily learned. For many areas of work-such as banking, insurance, property management, retail or public administration–simulated workplace experience can be difficult to recreate in a workshop, SASSETA (2012). This means that training systems, including curricula, need to be designed around close cooperation between employers and training providers, especially in those programmes providing vocational training. In some areas such as medicine, where work in teaching hospitals is an integral part of training doctors, this is well developed and could possibly provide a model for others, including professional organisations.

Given the demographics of the South African labour force, it is not enough to focus education and training on preparing people for formal-sector employment. Unemployment levels in South Africa are extremely high, particularly among youth. In the second quarter of 2013 the official unemployment rate was 25.6 per cent; if discouraged work-seekers are included, the rate was 38.4 per cent. As noted above, about a third of persons aged 15 to 24 were not in employment, education or training. The unemployment statistics demonstrate the value of an education: The highest unemployment rate (30.3 per cent) was among those without a National Senior Certificate (NSC) or equivalent, while those with an NSC or equivalent had an unemployment rate of 27 per cent. Among university graduates, the unemployment rate was only 5.2 per cent, while the rate for others with a tertiary education was 12.6 per cent, DHET (2013)

This situation means that we are providing training for individuals who will not, in the foreseeable future, be able to find formal employment in existing enterprises. To make a living, they will have to create employment opportunities in other ways – by starting small businesses in the informal or formal sector, or by establishing cooperatives, community organisations or non-profit initiatives of various types. The education and training system must cater for people in such circumstances by providing suitable skills. Education must also cater for the needs of communities by assisting them to develop skills and knowledge which are not necessarily aimed at income generation – for example: community organisation; knowledge of how to deal with

government departments or commercial enterprises such as banks; citizenship education; community health education; literacy. The minister of Higher Education and Training proposed community colleges are expected to play a particularly significant role in to this regard, and must therefore be designed to be flexible in meeting the needs of their own particular communities. The colleges must build on the experiences and traditions of community and people's education developed by non-formal, community-based and non-governmental organisations over many decades DHET (2013).

3.12 Education Quality

South Africa has made sustained educational progress over the past two decades. The South African Schools Act of 1996 made schooling mandatory until age 15 or grade 9, and the goal of full enrolment at primary and lower secondary has been nearly achieved. In 2004 about 89% of the population aged over 15 years and 98% of those aged 15-24 were literate. The formal educational attainment of the African population has been particularly marked and has converged with respect to Whites, as the relative gap in mean years of schooling between the two population groups has been halved since the end of apartheid. However, education quality remains poor on average and uneven across regions and population groups. South Africa's low performance in terms of average scores in international tests (PIRLS and TIMSS) and regional surveys (SACMEQ) reflects the large fraction of students who do not reach basic qualification standards. The national pass rate in the high-school graduation examination (the "matric"), was 57% among Africans and 99% among Whites in 2009 (Department of Basic Education, 2010). Moreover, the net enrolment rate in primary education has been falling since 1995, pointing to a significant rate of grade repetition and an increasing incidence of out-of-school children of primary school age (World Bank, 2012b). Educational attainment and quality are also unevenly distributed across regions, depending largely on urbanisation rates. While the percentage of children aged 7-15 attending compulsory basic education is broadly the same across regions, gross enrolment rates in secondary vary widely. There are two complementary strategies to overcome the legacy of the past: improving the functionality of the education system mainly through procedural reforms and easing resource constraints in specific areas.

There are various ways of increasing accountability at the administrative and school
Levels these includes the capacity and regulatory powers of the recently-created federal evaluation unit (NEEDU) could be bolstered to ensure that school, district and provincial authorities are evaluated regularly, Failing school principals could be granted training and

further surveillance and in the worst cases dismissed. School assessments could be made more publicly widespread, easier to interpret and involve comparisons with other schools provincially and nationally.

The recent implementation of Annual National Assessments, first run in 2008, the provision of "systemic studies" and the requirement for school leaders to provide school development plans all constitute crucial innovations to be maintained and supported by additional capacity-building to analyse these data. At the international level, it would be useful for South Africa to join the OECD's PISA and TALIS surveys to monitor progress and benefit, on an ongoing basis, from the possibility to carry out comparable policy relevant studies in the field of education DHET (2013). Assessing school principals ultimately serves the purpose of improving school outcomes. As recognised in the Action Plan to 2014, maintaining the right balance between monitoring and support is essential. School principal positions could be made more selective by requiring specific leadership certificates and specific training delivered at the national level. Similarly, the management capacity of incumbent school principals should be upgraded by increasing participation in the university-based Advanced Certificate of Education (ACE) programme. Establishing local networks of school principals and mentoring between well-experienced and new school principals are strongly encouraged (OECD, 2008b), as such practices are deemed to foster the local diffusion of good management practices.

Teacher-related reforms should aim at suppressing teacher absenteeism, simplifying teacher evaluation and improving teaching quality. Addressing teacher absenteeism by enforcing daily monitoring in less functional schools is a first important requirement that would again be facilitated by the provision of additional administrative and support staff. Recent evidence shows that only 17% of schools maintain up-to-date daily educator attendance registers, Department of Basic Education, (2011).

As with school principals, teacher assessment should ultimately seek to improve teaching quality. All teachers could be evaluated mainly through annual assessments by their principals, who would themselves become accountable for these assessments via government audits. Teacher peer reviews may also be encouraged, but it would seem premature to use students' performance in national and standardised tests as an important criterion for teacher evaluation. In addition, the frequency, content and place of instruction of teacher training could be jointly reviewed by evaluation authorities and unions with the aim of emphasising training quality over

quantity. Professional development could be based on needs identified through teacher evaluations rather than taking place, as now, in an automatic (and frequent) way. This would free up resources to improve subject knowledge of teachers with an incomplete curriculum.

Regarding wage incentives, teachers with low pay appear to be much better off than low-paid South-Africans, but teachers with high wages are worse off than South African high-wage earners, Burger and Van Der Berg, (2010). Consequently, the government is rightly considering hiring primary teachers without university qualification, who should nevertheless be qualified enough to teach in Foundation Phase. Secondly, wage increases for the best teachers who pass formal examinations of subject knowledge are being examined Department of Basic Education, (2011). Such increases should be applied in a very selective way to ensure containment of the teacher wage bill, and should target the best teachers working in disadvantaged and remote areas, which are the most affected by teacher shortages.

Adapting the curriculum to local needs is another area where efficiency gains could be realised. Large disparities in administrative capacity suggest that it would not be a good idea to generalise curriculum autonomy and decentralisation in an unconditional manner, as international evidence suggests that such decentralisation is only effective in mature education systems, and can lead to poor outcomes when local institutions lack capacity or when an operative accountability system is not in place. However, tailoring the curriculum to local conditions and/or by school quintiles would help to improve the match between educational content and local needs. For instance, greater emphasis on basic skills such as reading, writing and arithmetic is recommended in low-performing schools in Finland, one of the best performers in PISA tests.

In addition, there is widespread evidence that pupils with an African mother tongue perform significantly worse in English than first-language Afrikaans or English speakers. It would therefore seem desirable to strengthen the teaching of English as a second language in African-language schools, in part by introducing it earlier, at primary and pre-primary school level. At the same time, the switch in the main language of instruction from mother tongue to English, which theoretically happens currently at grade 4, appears to be abrupt and confusing for African students. International evidence (OECD, 2012b) suggests that it could be useful to make the switch to English as the language of instruction more gradually. Finally, making it easier for English teachers from other (English-speaking) countries to immigrate, or allowing Zimbabwean

teachers already living in South Africa to teach. The study that was conducted by the department of Home Affairs reviles that about 25% of Zimbabwean teachers migrate to South Africa annually. Due to this higher number of immigrants with a skills that is in demand in our country it can be on our advantage if we utilised those skills appropriately (profitable), the OECD (2013c) reviles that the education quality in Zimbabwe is very high when it compared to other African counties, this can help on our education if we allow these teacher to get on our system. Allowing these to happen it would help to address pressing and immediate teacher shortages. There is no way of talking seriously about social and economic transformation without talking about education and its role in human development and economic growth. Many agree that education is a fundamental tool for achieving sustainable development and delivering on the Millennium Development Goals, particularly Goal 1 on poverty eradication.

3.12 Expenditure on education distribution

Although total educational resources as a share of GDP are in line with OECD standards, they do not fully match the needs of South Africa's large school-age population, especially in poor and rural areas. In 2010, total public expenditures on educational institutions and administration amounted to 5.9% of GDP, above the OECD average of 5.4% World Bank, (2012b) and OECD, (2012c). However, when calculated per pupil and normalised by a proxy for income (GDP per capita), resources spent on pupils at primary and secondary levels are about 30% lower than the OECD average. The share of public expenditure on capital has been very low in contrast to expenditures on personnel. A rebalancing of the budget towards basic facilities (textbooks, school infrastructure through the 'ASIDI' programme) and ICT availability, which would offer access to information and communication infrastructure to children from poor households, is a declared and welcome objective of the Action Plan to 2014 Department of Basic Education, (2011). Empirical analysis using a large sample of South African pupils at grade 9 shows that the impact of school equipment (libraries and ICT in particular) on pupils' test scores is as large as the influence of parental socio-economic background NDP (2012).

Beyond school infrastructure, there is a clear shortage of teachers in primary and secondary schools, as reflected by very high pupil-teacher ratios which is (1:53). Moreover, teacher shortages are similarly observed at the secondary level. The provision of additional teachers is a difficult challenge, which can be overcome only over the medium term through a dramatic expansion of the pool of new teachers and the containment of teacher salaries, although the prospective reduction in the number of students due to demographic shifts will help reduce class

size conditionally on maintaining a constant number of teachers NDP (2012). As there is evidence of important credit constraints for undertaking upper secondary and university studies, fostering the expansion of conditional bursary schemes to become a teacher (through “Funza Lushaka” schemes) would be a promising way to raise both the quantity and the quality of young teachers over the next decade.

Public expenditure on education is still distributed inequitably despite bold action to mitigate the consequences of the past. Before 1994, funding was skewed towards the former White schools by a factor of 5 to 1. The introduction of a rule to calculate an “equitable” budget allocation per pupil (“Equitable Share Formula”) and the mo re recent use of national quintiles to fund schools in a progressive way (“National Norms and Standards for School Funding”) sought to address the stark socio-economic inequality perpetuated at school SASSETA (2012).

According to the finding on the research done by the department of higher education and training (DHET 2012), former White schools that can collect tuition fees to supplement teaching and other resources, and on the other hand “no-fee” schools that rely entirely on government funds, do not have enough teachers and generally perform poorly. Whereas school fees are only 7% of all school resourcing, they constitute a much larger share of financing of good schools. Moreover, fee-charging schools are subsidised by the government for each disadvantaged child exempted from paying fees, which on the one hand means that already relatively well-resourced schools get an additional advantage. At the same time, however, since the subsidy is typically much less than the fees charged to other students, additional pitfalls arise, such as a lack of information about their rights among poor parents or non-compliance of school management with their obligation to accept non-fee paying students.

There are two ways to reduce the duality of the basic education system. One is to phase out school fees gradually so as to avoid a collapse of the best-performing schools and a massive flight to private schools. Another is to increase the redistribution of school funding providing that schools are classified adequately by child socio-economic status rather than school geographical location as it is currently the case.

Despite this widespread belief that the investment in human capital development is a key determinant of economic growth, the empirical estimates especially focusing on low-income countries are less than conclusive. A range of different size effects and levels of significance

were found depending on a host of factors including data source used, estimation approach and selected sample countries. An added complication comes in the form of the measurement of the outcome of the investment in education and innovation, which is not at all straightforward. While a measure of learning is required, often studies are forced to use the available sources. Researchers use a range of proxies for education and innovation including the average years of education, enrolment rates and education expenditure.

3.13 Making educational investments pay

Empirical analysis presented by OECD (2013), points to large employability premiums and high private returns to tertiary education and to high school graduation (passing the matric). While returns are lower for the African population relative to Whites, part of the latter gap reflects differences in school quality as measured by pupil-teacher ratios. Raising and levelling out education quality standards would therefore contribute to lower income inequality and raise both private and social returns to education.

The high youth unemployment rate highlights the issue of skills deficiencies among those who fail to pass the matric exam. From that perspective, the vocational education and training system appears to be underdeveloped and not functioning as an alternative for high-school drop-outs. Further Education and Training (FET) colleges represent less than 10% of pupils enrolled at secondary schools, and display by far the highest pupil teacher ratios in the education system. In practice, technical colleges are characterised by high churn rates as students often drop out and return. Moreover, the pool of students in vocational education is often considered to be of lower quality. Successful vocational education and training (VET) systems in OECD countries often both provide a path to higher education, which raises the quality of new entrants, and offer a strong connection to the labour market thanks to up-to-date curricula in tune with labour market needs.

It is necessary to raise both the demand for and the supply of skilled students with a vocational degree. On the demand side, there is still too little on-the-job training for VET students in spite of recent action taken in this area, as firms may be reluctant to engage in burdensome administrative procedures. The VET system would benefit from simplified administrative procedures to hire trainees and from tax credits for firms that provide training. On the supply side, the VET system barely delivers the skills needed as its curriculum is deemed to be outdated, with shortcomings in the quality of both lecturers and infrastructure. Recent initiatives

involving better participation of firms in the definition of the curriculum are especially welcome. Moreover, developing partnerships between large companies and public or private FET colleges is a powerful way of raising the quality of the system. Several foreign companies have been involved in this kind of arrangement, unlike large domestic firms. To complement this, expanding the bursary system in well-identified segments of the VET system, such as those linked to booming economic sectors, would simultaneously help raise the quality of applicants while fulfilling strategic skill development needs of the country, DHET (2013).

Focusing on a specific part of the vocational system, the expansion of the apprenticeship system may be a useful tool to reduce youth unemployment. Restoring an effective apprenticeship system is an explicit goal of the New Growth Path, which plans for the training of 50 000 additional artisans by 2014-15. Among OECD countries, well functioning apprenticeship systems often have the following characteristics: students' pay is usually a fraction of the minimum wage, but in exchange they receive recognised skills from experienced supervisors and part-time schooling of usually not more than 2 days per week. The curriculum is established with the active participation of social partners, and Economics Departments/Ministries are usually co-responsible for such programmes.

The attraction for the employer is not only the availability of cheap labour during the time of the programme (usually 3-4 years), but also the prospect of having privileged access to tailor-skilled graduates. Except for the schooling part of the programme, public funds are usually provided only if companies agree to train more apprentices than they would want to keep at the end or when companies provide a training infrastructure for students who are not in employment, education or training, OECD (2012d).

3.14 Research and innovation for development

Research and innovation are integral parts of the work of universities. It is recognised that knowledge production must increase if South Africa's developmental goals are to be achieved. The National Development Plan acknowledges that, while South Africa's publication output is the highest on the continent, its innovation system is small by international standards. In particular, Doctoral graduate numbers are significantly lower than in equivalent developing countries. This means that the research and innovation system, which includes universities, does not adequately address the developmental needs of our society and economy.

One of the government's aims, as reflected in the Ten-Year Innovation Plan of the Department of Science and Technology, is to increase the number of patents owned by universities and other research institutions that enable product innovation by industry. This will assist the realisation of the aims of the National Development Plan, the New Growth Path and the Industrial Policy Action Plan, all of which identify research and technological innovation as important for job creation and for making South African industries more competitive globally DBSA (2011).

The National Development Plan states: The National System of Innovation needs to function in a coherent and coordinated manner with broad common objectives aligned to national priorities. The National System of Innovation, the higher and further education system, SOEs [State Owned Enterprises] and private industries should create a common overarching framework to address pressing challenges (NDP, 2012). The focus of policy must be on growing research and innovation, improving the quality of research, ensuring coherence of the policy frameworks guiding these areas across the higher education and research communities, and strengthening particular areas identified as important for national development. In short, collaboration must improve, both between universities and across the research community, which includes universities, research councils and other institutions in the private and public sectors. Quality must improve, with a focus on niche areas of national importance. High-level postgraduate output must increase, by encouraging those already in the system as well as by developing future researchers, and with a strong continued focus on improving equity in relation to gender, race and disability DHET (2012). In order to ensure the level of policy coherence and intergovernmental cooperation necessary to drive improved research and innovation, the DHET will work closely with primary partners like the Department of Science and Technology and the Department of Trade and Industry (DTI). Collaborative work will also ensure synergy in the distribution of funds and the generation of increased support for postgraduate study and for senior researchers, as well as a more stable funding model for all educational institutions that conduct research. This is critical as it will ensure the development of new academics to service both the envisaged growth of university enrolments and the need for high-end research production.

In a differentiated university system it is unrealistic for all universities to have similar research goals. However, all universities must be research-active. Developing research capacity for the future should take into account current research capacity and resourcing. Universities with lower

levels of research output must be supported through planning and funding to develop their research capacity in particular areas of specialisation, as well as to develop a research culture OECD (2011a). As stated earlier, this needs to be built on a solid foundation of strong undergraduate provision at all universities. The DHET will assist universities wherever possible to build their research capacity in various ways, inter alia: developing their research infrastructure, including up-to-date equipment and IT infrastructure; facilitating access to local and international journals and research databases, particularly through central procurement of electronic resources; promoting and encouraging participation by South African universities in global research networks; and increasing the numbers of postgraduate students and postdoctoral fellows in key areas.

3.15 Linking Education and the Workplace

After 1994 South Africa introduced policies and strategies, and created institutions intended to improve information about training needs and opportunities. These institutions were intended to plan for skills development, to radically expand the training available in workplaces – especially for previously disadvantaged people, including blacks, women and the disabled – and to improve the quality of formal education and training aimed at preparing learners for work. Sector Education and Training Authorities were created, as was a National Skills Fund (NSF) and a National Skills Authority (NSA). The SETAs are key institutions in the effort to bridge education and work. They are stakeholder bodies established in terms of the Skills Development Act (No. 97 of 1997).

The mechanism used to fund skills development is known as the levy-grant system. Employers pay levy for skills development, and 80% of this pool of funds is passed via SARS and the DHET, to the SETAs. They distribute portion of the levy funds to contributing employers for training provided t their workers. The remainder is used to support implementation of sector skills plan (SSP) and vireos types of training that combines formal institutional and workplace based training.

The National Skills Fund was also established through the Skills Development Act (SDA). It was created to be a fund which would allocate a proportion of the skills levy to those who would not normally benefit from employer training. The money was meant to be targeted at disadvantaged groups, including the unemployed and those preparing to enter or re-enter the labour market. Particular attention was to be paid to blacks, women, the disabled and others whose training

opportunities had previously been limited by law and custom. The NSF is currently allocated 20 per cent of the skills development levies collected from employers, and this is the Fund's main source of income.

The National Skills Authority was established as a stakeholder body. It was originally set up to advice the Minister of Labour, and has now been transferred to the Ministry of Higher Education and Training. To a considerable extent, the original goals set for these institutions have not been achieved. The institutions have been the subject of widespread criticism. The system has neither produced good information about skills needs, nor increased provision and quality of provision

One of the most serious weaknesses is in the area of skills planning. Inadequate research capacity, a lack of economics, labour market and industry expertise, poor data management, and lack of planning expertise have resulted in sector skills plans that have limited credibility and impact in their sectors. Furthermore, the plans are not viewed as contributing to the achievement of national economic and industrial development goals and plans. As a result, the usefulness of sectorally developed plans has been questioned. Many scarce skills occupations are found across economic sectors, not only in sector silos. Skills needs are increasingly being understood in terms of supply and value chains, and narrowly focused sector skills plans do not allow for the flexibility needed in a fast-changing economic environment. Currently, government economic and developmental priorities are not being adequately addressed, including skills requirements for strategic infrastructure projects and for implementing the Industrial Policy Action Plan and key sectors identified in the New Growth Path DBSA (2013).

There is now a level of consensus that in order to achieve inclusive growth there has to be much better coordination across government, with the state playing a more effective role in stimulating and sustaining the economy. The skills level of both existing employees and those entering the labour market is viewed as an important pillar of government strategy for attracting investment, industrial expansion and job creation. While some changes have been introduced, particularly with regard to strengthening governance, it is clear that further changes to the system are required. The more effective SETAs have demonstrated the positive role that these institutions can play in understanding the needs of the workplace and in supporting providers and employers to offer the required programmes. However, it has become clear that even the more effective SETAs are finding it difficult to respond to the changing demands being placed

on them. In particular, the requirement to reach out to the regions and rural areas is placing a strain on SETA finances. It is not realistic for all 21 SETAs to have a national footprint. Some rationalisation is needed in order to enable access to the skills system in more remote localities DHET (2010).

In the future, SETAs (or their equivalent if they are restructured) will be given a clearer and to some extent narrower and more focused role. The aim will be to locate certain functions (such as skills planning, funding and quality assurance) in well-resourced central institutions, thus enabling sector structures to focus on engaging with stakeholders in the workplace, establishing their needs and agreeing on the best way of addressing them, facilitating access to relevant programmes and ensuring that providers have the capacity to deliver programmes that have a genuine impact. A key role of the skills system structures will be to support efforts to implement workplace learning that complements formal education and training, DHET (2013).

Conclusion

At this point, one may be left wondering what the evidence ultimately achieves in terms of lessons for policy. The most useful perspective is probably to combine the various strands of evidence and see whether they form a coherent whole, despite the problems inherent in each. Labour economists seem to agree that the private rate of return to a year's extra schooling is typically between 5 per cent and 15 per cent. Working under similar assumptions, growth accountants find that increases in educational attainment account for perhaps a fifth of growth in output per worker. Labour economics and growth accounting have a relatively long history, and the strengths and weaknesses of the available evidence are well understood. It is possible that both approaches overstate the social benefits of education because of signal effects, or a correlation between education and unobservable characteristics. Acting in the other direction, the estimates provided by this research may understate the role of education, because they rarely allow measurement of externalities, or quantify the importance for productivity of an improved matching between workers and jobs.

The great strength of the emerging macroeconomic literature is that, at least in principle, it could provide a direct test of the productivity benefits. As we have seen, however, this field has significant weaknesses of its own. Answers that are sufficiently accurate and robust to allow confident conclusions are some way off. They may have to wait until growth economists have longer spans of data to work with, and greater skill at matching a variety of possible statistical

techniques to the question at hand. With these caveats in mind, a brief summary of the macroeconomic literature may be useful. Although in some ways such an exercise is rather premature, it should at least prevent the unwary from jumping to an over-hasty conclusion based on the reading of one or two papers alone. That would be an easy mistake to make. Over the last ten years, growth researchers have bounced from identifying quite dramatic effects of education, to calling into question the existence of any effect at all.

More recent research is placed somewhere between these two extremes, but perhaps leaning closer to the original findings that education has a major impact. In examining the studies that have not detected an effect, we have some convincing reasons (measurement error, outliers, incorrect specification) to doubt such results. The balance of recent evidence points to productivity effects of education which are at least as large as those identified by labour economists.

The single most important investment any country can make is in its people. Education has intrinsic and instrumental value in creating societies that are better able to respond to the challenges of the 21st century. Lifelong learning, continuous professional development and knowledge production alongside innovation are central to building the capabilities of individuals and society as a whole NDP (2012). South Africa needs to develop and strengthen collaboration with other education systems in the English-speaking world and the BRIC countries (Brazil, Russia, India and China) to ensure that students from the South African education system are equipped to be admitted into those systems. International collaboration in education will help South Africa to successfully tackle its education challenges. Stronger educational links with these countries will also help students to become increasingly broadminded in terms of how they look at both South Africa and the wider world NDP (2012).

Expanding the size, quality and diversity of post-school education in South Africa is vitally important. Without this, it is hard to see how we can meet critical national goals. Growing the economy, developing a highly trained civil service, encouraging business expansion, reducing unemployment, and strengthening the home-grown supply of well-trained educators all depend on access to tertiary education and its quality. How we achieve this requires investigation and debate, a process the government is currently leading.

Chapter 4: Methodology

4.0 Methodology

The first objective of this chapter is to specify the theoretical model known as the Cobb Douglas Function which will be used to estimate the statistical relationship between economic growth (the dependent variable) and a set of causal factors (independent variables) which include: education expenditure, tertiary enrolment, innovation, labour and capital . Additionally the sources, frequencies, and units of measurement of mentioned variables will be described and a justification for their selection will be presented. The second objective of this chapter is to specify the econometric methodologies used in this study, which begins with the stationarity tests followed by the test for cointegration, thereafter the Johansen (1990) and Johansen and Juselius (1991) VAR/VECM approach to estimating cointegrating relations will be outlined. The validity and reliability of the results obtained by the VAR/VECM methodology will be verified by comparing them to the single equations methodologies of FMOLS, DOLS, CCR as well as the results obtained from the single equation Auto-Regressive Distributed Lag (ARDL) model.

4.1 Specification of Theoretical Model

To analyze the contribution of the human capital variables to the labour productivity, we begin by focusing on the functional form of the production function. Functional forms are specific to both model and data. If the choice of the functional form is incorrect, the model will potentially predict responses in a biased and inaccurate way, Griffin *et al.,* (1987). The consequences of this error may include, among others, misleading policy implications. There are two commonly used functional forms; translog and Cobb-Douglas. Translog functional form provides a second order approximation to an arbitrary twice differentiable linearly homogenous function. The translog specification is attractive because of its flexibility, in a sense that it encompasses or approximates a number of popular models in the literature. However the translog functional form is vulnerable to multicollinearity and potential problem of insufficient degrees of freedom due to the presence of interaction terms, Coelli (1995). However estimation of this model lies beyond the scope of this study.

The Cobb-Douglas functional form, incorporating labour, capital, and physical output, has traditionally been employed to study the relationship between the level of output and the quantities of inputs used. Although the Cobb-Douglas model provides a simplified view of the economy, especially when many other factors and inputs affect economic performance, this

framework proved to be remarkably stable. The Cobb-Douglas functional form of production functions is commonly used to represent the relationship of an output to inputs. It was proposed by Knut Wicksell (1851 - 1926), and tested against statistical evidence by Charles Cobb and Paul Douglas in 1928. In 1928 Charles Cobb and Paul Douglas published a study in which they modelled the growth of the American economy during the period 1899 – 1922 using aggregate time series data from the US manufacturing sector on labor, capital, and physical output, with the goal of understanding the relationship between the level of output and the quantities of inputs employed in production. They considered a simplified view of the economy in which production output is determined by the amount of labor involved and the amount of capital invested. While there are many other factors affecting economic performance, their model proved to be remarkably accurate

The Cobb-Douglas form is derived from the translog form by restricting the coefficients of the second order terms of the translog to zero. In this study, value added Cobb-Douglas production function was specified and estimated. We focus on the Cobb-Douglas form considered as a special case of the translog frontier. In addition to being the most commonly used functional forms; this form allows comparisons to analyze the relationship between the variables. The Cobb-Douglas form is used mainly because of its simplicity and parsimony. In addition, when the model is transformed into logarithms, one obtains a model that is linear in inputs and is thus straight forward to estimate. However, Cobb-Douglas functional form has the following limitations. The Cobb-Douglas form is restrictive with respect to returns of scale, which take the same value across all firms in the sample and are constant across output levels. The Cobb-Douglas assumes all inputs are technical compliments. It is also inflexible in such that it provides only a first order approximation to a function, which limits it ability to approximate other functions. However, these limitations do not affect this analysis in any significant way for the study is merely interested to assess if the variables in question are statistically related.

Under the assumption that the production function takes what is now known as the Cobb-Douglas form. The procedure was introduced in Cobb and Douglas's 1928 paper "A Theory of Production", and Douglas continued to work with it for the next 20 years, producing a stream of studies in which the regression was applied to both cross section and time series data sets.
The original Cobb-Douglas model is as follow,

$$Y_t = AX_{1t}^{\beta 1}X_{2t}^{\beta 2} \quad \text{.....} \quad (4)$$

Where Y_t is the total outputs of the economy on the given time with it resources, where *A* is the constant (efficiency given parameter), where X_{1t} is the units of capital in a given time in the economy, X_{2t} is a units of labour and β_1 and β_2 represent the output elasticities of capital and labour, respectively.

The core of the model is the production function. The specification used in this study is a modification of the Cobb Douglas production function, to include variables identified by the endogenous growth theoretical literature discussed in chapter 2 as well as the empirical literature discussed in chapter 3. A modification of the standard Cobb-Douglas production function which has the property that a percentage increase in one of the inputs always causes the β_i percentage increase in output (constant elasticity). Hence β_i is the output elasticity of inputs. Our production function is specified with five inputs which justified by the new growth theories which allows the addition of the other variables that have a impact on output: expenditure on education, registered patents, tertiary enrolment, while capital and labour is the traditional variable used in the production function will be included to serve as the control variable.

$$Y_t = AX_{1t}^{\beta 1} X_{2t}^{\beta 2} X_{3t}^{\beta 3} X_{4t}^{\beta 4}\ X_{5t}^{\beta 5}\ e^{ui} \quad \text{..... (5)}$$

Y_t = GDP

X_{1t} = expenditure on education

X_{2t} = Patents (registered patents by residents)

X_{3t} = Tertiary enrolment / school enrolment (this variable will be used as an alternative)

X_{4t} = Labour (control variable)

X_{5t} = capital (control variable)

e^{ui} = exponential error term

The logarithmic conversion of equation (5) above yields the structural form of the production function as:

$$\ln Y_t = \beta_0 + \beta_1 \ln X_{1t} + \beta_2 \ln X_{2t} + \beta_3 \ln X_{3t} + \beta_4 \ln X_{4t} + \beta_5 \ln X_{5t} + \beta_6 D_1 + u_i \quad \text{..... (6)}$$

Additional, a dummy variable was included in the model to accommodate for a structural factors, in to this study the dummy represent the political movement in the South Africa.

A priori I expect the following:

$\beta_1 > 0$ I expect education expenditure to have positive impact on GDP growth.

$\beta_2 > 0$ I expect the patents to have positive effect on economic growth.

$\beta_3 > 0$ I expect tertiary enrolment or school enrolment to have positive effect on the GDP growth.

$\beta_4 > 0$ I expected labour to have a positive effect on the economic growth

$\beta_5 > 0$ I expect capital to have positive effect on the economic growth.

Now, one can see that the model is linear in parametersβ_0, β_2, β_2, β_3, β_4, and β_5 and is therefore a linear regression model. Though, it is nonlinear in variables Y and X but linear in the log of these variables. The equation (6) is a log-log, double-log, or log-linear model.

The coefficients of equation 6 may be interpreted as follows:

β_1 is the elasticity of GDP with respect to education expenditure input, that is, it measures the percentage change in GDP for 1% change in education expenditure input, holding the other variables constant.

β_2 is the elasticity of GDP with respect to the innovation (proxied by registered patents by residents) input, that is, it measures the percentage change in GDP for 1% change in innovation input, holding the other variables constant.

β_3 is the elasticity of GDP with respect to tertiary education enrolment input, that is, it measures the percentage change in GDP for 1% change in the tertiary education enrolment input, holding the other variables constant.

β_4 is the elasticity of GDP with respect to labour input, that is, it measures the percentage change in GDP for 1% change in the labour input holding other variables constant.

β_5 is the elasticity of GDP with respect to capital input, that is, it measures the percentage change in GDP for 1% change in capital input, holding the other variables constant.

The sum of five betas (β_1+β_2+β_3+β_4+β_5) will yield the information about the returns of the scale. The sum (β_1+β_2+β_3+β_4+β_5) gives information about the returns to scale, that is, if sum

$(\beta_1+\beta_2+\beta_3+\beta_4+\beta_5)$ =1 then there are constant returns to scale, that is, doubling the inputs will double the output, tripling the inputs will triple the output, and so on. If sum $(\beta_1+\beta_2+\beta_3+\beta_4+\beta_5)$ >1 then there are increasing return to scale, that is, doubling the inputs will more than double the output and finally, if sum $(\beta_1+\beta_2+\beta_3+\beta_4+\beta_5)$ <1 then there are decreasing return to scale, that is, doubling the inputs will less than double the output.

4.2 Estimation Technique

This section will first justify the need for conducting stationarity tests and will provide a brief outline of statistical tests. Thereafter this section will provide an in-depth discussion of the key principles behind the cointegration methodologies and the VAR/VECM modelling techniques. This will be followed by a brief outline of the single equation methodologies to be used in the study. These single equation models will be Fully Modified Ordinary Least Squares (FMOLS), Canonical Cointegrating Regressions (CCR) and Dynamic Ordinary Least Squares (DOLS). Finally the single equation Autoregressive Distributed Lag (ARDL) model involving an error correction mechanism will also be discussed.

4.2.1 Unit Root

Methods for detecting the presence of the unit root in parametric time series models have lately attracted a good deal of interest in both statistical theory and application Peter and Pierre (1987). Articles by Fuller (1984) and Dickey *el al* reviewed much of the literature in the field.

One major field of application where the hypothesis of unit root has important implications is economics. This is explained by fact that presence of unit root is often a theoretical implication of models which postulate the rational use of information that is available to economic agents.

This study followed the same path of the other researchers, we first perform unit root test on the time series macro-variables in our sample. This is because most macroeconomic time-series data have unit roots and that regressing non-stationary series on each other is bound to yield spurious regression results, spurious result arise due to the existence of common trends (stochastic or deterministic) running through the data and not as presumed by the researcher-due to the strength of the regressors explanatory power reflecting the fundamental economic relationship between variables suggested by theory. Also, the determination of whether a variable exhibits a unit root is to know if the variables exhibit certain characteristics such as

mean reversion and finite variance, transitory shocks with the autocorrelations dying out with the increase in the number of lags under the alternative hypothesis of stationarity. Thus, we first test the nature of the time series to determine whether they are stationary or non stationary and also their order of integration, formal statistical test of the unit root hypothesis are of additional interest to economist because they can help to evaluate the nature of nonstationary that most of macroeconomic data exhibit. The order of integration should assist us in determining the subsequent long-run relationship among the variables. The Phillip-Perron unit root test is adopted for this purpose. The unit root test will be useful in determining whether the trend is stochastic, through the presence of a unit root, or deterministic, through the presence of polynomial time trend.

Although trend-stationary and difference-stationary series are both "trending" over time, the correct approach needs to be used in each case, if we first difference the trend-stationary series, it would "remove" the non-stationarity, but at the expense of introducing an MA(1) structure into the errors. Conversely if we try to de-trend a series which has stochastic trend, then we will not remove the non-stationarity, we will now concentrate on the stochastic non-stationarity model since deterministic non-stationarity does not adequately describe most series in economics or finance.

Consider the simplest stochastic trend model:

$$yt = yt - 1 + ut \ldots\ldots\ldots (7)$$

$$\Delta yt = ut \ldots\ldots\ldots (8)$$

We can generalise this concept to consider the case where the series contains more than one "unit root". That is, we would need to apply the first difference operator, Δ, more than once to induce stationarity. The majority of economic and financial series contain a single unit root, although some are stationary and consumer prices have been argued to have 2 unit roots. The data employed in to this study were differenced one and obtain the stationarity.

There are some questions that arise before such tests are done include; "Does the data possess the property of deviating too far from its mean value over time or in the long-run? Are the deviations stationary or non-stationary?" This study used Augmented Dickey Fuller (ADF, 1979) to test for unit root, that is, to check whether the data is stationary or in simple terms, if it

is mean reverting. The ADF test equation used to test the stationarity of variables is described below;

$$\Delta y_t = a + b_T + \emptyset y_{t-1} + \sum_{t-1}^{p} \Psi i \, \Delta y_t + \varepsilon_t \ldots\ldots\ldots\ldots 9$$

Where,

Y_t = the level of the variable (independent variable, expenditure on education)

a = the constant

t = the time measured at some frequency of the recorded time series observations

T = the time trend (dependent variable- economic growth; GDP) with the null hypothesis $H_0 \Phi$ = 0 as well as its alternative hypothesis H_1: $\Phi \neq 0$

ε_t = normally distributed random error term which has a zero mean and constant variances

p = the number of lags required to obtain the noise.

The initial DF unit root tests assumed that under the unit root null hypothesis, the first differences in the series are serially uncorrelated. Since first differences of most macroeconomic time series are serially correlated, these tests were of limited value in empirical macroeconomics. This problem was addressed in the development of the Augment Dickey-Fuller test (ADF test) and the Phillips-Perron test (PP test). The ADF test relies on a parametric transformation of the model that eliminates the serial correlation in the error term without affecting leaves the asymptotic distributions of the various *t* statistics. Phillips and Perron (Biometrika, 1988) proposed nonparametric transformations of the τ statistics from the original DF regressions such that under the unit root null, the transformed statistics (the "z" statistics) Dickey and Fuller (1979) showed that under the null hypothesis of a unit root, the t-statistic for α does not follow a conventional t-distribution, and derive asymptotic results and simulate critical values for various test and sample sizes.

McKinnon (1991, 1996) implements a much larger set of simulations than those given by Dickey and Fuller. Moreover, he estimates response surfaces for the simulation results, permitting the calculation of DF critical values and p-values for arbitrary sample sizes. It is McKinnon's values that are most commonly used now. Dickey and Fuller (1979) showed that under the null hypothesis of a unit root, the t-statistic for α does not follow a conventional t-distribution, and derive asymptotic results and simulate critical values for various test and sample sizes. McKinnon (1991, 1996) implements a much larger set of simulations than those given by Dickey

and Fuller. Moreover, he estimates response surfaces for the simulation results, permitting the calculation of DF critical values and p-values for arbitrary sample sizes. It is McKinnon's values that are most commonly used now.

4.2.2 Extension to Unit Root

The DF, ADF and Phillips Perron tests have been found to exhibit poor size and poor properties, ie, the tendency to over reject the null hypothesis when it is true and under reject it when it is false, respectively. This problem arises because of the near equivalence of stationary and non-stationary processes in finite samples which makes it difficult to distinguish between trends stationary and difference stationary processes, Dickey and Fuller (1979). A wide variety of test have emerged in the recent literature which include an adaption of the DF and ADF test through including moving average components, developing instrumental viable to estimate ρ, modification of the Phillisp Perron tests, test based on weighted symmetric estimators and tests involving forward and reverse DF regressions, to mention a few of the more important tests.

4.2.3 Cointegration

The process of differencing for the purposes of achieving stationarity result in a loss long run information which contained in the levels but not in the differences of the variables Hendry (1986). The method of cointegration - developed by Granger in his paper, conveniently avoids this dilemma. Granger (1981) developed the concept of cointegration, which reconciled non-stationary processes with long run equilibrium concept. He discovered that when regressing non- stationary variable integrated to the same order (I(d)), in their level form, did not produce spurious results. This occurred because variables that are integrated in same order, share common trends which are cancelled out when these variables are regressed on each other. The cancelling out of the trend component reveals the equilibrium or long run relationship between these variables.

Note that subsequent studies have demonstrated that it is possible to have unbalanced cointegration regressions, ie, regressions involving variables with different orders of integrations on both sides of the equation, which must meet specific criteria in order to be to be valid. For instance according to Charemza and Deadman (1992) the dependent variable should be of a lower order than any one of the explanatory variables. Banerjee *et al.,* (1993) reports Monte Carlo studies on unbalanced regressions involving I(1) and I(0) as well I(2) variables and

concludes that the fact that a regression may be unbalanced may not be a matter of concern and that they are valid tools of inference as long as the correct critical vales are used. Maddala and Kim (1998) on the other hand suggest that this view by Banerjee *et.al* is quite optimistic. Note that for the purposes of this study only I(1) variables will be employed to develop cointegrating relationships. However ARDL model may be both I(0) & I(1) variables.

Returning to the long run equilibrium relationship between cointegrated variables, Engle and Granger (1987) regard this equilibrium as a stationary point characterized by forces that tend to push the economy back towards equilibrium whenever it moves away. Consider the following regression equation:

$$y_t = b_1 + b_2\, x_t + z_t \ldots\ldots\ldots\ldots\ldots (10)$$

$$z_t = y_t - b_1 - b_2\, x_t \ldots\ldots\ldots\ldots\ldots (11)$$

Where b_1, b_2 are the cointegrating parameters, while Y_t and X_t are integrated of the same order I(d) and z_t represents random shocks and is therefore I(0) i.e, stationary. This disturbance or equilibrium error term shows the extent of the system deviation from equilibrium. Since the equilibrium error is stationary, thus it follows that the relationship between the cointegrated variables on the right hand must also be I(0). Stock (1987) came to the conclusion, that if two time series x and y, for example are cointegrated, then OLS estimators of b_1 and b_2 in the equilibrium relationship (10) will be consistence regardless of whether or not there is correlation between explanatory variables and error terms in the functional form. Normally such correlation leads to bias and inconsistency. This result is significant since in most macroeconomics time series data such correlations are likely to exist. Moreover some econometrics models may omit important lagged variables and only concentrate on the long run equilibrium relationship, however Stock's conclusion implies that provided x and y are cointegrated and the sample size is sufficiently enough one may not need to concern about correlation problems.

Thereafter, we test for cointegration among the series. Cointegration indicates the presence of a linear combination of non-stationary variables that are stationary. In a case where cointegration does not exist, it means the linear combination is not stationary and the variable does not have a mean to which it returns. The presence of cointegration however implies that a stationary long-run relationship among the series is present.

4.2.4 VAR Model

VAR model may be as an extension of the univariate model in the following way. Suppose economic theory suggests a relationship between two variables y_{t1} and y_{t2}, modelling each variable separately may involve autoregressions of y_{t1} on lagged values of y_{t1} and y_{t2} on lagged of y_{t2}. However such separation approach would not capture the interaction between the variables that might be present. For example suppose y_{t1} is the economic growth in a proxy of GDP and y_{t2} is the innovation proxy, then it is likely that these two variables are related and modelling these variables should take place in a multivariate frame work. In a VAR y_{t2} is related not just to it own lagged values and those of y_{t1}. A VAR has two dimensions: the length or order p of the longest lag in the autoregression and the number k, of the variables being jointly modelled.

When the variables in y_t are I(1) then a linear combination may be I(0) and are said to be cointegrated, and hence they may be modelled in levels via the use of a VAR model. However more than one cointegrating combinations may arise from the k I(1) variables which are stationary, each of which may be a candidate regressors. Under these circumstances implication four of Granger representation theorem is invoked to formulate models that capture the short run responses while the long run relationships are represented in a cointegrating combinations. This involves applying implication four of Granger Representation theorem which state that if the k x 1 vector of variables y_t is Ci(1.1) then there exists an error correction. The below equation represent error correction or shows how the Granger implication four utilised.

$$\Delta y_t = \alpha z_{t-1} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} \ldots\ldots \Gamma_{\rho-1} \Delta y_{t(p-1)} + \varepsilon t \ldots\ldots\ldots\ldots (12)$$

Where z_{t-1} = β y_{t-1} are the Γ linear cointegrating combination amongst the k variables, with β the $k\ x\ r$ matrix of the r cointegrating vectors and εt a matrix of disturbances. The above error correction representation may be interpreted as the long run or equilibrium relationships in the levels of the variables, which are captured by the cointegrations z_{t-1} = β y_{t-1} ; z_{t-1} represent lagged disequilibrium that are removed through the adjustment coefficients in α. α is a $K\ x\ \Gamma$ matrix of coefficients, with each column associated with one of the r cointegrating combinations. The short run dynamic combinations are captured by the elements in Γi. Note that the vector error correction representations modelled entirely with I(0) variables since β y_{t-1} is I(0) through cointegration and Δy_t is stationary though differencing.

4.2.5 Cointegration in the VAR

General the numbers of cointegration relationships among the k variables is not know the limits are 0 and k while the economic theory might provide a guide to the number of equilibrium relationships. In practice the Johansen (1991) full maximum like hood procedure is wildly used to estimate cointegration relationships.

The first step of Johansen procedure, which distinguishes between equilibrium and dynamic adjustment to equilibrium, involves the estimation of a congruent, unrestricted, closed *p*th order VAR in a k variables. In this framework linearity is assumed, perhaps in logs of the variables. The VAR is pth order in the sense that longest lag length p, which becomes $p-1$ on the Δy_t in the VECM is chosen to eradicate serial correlation among error terms. There are k equations in the VAR/VECM thus no variables are left unexplained implying that the system is closed. Moreover no current dated stochastic variables appear as explanatory variables thus the model is a reduced form model. The lag length and the information set (ie., the y_t and z_t vectors) are determined in a practical application. The model design criteria requires that the estimated model must exhibit congruency in the sense that the estimated residuals must not demonstrate serial correlation (autocorrelation) and should not be heteroscedastic conditional on the information set, in addition the residuals must be normally distributed. In the effort to attain autocorrelation free residuals the key decision variable in practice is the choice of the lag length p via the use of AIC, SBC or Lagrange multiplier interests. Further under certain circumstances intervention dummy and I(0) exogenous variables may be required to remove outliers that contribute to the evidence of non-normality and heteroscedasticity, as you can see to the above equation that the dummy variable were introduced to cater for this.

The procedure adopted in this study is a representation of the approach of analyzing multivariate cointegrated systems developed and expanded by Johansen and Juselius (1990) Unlike the Engle Granger static procedure, the Johansen Vector Autoregressive (VAR) procedure allows the simultaneous evaluation of multiple relationships and imposes no prior restrictions on the cointegration space. The Johansen cointegration approach tests for the cointegration rank for a VAR process, estimates the TRACE and LMAX stats, the eigen values, and the eigenvectors. It computes the long-run equilibrium coefficients, the adjustment coefficients, the covariance matrix of the errors, and the R-squares for each of the equations in the VECM. In addition, it also tests for linear restriction on the long-run equilibrium coefficients. Thus, the approach consists of full information maximum likelihood estimation (FIML) of a

system characterized by *r* cointegrating vectors. If for instance, we assume y_t such that $t = 1 \ldots T$, whereby *(px1)* denotes a vector of random variables and follows a p-dimensional Vector Autoregressive (VAR) model with Gaussian errors (whereby p is the number of jointly endogenous variables).

The following model is estimated:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta y_{t-i} + \mu + \varepsilon_t \ldots\ldots\ldots\ldots 13$$

Where, y_t is a (*n x 1*) vector of the *n* variables of interest, i.e. state education expenditure, economic growth, education enrolment (both tertiary and higher) and innovation (proxy by patent registration), *μ* is a (*n x* 1) vector of constants, Γ represents a $(n\, x\, (k-1))$ matrix of short-run coefficients, εt denotes a (*n x 1*) vector of white noise residuals, and $\prod$ is a (*n x n*) coefficient matrix. If the matrix $\prod$ has reduced rank (*0 < r < n*), it can be split into a (*n x r*) matrix of loading coefficients α , and a (*n x r*) matrix of cointegrating vectors β. The former indicates the importance of the co-integration relationships in the individual equations of the system and of the speed of adjustment to disequilibrium, while the latter represents the long-run equilibrium relationship, so that $\prod = \alpha, \beta$. *k* is number of lags, *t* denotes time and Δ is a difference operator.

The model in equation ten (13) is the vector error correction model for the cointegrated series. In this case, the short-run dynamics of the variables in the system are represented by the series in differences and the long-run relationships by the variables in levels. A shock to the i_{th} variable not only directly affects the i_{th} variable but is also transmitted to all of the other endogenous variables through the dynamic (lag) structure of the VAR. An impulse response function traces the effect of a one-time shock to one of the variables on current and future values of the endogenous variables. The accumulated response is the accumulated sum of the impulse responses. It can be interpreted as the response to step impulse where the same shock occurs in every period from the first. If the estimated ARMA model is stationary, the impulse responses will asymptote to zero, while the accumulated responses will asymptote to its long-run value. If the variables are contemporaneously uncorrelated, interpretation of the impulse response is straightforward. Variables, however, are usually correlated, and may be viewed as having a common component that cannot be associated with a specific variable. While impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VAR, variance decomposition separates the variation in an endogenous variable

into the component shocks to the VAR. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR.

4.2.6 Deterministic Components in a VAR Model

The presence of the intercepts and trends in the short run (VECM) and/or the long run model is crucial in determining which table of critical values should be used in determining the number of cointegration relationships in the model.

If the levels of data contain linear trends then the specified model must cater for the non-stationary relationships in the model to drift, (*i.e* the trend component between the cointegrated variables cancel out each other). Moreover in specifying this model it is assumed that the constant in the cointegrating space is cancelled out by the constant in the short run model (VECM), thus leaving only one intercept in the VECM. If the a constant term is included in a VECM and not in the cointegrating space leads to linear trends in the data, while confining the intercept to the cointegrating space alone is only relevant for data which exhibits no linear trends component. Thus it is necessary to include the intercept into both VECM and cointegrating space, in order to prevent the above mentioned problem.

Furthermore when the individual data series contain a linear trend which do not cancel in a cointegrating space it is necessary to include a linear trend in a cointegrating space. Note that the role played by the linear trend differs by one level if it is in the VECM and no in the cointegrating space; a linear trend in a VECM but not in a cointegrating space leads to a quadratic trends in the data; a quadratic in VECM and not in the cointegrating space leads to cubic in the data. Thus models with unrestricted intercepts and trends allows for quadratic trends in the data, which seldom occurs, Patterson (2000) suggest that the cause of these quadratic trends must be found and explained via other variables instead of using the quadratic trend term. Thus unrestricted intercepts and trends models as well as non intercept and trends models mentioned earlier are considered as extremes which are not useful in practice, hence the study will not consider them.

The most common models used in practice are the restricted intercepts (the intercept is restricted to the cointegrating space) no trends model (model A) and unrestricted intercept (the intercept is partitioned in the VECM and the cointegrating space implying that a linear trend in the cointegrating space arises) no trends model (model B). The choice between model A or B

depends upon whether there is a need to allow for the possibility of the trends in the data. A preliminary graphing of the data is often useful in this respect. If model B is preferred to model A then only does the one involving unrestricted intercepts and restricted trends (model C need to be considered, since the data has to have a linear trend, if one is to consider allowing a trend in a cointegrating space Patterson (2000).

Patterson (2000), suggested that a plot of residuals of model B against time should prove useful in deciding whether to choose Model C. If the residuals are clustered around the origin model C is not preferable, however if the residuals demonstrate a significant trend over time the model C must be considered. However Harris (1995) suggests that this approach provides little information because the choice of model C arises when the available data cannot account for the unmeasured factors that induce autonomous growth in some or all variables. As an alternative approach, he prefers invoking the Pantula Principle which Johansen (1992) had suggested. The Pantula Principle requires that all three models must be first estimated, thereafter their trace/maximum eigenvalue statistics must be compared and the model whose trace/maximum eigenvalue statistics selects the smallest r value (*ie.*the most restricted model) is regarded as the most appropriate model for estimation. The study applied the Pantula Princeple in deciding upon which deterministic components ought to be included.

4.2.7 The Fully Modified Ordinary Least Squares (FMOLS) Test

This cointegration method by Philips and Hansen (1990) assumes the existence of a single cointegrating vectorand involves adjusting OLS estimates of both long run parameters and their associated t-values to accommodate for any bias owing to autocorrelation and endogeneity problems present in OLS residuals Harris, (1995); Harris and Sollis, (2003). Consequently, the resulting estimator is asymptotically unbiased and has fully efficient normal asymptotical properties allowing for the use of standard Wald tests using asymptotic chi-square (χ^2) statistical inference (Belke and Czudaj, 2010). Following Belke and Czudaj (2010), consider the following $(\mathrm{y_t}, \mathrm{X_t'})$ vector process:

$$y_t = X_t'\beta + D_t'\gamma_1 + u_{1t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

where y_t is the $I(1)$ dependent variable and X_t' denotes the stochastic regressors governed by $X_t = \Gamma_{21}' D_{1t} + \Gamma_{22}' D_{2t} + \varepsilon_{2t}$ with $\Delta\varepsilon_{2t} = u_{2t}$. Moreover, $D = (D_{1t}', D_{2t}')$ are the deterministic trend

regressors and u_{1t} is error term with zero mean and covariance(Ω). The FMOLS estimator is therefore given by:

$$\hat{\theta}_{FMOLS} = \begin{bmatrix} \hat{\beta} \\ \hat{\gamma}_1 \end{bmatrix} = \left[\sum_{t=1}^{T} Z_t\, Z_t'\right]^{-1} \left[\sum_{t=1}^{T} Z_t\, y_t^{+} - T \begin{bmatrix} \hat{\lambda}_{12} \\ 0 \end{bmatrix}\right] \ldots\ldots\ldots\ldots\ldots (15)$$

where $Z_t = (X_t', D_t')'$, $y_t^{+} = y_t - \hat{\omega}_{12}\hat{\Omega}_{22}^{-1}\hat{u}_2$ signifies the transformed data and $\hat{\lambda}_{12}^{+} = \hat{\omega}_{12}\hat{\Omega}_{22}^{-1}\hat{\Lambda}_{22}$ represents the estimated bias correction term with the long-run covariance matrices $\hat{\Omega}$ and $\hat{\Lambda}$ and their respective elements, which are computed using $u_t = (\hat{u}_{1t}', \hat{u}_{2t}')'$.

4.2.8 Canonical Cointegrating Regressions (CCR)

The CCR estimation method, developed by Park (1992), is a non-parametric approach for statistical inference in a cointegrated model involving adjustments of the integrated processes using only stationary components to account for long run correlation between regressors and the error term. According to Han (1996), this method yields asymptotically efficient estimators and χ^2 inference. Drawing from equation (a), the CCR estimator is defined as:

$$\hat{\theta}_{CCR} = \begin{bmatrix} \hat{\beta} \\ \hat{\gamma}_1 \end{bmatrix} = [\textstyle\sum_{t=1}^{T} Z_t^{*}\, Z_t^{*\prime}]^{-1} \textstyle\sum_{t=1}^{T} Z_t^{*}\, y_t^{*} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (16)$$

where $Z_t^{*} = (X_t^{*\prime}, D_t')'$, $X_t^{t} = X_t - (\hat{\Sigma}^{-1}\hat{\Lambda}_2)'\hat{u}_t$ and $y_t^{*} = y_t - \left[\hat{\Sigma}^{-1}\hat{\Lambda}_2\tilde{\beta} + \begin{bmatrix} 0 \\ \hat{\Omega}_{22}^{-1}\hat{\omega}_{21} \end{bmatrix}\right]' u_t$ represents the transformed data. The $\tilde{\beta}$ coefficients are estimates of cointegrating equation applying static OLS, $\hat{\Lambda}_2$ is the second column of $\hat{\Lambda}$ and lastly, $\hat{\Sigma}$ denotes the estimated contemporaneous covariance matrix of the error terms.

4.2.9 The Dynamic Ordinary Least Squares (DOLS) Test

The DOLS test is another alternative to the EG approach. Suggested by Stock and Watson (1993), the test is a parametric method in which the lagged first difference terms are explicitly estimated Saayman, (2010). It extends the cointegrating regression by augmenting the errors with leads, lags and contemporaneous values of the regressors (ΔX_t) Saayman, (2010), such that the new cointegrating equation error term is orthogonal to the entire history of the stochastic regressor innovations Belke and Czudaj, (2010). The DOLS results in a more powerful test for

cointegration and gives unbiased estimates of the long-run relationship Harris, (1995); Harris and Sollis, (2003). According to Belke and Czudaj (2010), this method assumes that the added q lags and r leads of ΔX_t (exemplified in equation (17)), completely eliminate the long run correlation between error terms, u_{1t} and u_{2t}.

$$y_t = X_t'\beta + D_t'\gamma_1 + \sum_{j=-q}^{r} \Delta X_{t+j}'\delta + v_{1t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

The DOLS estimator of equation is hence given by $\hat{\theta}_{DOLS} = (\hat{\beta}', \hat{\gamma}_1')'$.

In all the above-discussed single equation approaches, when variables in a regression model are found to be cointegrated through the use of hypothesis testing, then the long run relationship between them can be estimated by the cointegrating regression. In these circumstances, OLS estimation would yield super consistent estimators of the long run parameters Enders, (2010). Conversely, a drawback of these approaches arises due to their lack of systematic procedures to separately estimate multiple cointegrating regressions when there are more than two variable in a model. According to Harris and Sollis (2003), assuming that there is only one cointegration vector when there actually is more than one, leads to inefficiency as only a linear combination of these vectors can be obtained.

4.2.10 ARDL model

In this study, the Autoregressive Distributed Lag (ARDL) approach to cointegration, which is proposed by Pesaran and Shin (1997, 1999) and Pesaran, (2001), is used to determine/test the long-run co-integration relationships between variables and confirm the result that has been produced by the VAR model, because this approach have a lot of advantages over the Johansen maximum Likelihood (1988) cointegration method. The ARDL cointegration test, assumed that only one long run relationship exists between the dependent variable and the exogenous variables.

The bound test is basically computed based on an estimated of unrestricted error-correction models (UECM) or error correction version of autoregressive distributed lag (ARDL) model, by Ordinary Least Square (OLS) estimator (Pesaran *et al.,* 2001). First, the ARDL approach can be applied irrespective of whether the regressors are I(1) and I(0). Second, while the Johansen cointegration techniques require large data samples for validity, the ARDL procedure provides

statistically significant result in small samples, Pesaran and Shin, (1999); Narayan, (2005); Udoh and Ogbuag, (2012). That means, it avoids the problem of biasness that arise from small sample size Chaudhry & Chaudhry, (2006).Third, the ARDL procedure provides unbiased and valid estimates of the long run model even when some of the regressors are endogenous Harris and Sollis, (2003),. Further, in using the ARDL Approach, a dummy variable can be included in the co-integration test process, which is not permitted in Johansen's method Rahimi and Shahabadi, (2011). Therefore, the following ARDL model is specified.

$$\Delta \ln Y_t = \lambda_0 + \lambda_1 \ln X_{1t} + \lambda_2 \ln X_{2t} + \lambda_3 \ln X_{3t} + \lambda_4 \ln X_{4t} + \lambda_5 \ln X_{5t} + \lambda_6 D_1 + u_i \ldots\ldots\ldots\ldots (18)$$

$$\Delta \ln Y_t = b_0 + \sum_{i=1}^{n} b_1 \; lnX1_{t-i} + \sum_{i=1}^{n} b_2 \; lnX2_{t-i} + \sum_{i=1}^{n} b_3 \; X3_{t-i} + \sum_{i=1}^{n} b_4 \; lnX4_{t-i} + \sum_{t=1}^{n} b_5 \; lnX5_{t-i} + e_t \ldots\ldots\ldots\ldots (19)$$

Where:

$\ln Y_t$ is natural logarithm of GDP at time *t,*

$\ln X_{1t}$ is natural logarithm of labour at time *t,*

$\ln X_{2t}$ is natural logarithm of patents at time *t,*

$\ln X_{3t}$ is natural logarithm of education expenditure at time *t,*

$\ln X_{4t}$ is natural logarithm of tertiary enrolment at time *t,*

$\ln X_{5t}$ is natural logarithm of capital at time *t,*

D_1 is the dummy variable

u_i *and* e_t is an error terms

λ_0 is an constant coefficient

λ_1 to λ_6 are the coefficient that measures long run relationship

b_1 *to* b_5 are the coefficient that measures the short run relationship

n denotes the length of the autoregressive process and *t* is the time trend of the model

To test whether there is a long run equilibrium relationship between the variables; bounds test for co-integration is carried out as proposed by Pesaran and Shin (1999) and Pesaran, *et al*. (2001). The hypotheses are shown below:

H_0 : $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6$=0, that means there is no long run relationship among the variables.

H_1 : $\lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq \lambda_6$=0, means there is a long run relationship among the variables. Basically, the bound test developed by Pesaran *et al.* (2001) is the Wald test (F-statistic version of the bound testing approaches) for the lagged level variables in the right-hand side of UECM. That is, we test the null hypothesis of non-cointegrating relation (H_0 : $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6$=0) by performing a joint significance test on the lagged level variables. The asymptotic distribution of the F- statistic is non-standard under the null hypothesis of no cointegrating relation between the examined variables, irrespective whether the explanatory variables are purely I(0) or I(1).

Under the conventionally used level of significance such as 10%, 5% and 1%, if the statistic from Wald test falls outside the critical bounds value (lower and upper values), a conclusive inference can be made without considering the order of integration of the explanatory variables. If the F-statistic exceeds upper critical bound, then the null hypothesis of no cointegrating relation can be rejected. If the test statistic (F-statistic) falls below the lower critical bound, we cannot reject the null of non cointegration. In the case, the F-statistic falls between the upper and lower bounds, a conclusive inference cannot be made. Here, the order of integration, I(d) for the explanatory variables must be known before any conclusion can be drawn Pesaran *et al*., (2001).

4.3 A theoretical and practical basis for the choice of variables

Y_t vector of jointly determined (or endogenous) variables were chosen on the basis of the theoretical considerations of chapter two, the South African economic growth experiences and on the economic growth modelling experiences of south Africa and other countries covered in chapter three.

The change in the GDP was used as an indicator of the economic growth rate because it a popular choice of the performance level economic growth indicator in the South African economy that is available on a quarterly and yearly basis.

Theoretically, labour force is a major element for sustainable rate of economic expansion. It could be the engine of growth for labor intensive economies like South Africa. But if it couldn't be used efficiently and if it is less productive, it may be a burden for the economy because of high rate of unemployment. It is incorporated in the model in its growth rate.

The choice of the education expenditure was based on the theory of human capital, as part of the development or intervention that took place with any aim of advancing the human capital. This variable refers to the ratio of the sum of recurrent and education expenditure budget of the South African government to GDP. To avoid double counting government expenditure on human capital is deducted from total government expenditure; the government expenditure on education is taken only the expenditures from domestic sources (excluding the external assistance and loan). It is entered in to the model as a share of GDP. Since, budgetary expansion would boost the economy and would cause an increase in the GDP growth rate.

The tertiary enrolment represents the human capital variable (loosely speaking, human capital corresponds to any stock of knowledge or characteristics the worker has (either innate or acquired) that contributes to his or her "productivity". This definition is broad, and this has both advantages and disadvantages) in the Cobb-Douglas production function. According to the human capital theory as discussed on chapter three, if the labour force is educated this increase their productivity on the work place and the productive labour force boost the output which means the GDP or economic growth will increase. Human capital is a factor influencing labour productivity because it facilitates the absorption of new technology, increases the rate of innovativeness and promotes efficient management Sankay *et al*. (2010). Consequently, for high labor productivity, investment in human capital is termed as endogenous factor that enhance accumulation of physical capital through knowledge, skills, attitudes and health status of the people who participate in the economic process. Therefore, this variable is included in the model to represent the "knowledge, skills, competence and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being. It is represented by the share of public health expenditure (recurrent and capital) to GDP and secondary school

enrolment. Therefore, higher level of human capital development in the form of education is expected to have a positive impact on economic growth.

The choice of the innovation variable has been supported as the factor of production as reflected in chapter 2 and 3, evidence has become overwhelmingly convincing to show that economies, which may be poor in natural resources but skilled in knowledge creation and utilisation, generally outperform those economies that have abundant natural resources but vare lacking in knowledge competence and skills. Knowledge has now emerged as the primary resource for economic development; and land, labour and capital – the economist's traditional factors of production have become secondary.

Changes in economic policies being influenced by the political movement can influence the performance of the economy through investment on human capital and infrastructure, improvement in political and legal institutions and so on Easterly, (1993). Therefore, policy change influenced by political movement dummy ($D1$) is added in to the model. The dummy for changes in economic policies take zero for the period 1981-1990 and one otherwise.

All of the variables discussed above are given in logarithm form (except the policy change in South African politic dummy). The log-linear form of specification enables the researcher to interpret the coefficient of the dependent variables directly as elasticity with respect to the independent variables Sarmad, (1988). In addition it is also useful for accommodating the hetreoskedasticity problem Goldstein and Khan, (1976).

4.4 Data Issues and sources

We are using time series annual data that cover the period of 1981-2012, with the following variables, gross domestic product (this variable was extracted in real terms this will the variables that will measure the economic growth in our model. It will be also represent the productivity of the country), education expenditure (is the total expenditure on education by South African government and private stakeholders listed on the web site of the World Bank, the linear extrapolation techniques was utilised for the intervening years to get the full data set on this variable because some of the years were not recorded this includes 1989-1994), Innovation which is the proxy of the registered patents in South Africa, (as you can see on the data that during 1990 there were huge decline on the people who register as patents, this may caused by the release the first democratic president Nelson Mandela), tertiary enrolment), capital and

labour (capital and will play a significant role as a control variables to make sure that the production function is correctly specified taking in to consideration the traditional Cobb-Douglas function includes labour, capital and output).

The annual series for national income and capital were downloaded from the South African Reserve Bank website. All the series employed in the Cobb-Douglas (equation 1) model were transformed into natural logs (equation 3) and were found to be I(1) non-stationary variables that were rendered stationary upon first differencing.

Yearly data were obtained from the following sources, Department of Higher Education and Training, Statistic South Africa, South African Reserve Bank, Productivity South Africa and World Bank (www.statsa.org.za, www.sarb.org.za, www.productivitysa.co.za, and www.worldbank.org)

4.5 Conclusion

The main purpose of this chapter was to outline the statistical techniques and specify the models that will be employed in the next chapter to derive the long and short run relationship between the economic growth, education expenditure, tertiary enrolment, innovation, capital and labour.

This chapter outlining the problem of the spurious regressions and showed that by applying integration test and by formulating regression specifications involving cointegrated variables long run relationship between time series variables may be achieved, which not only avoid the problems of the spurious regressions, but also obtain super consistent parameter estimates. Moreover the relevant integration and cointegration test, which included the much-preferred Johansen's VAR multivariate approach to cointegration have been outlined and will be applied in the succeeding chapter to derive stable long run relationship between the mentioned variables. The Johansen approach is preferred to the Engle Granger single equation approach because it identifies more than one cointegrating relationship that may exist amongst the variables and cointegration tests are more powerful than the letter approach because it leads to smaller variances even in cases of a single cointegrating vector.

It was also demonstrated that if variables are cointegrated, then short run dynamics may be captured via error correction models, the estimation of which is one of the main aims of the study.

Additionally this chapter specified the econometric models to be estimated in the succeeding chapter and motivated that the relevant variables to be modelled were chosen in accordance with the theoretical and practical considerations chapters two and three. Moreover the study used the ARDL, FMOLS, DOLS and CCR models for the confirmation purpose.

Chapter 5: Empirical Analysis

5.0 Introduction

This chapter gives a detailed account of the empirical estimation procedure that was undertaken, together with a presentation and interpretation of the results.

As mentioned previously the primary focus of the empirical investigation is to derive the long run cointegration relationships between economic growth and it determinants, and to then exploit these relationships to derive short run models, which include error correction models that explains the adjustment of the economic growth as a result of a temporary deviation from it long run equilibrium relationships due to the temporary shocks.

The empirical analysis was conducted in five stages and which are captured in the following in the following sub-sections of this chapter:

Stage one (section 5.1); of the estimation procedure involves the transformation of the data; this stage includes the log transformation of all variables.

Stage two (section 5.2); of the estimation procedure undertakes the stationarity tests which include: the Augmented Dickey-Fuller (ADF), Elliott-Rothenberg-Stock (DF-GLS) and Kwiatkowski Phillips-Schmidt-Shin (KPSS) tests. These tests are routinely undertaken in order to separate out the I(0) variables from I(1) variables and for the purposes of avoiding spurious regressions. This section also presents and discusses the results based on the mentioned stationarity tests.

Stage Three (section 5.3); estimates the p_{th} order VAR model which is then used to undertake the Johansen based cointegration tests involving the trace and maximum eigen value statistics, for the purposes of identifying the rank of the cointegrating matrix.

Stage four (section 5.4) first defines the long run vectors that are expected to emerge from the ***r*** cointegrating vector through the use of economic theory and appropriate identifying restrictions. This gives rise to estimation of the long run equilibrium elasticities base on the three-variable cointegrating vectors. These long run relationships are then exploited in order to develop the

VECM based equation that captures the short run dynamics between economic growth rate and its deviations from the cointegrating combinations.

Stage five (section 5.5), estimates the single equation ARDL, FMOLS,DOLS and CCR model for comparison purposes to the main result concerning determinants of economic growth reported in section 5.4.

5.1 Stage one - Data Transformation

It is standard practice to transform macroeconomic time series data into natural log form because the non-transformed data usually trends upwards and units root tests often diagnose the series to be non-stationary. Once natural logarithm transformation of data undertaken the series remain roughly constant thus their percentage growth may be considered as $(x_t - x_{t-1})/x_{t-1}$.

Note that the expenditure on education variable already exist in the percentage form thus there is no need to transform it into natural log form since this will allow direct interpretation of the expenditure on education elasticities.

5.2 Stage two - Estimation of Order of Integration

This stage involves testing for the order of integration of the data and the reporting and discussing of the results. The outcome of the stationarity test is crucial to determining the final specification of the VAR model. The expectation of this study is that the South African macroeconomic time series data are I(1).

Usually the variables entering a VAR model must be stationary in order for valid conclusions to be drawn, however robust VAR models can also be estimated if the vector of variables entering the VAR model are of the order I(1). It is often assumed that the data in the multivariate set are non-stationary, and that a stationary cointegrated relationship(s) would therefore need to be found to avoid the problem associated with spurious regression. The order of integration of each variable that enters the multivariate model therefore becomes important, and the following table shows the Augmented Dickey-Fuller (ADF), Elliott-Rothenberg-Stock (DF-GLS) and Kwiatkowski Phillips-Schmidt-Shin (KPSS) tests that have been performed to test for variable stationarity in level terms.

Table 1: ADF and KPSS Test Result base on the SIC Lag choice

	Sample period 1983 to 2012				
Variables	**ADF (SIC)**	**DF-GLS.**	**Critical t-values**	**KPSS**	**Order of Integration**
LGDP	-3.947748*	-4.306944*	-2.89	0.146000	I(1)
LL	-5.648350*	-5.796870*	-2.89	0.143787	I(1)
LK	-5.057313*	-3.246830*	-2.89	0.099888**	I(1)
LExpenditure	-4.711728*	-4.754878	-2.89	0.073692*	I(1)
LEnrolment	-4.961517*	-5.106120*	-2.89	0.069818*	I(1)
LInnovation	-5.237277*	-5.337681*	-2.89	0.106455	I(1)

Source: Author's own calculations using World Bank data

Notes: ADF (SIC): number of lags determined by the Schwartz information criteria

DF-GLS: Elliott-Rothenberg-Stock (DF-GLS) test statistic

KSS: Kwiatkowski Phillips-Schmidt-Shin (KPSS) test statistic

* denotes significance at the 5 per cent level

** denotes significance at the 1 per cent level

LL and LK represents the natural logs of labour and capital, respectively.

The above results were generated on the basis of intercept and no trend since their respective coefficients were found to be insignificant when we add trend. In addition, despite the results not being shown here in Table 1, all the standard order of integration tests confirm first difference stationarity "I(1)" at the 5 per cent level. Since this study is primarily concerned with the long-run properties of the model to derive the equilibrium economic growth, attention is now focused on the existence of cointegration between the various variables of the model. The process first determines whether there are cointegrating vectors, and secondly how many of these vectors exist.

Given the above results each I(1) variable satisfies the necessary requirements in order to be included in a long run cointegration model.

5.3 Stage Three - VAR Model selection

This stage involves selecting the order (P) of the VAR model and thereafter deciding whether intercepts and/or trends (deterministic components) should be included in the Johansen cointegrating VAR model for the purposes of testing for the number of cointegrating vectors (ie., the rank of the VAR/VECM model). Since numerous models were generated and hence in the interest of brevity only the more relevant results will be reported for the purposes of demonstrating how the VAR order was selected.

5.3.1 The VAR Order $(\boldsymbol{P})$ Selection, Presentation and Discussion of the Results

Patterson (2000) suggest that the AIC and SIC tests should be used in selecting the order (p) of the VAR model.The choice of the appropriate lag length is critical for obtaining models whose disturbance terms exhibit 'white noise'. The Eview's 8 multivariate menu under the unrestricted VAR option provides the facilities for determining the VAR order by setting the maximum order to $p = 2$ for the case of annual data. The selection procedure involves choosing the VAR(p) model with the highest value of the AIC or SIC. In practice, the use of the SIC is likely to result in selecting a lower order VAR model than when using AIC. This introduces a degree of uncertainty in VAR(p) model choice; however Pesaran and Shin (1997) suggests that in using both criteria it is important that the maximum VAR (p) order chosen is high enough for high order VAR specifications to have a reasonable chance of being selected. The approach this study employed was to choose the highest value selected by AIC wherever SC chose a lower order. Additionally the VAR order of $p = 2$ is also supported by three other tests reported in Table 2.

Table 2: Lag-order selection criterion

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	69.34319	NA	8.82e-10	-3.822880	-3.262401	-3.643578
1	216.0351	215.1481	5.95e-13	-11.20234	-8.960421*	-10.48513
2	271.9745	59.66871*	2.33e-13*	-12.53163*	-8.608279	-11.27652*

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

5.3.2 Selection of the Deterministic Components in the VAR Model

As discussed I the previous chapter, that before the cointegrating relationship are estimated, the choice must first be made between three types of models in regard to the cointegrating equations: Model A, which contains a constant in the cointegrating space, Model B, which allows for linear trends in the data and a constant in the cointegrating space and Model C, which allows a linear trend I n data as well as a constant and linear trend I n the cointegrating space. Microsoft and its accompanying manual by Pesaran and Pesaran(1997) refers to models A, B and C as restricted intercept VAR model with no trends, unrestricted intercept VAR model with no trends and unrestricted intercept VAR model with restricted trends, respectively. Note that the mentioned three models occur commonly in macroeconomic time series data, however, Eviews offer two other models, viz., the no intercept and trend model and the intercept and quadratic trend model. This study ignored these two options on the basis they are rarely used in time series modelling and are only used in exceptional circumstances based on strong a priori knowledge.

Patterson (2000) states that there is a presumption that variables which are stochastically cointegrating are also deterministically cointegrated, thus in practice the dominant models will be model B model A in that order. In addition if model B preferred to Model A then Model C must also be considered by observing in the graphs of error terms against time of the cointegrating combinations of Model B. If a clear trend is discernable then model C be used instead of Model B. However Harris (1995) contends that such graphs provide little information on whether Model C should be chosen, since this choice arises when the available data cannot account for other unmeasured factors that cause autonomous growth in the variable(s). Thus he advocates the Pantula Principle which was suggested by Johansen (1992), whereby all three models are estimated and that model which chooses the smallest ***r*** value (ie., the most restricted model) via the trace and maximum eigenvalue statistics is selected. This study adopts the Pantula Principle as a preferred approach.

An estimation of VAR (p) Models of the A,B,C variety showed that in the majority of instances the trace and maximum eigenvalue statistics for Models A and C tended to generate a r value that was greater than the r value of model B by a magnitude of 1(ie., they tended to produce one extra cointegrating vector). Hence this study based on the Pantula Principle opted to estimate cointegrating equations based on the assumptions of model B.

5.4.0 Stage Four-identification and Estimation of the cointegration Vectors

The following cointegration analysis sets out to identify up to three long run cointegrating relationships based primarily on the economic theory covered in chapter 2 and to a lesser extent on the qualitative discussions undertaken in chapter 3.this procedure is necessary in order to uniquely identify each cointegrating vector that spans the cointegrating space.

5.4.1 Identification of the Cointegrating vectors

The main cointegrated relationship that was tested for in all the cointegrating relationships involved the long run relationship between the economic growth, Labour, Fixed capital formation, tertiary enrolment education expenditure and innovation, which may be represented as an error correction mechanism (ECM):

$$CV1 = ECM1 = LGDP - \beta_0 - \beta_1 LL - \beta_2 LK - \beta_3 LENROLMENT - \beta_4 LEXPENDITURE - \beta_5 LINNOVATION \ldots\ldots\ldots\ldots \quad (20)$$

In the above relationship the expectation is that $0 < \beta_i < 1$ with the expected signs reflected in the above cointegrating vector (CV1). Note in the ECM form the β_i are reflected as being negative, however if the equation is written in its standard long run regression form then one can easily notice that all the coefficients are positive:

$$LGDP = \beta_0 + \beta_1 LL + \beta_2 LK + \beta_3 LENROLMENT + \beta_4 LEXPENDITURE + \beta_5 LINNOVATION + ECM1 \ldots\ldots\ldots\ldots \quad (20')$$

A similar reasoning applies to the rest of the cointegration vectors discussed below. The theoretical discussions of chapter 2 confirm that economic growth is a function of the skills levels of labour (proxied by the tertiary enrolment rate), government investment on education and intellectual property (measured by innovations or patents).

The second long run cointegrating vector is between the labour on one hand and fixed capital formation, education expenditure, tertiary enrolment and innovation on the other which can be written as:

$$CV2 = ECM2 = LL - \beta_1 LK - \beta_2 LENROLMENT - \beta_3 LEXPENDITURE - \beta_4 LINNOVATION \ldots\ldots\ldots\ldots\ldots \quad (21)$$

The third long run cointegrating vector is between the fixed capital on one hand and formation, education expenditure, tertiary enrolment and innovation on the other which can be written as:

$$CV3 = ECM3 = LK - \beta_2 LENROLMENT - \beta_3 LEXPENDITURE - \beta_4 LINNOVATION \ldots\ldots\ldots\ldots \quad (22)$$

In all the above relationships the expectation is that $0 < \beta_i < 1$, however, the expected signs are reflected as negative in the above cointegrating vectors (CV1, CV2 and CV3) due to the ECM form as explained above. The positive signs of the coefficients in CV2 are consistent with the theory of human capital as mentioned in chapter 2 which suggests that any attempts that are made to improve the human capital must have the positive relationship to labour. Hence further education and training, state investment on education and the availability of intellectual property all contribute positively to human capital development. The signs of CV3 are consistent with the findings of Asteriou and Agiomirgianakis 2001 in the Greece economy where they find the similar relationship among their estimated variables.

Note that the above coefficients must be interpreted as elasticities i.e., a $x\%$ rise in the independent variable result in a $x\%$ change in the normalized variable that is equal to the magnitude of coefficient in equation.

5.4.2 Identifying the Restrictions

If the combination of variables contain more than one cointegrating relationship, then the appropriate restrictions needs to be introduced into each cointegrating vector in order to distinguish the different long run relationship from one another, this is termed just identification. The identification rule states that if the set of variables have ***r*** cointegrating relationships *r-1* restrictions must be placed on the chosen coefficients of each cointegrating vector for the purposes of just identification. If *r*=3 then 2 restrictions must be placed on each cointegrating vector. Although some of the cointegrating vectors may share the same restriction on the coefficient of a specific variable, but a combination of restrictions on each cointegrating vector must be unique for just identification to arise. Commonly a restriction of 1 or 0 is place on the coefficient of a particular variable, which is determined on the basis of economic theory; however any reasonable numeric value may be used based on economic theory or practical experience. Further *r-1* restrictions placed on each cointegrating vector does not include the restriction (normalization) of 1 placed on the coefficient of the normalized variable.

5.4.3 The Cointegration test

First the empirical assumption in estimating the cointegrating vectors is outline, thereafter the conclusions of the trace and maximum Eigenvalue statistics are discussed below:

Table 3: Summary of Cointegrating Assumptions

Data Trend:	Case 1: None	Case 2: None	Case 3: Linear	Case 4: Linear	Case 5 Quadratic
Test Type	**No Intercept No Trend**	**Intercept No Trend**	**Intercept No Trend**	**Intercept Trend**	**Intercept Trend**
Trace	3	3	2	2	2
Max-Eig	3	3	2	2	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

Table 3, above shows the five different assumptions that can be made with regard to the possible cointegrating relations that might exist among the variables in the dataset. However, in practice case 1 and case 5 are considered to be implausible for macroeconomic time series data and are rarely applied, while cases 2, 3 and 4 were discussed as Models A, B and C, in Section 5.3.2., above. Thus of the remaining three cases, the results show that case 2 (Model A) and 3 (Model B) with an intercept and no trend, tends to not agree on each other, case 2 says there will be three cointegrating relationship and case 3 tends to the 2 cointegrating relationship, which agree with case 4 (Model C). Cases 3 and 4 tend to reveal the contradictory signs of the coefficients with the growth theories and human capital theory. Case 2 is the only case that provides plausible results that make sense from an economics perspective. In case 2, both the trace and maximum statistics confirm the existence three cointegration relationships among the variables. Hence the study proceeded to estimate a cointegrating relationship based on case 2.

Table 4: Results of Cointegration Test

		Trace-Statistic	Trace	Maxim Eigen Value Statistic	
H0: rank =ρ	λ	**-Tlog(1- λ)**	λ_{TRACE} **95%**	**-Tlog(1- λ)**	λ_{MAX} **95%**
$\rho = 0$*	0.858739	154.8030	103.8473	58.71445	40.95680
$\rho < 1$*	0.715982	96.08853	76.97277	37.76151	34.80587
$\rho < 2$*	0.631637	58.32702	54.07904	29.96059	28.58808
$\rho < 3$ ***	0.381128***	28.36643***	35.19275***	14.39569***	22.29962***
$\rho < 4$	0.311552	13.97073	20.26184	11.19944	15.89210
$\rho < 5$	0.088238	2.771289	9.164546	2.771289	9.164546

Trace and Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**Mackinnon-Haug-Michelis (1999) p-values

*** denotes the acceptation of the hypothesis at the 0.05

The results of the co-integration tests on Trace and Eigen Maximum indicated that the time series variables are cointegrated with 3 vectors. The results are consistent with the findings of Gupta and Chakraborty (2004) among others. Results are presented in Table 4. Therefore, a long run equilibrium relationship exists among all variables in the model. Both the Trace and Eigen test rejects the null hypothesis of no co integrating vectors (r = 0) at the 5% level when tested against the hypothesis of one co-integrating vector (r =1) since the test statistic of 154.80 is greater than the critical value of 103.8 for the trace statistic and the same for Eigen were the test statistic is 58.7 which is greater than the critical value of 40.9. Likewise, r =2 is also rejected by both tests. However, both tests show that there are 3 integrated vectors in the system.

5.4.4 VAR/VECM Long Run Cointegration Results

Having verified that the variables are co-integrated and that there exist three cointegrating vectors the study went on to apply the restrictions outlined in sections 5.4.1 and 5.4.2 of this chapter, to estimate the VECMs incorporating the long run cointegrating relations in the ECMs.

The results presented below, in table 5, shows the cointegration equation in a similar format to equation 9 and 10 which are presented in chapter 4, the estimated parameters appears with negative signs due to the ECM rendition of the equation. However, the three coefficients must be interpreted as positive elasticities.

With reference to Table 2 Appendix A the overall the identified three long run cointegration relations for the natural logs of GDP, labour and capital show plausible relations between the variables. The succeeding subsection shall now state and discuss each of the three cointegrating equations, in turn:

$$LGDP = \underset{[4.471]}{0.49LENROLMENT} + \underset{[4.093]}{0.28LEXPENDITURE} + \underset{[3.308]}{0.27LINNOVATION} + ECM1 \ldots\ldots\ldots \quad (23)$$

With reference to equation 23, all the estimated slope coefficients are significant at the 1% significant level, the t-critical value is 2,779 for 26 degrees of freedom (30 - 4 estimated coefficients). The magnitude 0.49 for the enrolment suggests that in the long run a 1 percent rise in the tertiary enrolment will cause 0.49 percent increase in the economic growth per annum. In other words, it will take about two years for economic growth to grow by one percent. Hence the result confirms that the level of skill in the economy plays a critical role of promoting economic growth. The results are consistent to the result that was reported by Ahmed (2009). Expenditure on education coefficient (0.28) has a correct sing sign and it is statistically significant at 95% confidence level, the magnitude of this coefficient shows that it takes two almost slightly more than three years for a one percent increase in education expenditure to have the same effect on the economic growth. This result is consistent to with the experiences of other emerging economies, for example, Lin (2004), and Boldin, et al., (2008), found it takes about two to three years for education expenditure to have an appreciable positive impact on the economy. A 1% rise in registered patents increases output in the long run by 0.27%, moreover, the results are statistically significant at 1% significance level.

$$LL = \underset{[1.749]}{0.13LENROLMENT} + \underset{[3.436]}{0.16LEXPENDITURE} + \underset{[1.887]}{0.11LINNOVATION} + ECM2 \ldots\ldots\ldots \quad (24)$$

With reference to cointegrating equation 24 all the variables appear to be significant at the conventional significance levels, with enrolment and innovation being significant at the 10% significance level, the t-critical of which is 1,706 for 26 degrees of freedom (30 - 4 estimated coefficients). Education expenditure on the other hand is significant at the 1% significance level. A 1% rise in tertiary enrolment results in labour input rising by 0.12%. If government expenditure on education increases by 1% then labour supply rises by 16%, effectively this implies that it will take a little more than 6 years for employment to rise by a percent as a result of the initial

spending impetus. Additionally, a 1% rise is registered patents results in the labour force rising by 11%.

These results supports the theory of human capita which states that the more educated people are the higher will be the employment level and the higher will be the innovation rate, which in turn, produces more jobs in the economy through various channels, the same conclusion was drown by Zahid and Tayyaba (2013

The above finding are encouraging since it implies continued government support for tertiary education and the promotion of innovations will ensure positive spinoffs for long term employment. This is an especially important finding given the state of our economy where currently the unemployment rate is sitting at 25.4 % and youth unemployment is about 36.1 %.

$$LK = \underset{[3.65]}{0.83LENROLMENT} + \underset{[3.29]}{0.46LEXPENDITURE} + \underset{[3.39]}{0.59LINNOVATION} + ECM3 \ldots\ldots\ldots \quad (25)$$

With reference to equation 25, all the estimated slope coefficients are significant at the 1% significant level , the t-critical value is 2,779 for 26 degrees of freedom (30 - 4 estimated coefficients). The enrolment coefficient of 0.83 suggests that a 1% rise in the tertiary enrolment rate will result in fixed capital formation rising by 0.83%. This result is consistent will economic reality where high levels of human capital development are required for the utilisation of advanced technology hence the strong and highly significant association between both variables as revealed by the slope coefficient the related statistics. In respect of government education expenditure, a 1% rise in government expenditure results in 0.46% rise in fixed capital formation. Furthermore, a 1% rise in patent registration results in a 0.59% rise in fixed capital formation. The highly significant and relatively large magnitudes of these slope coefficients suggest there are strong interactions between the variables in the cointegrating vector.

5.4.5 VECM-Short Run Adjustment Models

This subsection will report the short run adjustment equations for economic growth, labour and capital respectively which were discussed in chapter four under the following generic equation which is repeated here for convenience:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \mu + \varepsilon_t \qquad (26)$$

It was established earlier in this chapter that the rank of matrix Π is three (ie., r=3, imply there exist three cointegrating vectors), hence the matrix can be written as $\Pi = \alpha\beta'$, with β containing the r cointegrating vectors and α describing the speed of adjustment to the long run equilibrium. Additionally Γ_i are $k \times k$ coefficient matrices capturing the short run dynamic effects. However since the study used a second order VAR model (p=2) and in VECM form it is differenced to result in a first order VECM model (ie., p-1) Γ_i becomes a single $k \times k$ coefficient matrix capturing just the first order lags. Further, μ captures the vector of constants; however these have been suppressed by Eviews. Moreover Πy_{t-1} can be expanded as follows:

$$\Pi y_{t-1} = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} \\ \alpha_{61} & \alpha_{62} & \alpha_{63} \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & \beta_{41} & \beta_{51} & \beta_{61} & \beta_{01} \\ 0 & 1 & 0 & \beta_{42} & \beta_{52} & \beta_{62} & \beta_{02} \\ 0 & 0 & 1 & \beta_{43} & \beta_{53} & \beta_{63} & \beta_{03} \end{bmatrix} \begin{pmatrix} LGDP \\ LLabour \\ lcapital \\ Enrolment \\ Expenditure \\ LPatent \\ 1 \end{pmatrix}_{t-1} \qquad (27)$$

Equation 27 shows the three cointegrating vectors and the imposed identification restrictions on the long run coefficients (ie., β_{ij}) discussed earlier in sections 5.4.3 above. Notice in the Π matrix the long run cointegrating relations serve as the ECM which shows that if LGDP, LLabour or Lcapital overshoots their respective long run equilibria then the adjustment process to the long run equilibria are captured by the α_{ij} coefficients, for example assume LGDP overshoots (undershoots) its long run relationship with the other variables in the previous period then in the current period it will decrease in order to restore equilibrium hence α_{11}<0 while all the other variables ought to rise in order to restore equilibrium, ie., $\alpha_{21}, \alpha_{31}, \alpha_{41}, \alpha_{51},\ and\ \alpha_{61} > 0$. By a similar argument the expectation is that $\alpha_{12}, \alpha_{13} < 0$, while $\alpha_{22}, \ldots, \alpha_{63} > 0$. Notice the unit scalar in the variable vector, its purpose is to capture the intercept terms in the cointegrating vectors (ie., β_{0j})

The full results of the VECM (equations 26 and 27) are presented in Table 2 Appendix A. In regard to the adjustment coefficients the results show that most of the coefficients are statistically insignificant. This makes sense since it takes a long while for most of the variables

to adjust to disequilibria in the system. In equation 27 we highlighted in yellow the $\alpha_{51},\ and\ \alpha_{61}$ which are statistically significant and have the correct positive signs, however the coefficients are implausibly high. They may be interpreted as a 1% overshooting of LGDP from its long run equilibrium leads to government's education expenditure and changes in the rate of patent registrations overcompensating in the current period by rising by 10% and 9.5%, respectively.

The green highlighted coefficients are also statistically significant but they have the incorrect signs implying they compensate in the opposite direction to an over shooting of the respective normalized (ie dependent) variables. This is puzzling from an economic perspective and could arise from a problem with short data sets, multicollinearity issues or incorrect functional forms and warrants further investigations in the future.

5.5 Verification

It is common in economic time series data to use the verification models to verify the result of the main model that was tested. In chapter four the study mentioned that we will use the ARDL, FMOLS, DOLS and CCR models for verification purposes of the VAR/VECM result, as you can see the result of the VECM presented in table 5 shows that there is a long run relationship amongst the estimated variables.

5.5.1 Autoregressive Distributed Lag Model (ARDL)

The ARDL bounds test procedure for cointegration testing examines the presence of a unique long run relationship among variables under the null hypothesis that no long run exist cointegrating vector between the series against the alternative that cointegration exists among the variables. Under the ARDL bounds testing hypothesis testing approach, the null hypothesis can be rejected if the computed -statistic is shown to be higher than the upper bound of the critical values. Accordingly, the null cannot be rejected if the computed -statistic is lower and if the computed -statistic falls in-between the bounds, the test is inconclusive, therefore prior information about the order of integration of the variables is needed to make a decision. Similar to the VECM approach, the existence of the cointegrating equation under the ARDL approach must be ascertained prior to analysing the long and short run relationships between the variables as explained by Brown, Dublin, and Evans (1975). The first step of the ARDL-bounds testing procedure is to determine the lag lengths on the first differenced variables from the unrestricted models, and for that purpose, this study makes use of the AIC. Thus, as

recommended by the AIC, the ARDL (2,2,0,1,2,2) model is estimated and the F-statistics of the bounds tests results are given in Table 1, appendix B.

5.5.1.1 The Long Run Cointegrating Relationship

The first panel of Table 1, Appendix B, captures the following long run ARDL model that was estimated;

$$\text{LGDP} = 4.3 + 0.1\ \text{LL} + \mathbf{0.41}\ \text{LK} + \mathbf{0.000165}\ \text{LInnovation} - 0.005\ \text{LExpenditure} + \mathbf{0.17}\ \text{LEnrolment} + \varepsilon_t \quad (28)$$

The results for the long run elasticity coefficients show that while economic growth responds positively to capital, enrolment and innovation as suggested by economic theory, expenditure on education has an inverse effect on economic growth and employment has a correct sign with an insignificant coefficient. Hence, in the long run, when capital increases by one percent, the South African economy will grow by 0.41 percent, significant at the 1% significance level. Likewise, if enrolment in tertiary education should increase by 1 percent, the economy would expand by 0.17 percent significant at the 1% level. It is also observed that a 1 percent rise in innovation causes a 0.00165 percent rise in economic growth, the coefficient is significant at the 1% significance level. However, education expenditure and employment, which carries an insignificant coefficient, inferring that it has no bearing on economic growth in the long run. It is a surprise that expenditure on education does not have a significant positive impact on GDP over the long run, especially since the VECM, FMOLS, CCR and DOLS methodologies suggest a positive long run relationship. Lastly note D1 represents a dummy variable that was introduced into the model to capture the structural break in the data that occurred in the 1990 and that was included in the ARDL model in order to improve the fit. D1 = 1 post 1990 otherwise, D1 =0. Note that this structural break roughly co-insides with the political changes that emanated in the country, however this dummy proved not to be too useful in the VECM, FMOLS, CCR and DOLS models and was hence excluded from them.

5.5.1.2 Short Run Dynamic Adjustments

The ARDL (2,2,0,1,2,2) short run adjustments model estimates based on the associated long run coefficients are presented in Table 2, Appendix B. The Microfit 6 Software automatically selects the lag order of the variables entering the ARDL model using the Akaike Information Criterion. The second panel of Table 2, shows all first and second order lagged differenced

variables used to capture the short run dynamic adjustment or change in LGDP in the current period, as a result of short run changes in the first and second differenced variables. The short run adjustment also includes the ECM component which captures the short run adjustment of LGDP in the current period to a disequilibrium arising in the cointegrating vector in the previous period and is a manipulation of equation 19 to give rise to the following expression:

$$\mathbf{ECM} = LGDP - 4.3 - 0.1\ Llabour - \mathbf{0.41}\ LCapital - \mathbf{0.000165}\ \mathrm{LPa}tent + 0.005\ \mathrm{L}Expenditure - \mathbf{0.17}\ LEnrolment \ldots\ldots\ldots\

Additionally, since the ECM is statistically significant, this further confirms the existence of a stable long run relationship among variables and implies causality from, capital, enrolment, and innovation to economic growth. Labour has a short run positive impact while expenditure does not seem to have a short or long run impact on GDP.

Interestingly, the results also show that, in the short run, economic employment has a positive and statistically significant effect on economic growth with a magnitude of 0.28 percent. This implies that employment is an important determinant of economic growth in South Africa in the short run. On the contrary, the results show that when government increases investment in education by one percent, economic growth would decline significantly by -0.13 percent in the short run the same conclusion can be drown on the enrolment, considering this relationship of both variable it make a perfect sense to see a decline in to the enrolment if government reduce its investment in education. Capital seems to have a positive and highly significant effect on the growth of the South African with an elasticity of 0.129. Based on the results, there is also a positive relationship between innovation and economic and its coefficient is statistically significant and therefore does bear an effect on growth in the short run.

Two issues were addressed in the results given in Table 1, Appendix B. The results showed that there is cointegration among GDP, labour, capital, education expenditure, tertiary enrolment and innovation. The second issue addressed is the stability of the long run coefficients that are used to form the error-correction term in conjunction with the short run dynamics. As pointed by Laidler (1993) and noted by Bahmani-Oskooee (2001), some of the problems of instability could stem from inadequate modelling of the short run dynamics characterizing departures from the long run relationship. Hence, it is expedient to incorporate the short run dynamics in testing for constancy of long run parameters.

In view of this we applied the CUSUM and CUSUMSQ tests proposed by Brown, Dublin, and Evans (1975). The tests are applied to the residuals of each model in Table 1. The CUSUM test is based on cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical lines. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines. Similar procedure is adopted to carry out the CUSUMSQ, which is based on the squared recursive residuals. The graphical presentation of these two tests applied to the model selected by adjusted R^2 criterion is as shown in Figs. 2 and 3 in Appendix B. Fig. 2 shows the plot of cumulative sum of recursive residuals. The statistic

stays within the critical bounds indicating stability of the model. Fig. 3 shows the plot of cumulative sum of squares of recursive residuals. The cumulative sum of squares is completely stable as the statistic is within the critical bounds.

5.5.2 Fully Modified Ordinary Least Squares (FMOLS)

The results of estimated model are reported in table 5. The estimated regression line is as presented bellow;

$$LGDP = -0.60 + 0.54LL + 0.25LK + 0.18LEnrolment + 0.017LExpenditure + 0.04LInnovation \quad (31)$$

It is observed that all of the estimated coefficients are statistically significant from zero and have expected signs. It is further observed that the employment, capital, enrollment rate, expenditure on education and innovation have a positive impact on the growth of GDP, with. The results of estimated model show that natural log employment rate is statistical different from zero at 1% level of significance. As you can see that natural log of capital, natural log of education expenditure, natural log of enrolment in higher education and natural log of innovation inputs are statistical different from zero at 5% and 10% level of significance. The positive sign of the coefficient of the estimated model implies that there is a positive relation between employment, capital, enrolment, expenditure, and GDP. A rational of this positive sign is that GDP increase due to increase in higher mentioned independent variables.

The GDP elasticities of natural log of employment rate, natural log of capita, natural log of education expenditure, natural log of enrolment in higher education and natural log of innovation are 0.54, 0.25, 0.18, 0.017 and 0.04 respectively. In other words, holding capital, enrolment in higher education, expenditure education and innovation inputs constant, a 1 percent increase in employment rate input leads to 0.54 percent increase in GDP, holding employment rate, enrolment in higher education, expenditure education and innovation inputs constant, a 1 percent increase in capital input leads to 0.25 percent increase in GDP, holding employment rate, capital, expenditure education and innovation inputs constant, a 1 percent increase in enrolment in higher education input leads to 0.18 percent increase in GDP, holding employment rate, capital, enrolment in higher education, and innovation inputs constant, 1 percent increase in expenditure leads to a 0.17 increase in GDP and holding employment rate, capital, enrolment in higher education and expenditure on education inputs constant, 1 percent increase in

innovation will leads to 0.04 percent increase in GDP It is clear from the regression equation that enrolment in higher education input has a stronger positive impact on GDP.

The impact of employment rate, higher education expenditure and enrolment in higher education on GDP can be justified as followed. With the increase in expenditure on higher education from government side, people become more interested in getting higher education. So enrolment in higher education also increases. The estimated equation, as mentioned above, shows that these two variable s have a positive impact on GDP because higher education provide more skilled and qualified labour forces that is essential for the progress of the economy.

Adding all GDP elasticities we come up with the value 1.03, which indicates that the function exhibits the property of increasing returns to scale i.e. doubling the inputs (employment rate, higher education expenditure and enrolment in higher education) will result in increase in the output (GDP) more than doubled.

Table 5: Fully Modified Ordinary Least Squares (FMOLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LL	0.541872	0.106044	5.109872	0.0000
LK	0.249594	0.023394	10.66926	0.0000
LENROLMENT	0.177575	0.015298	11.60769	0.0000
LEXPENDITURE	0.016557	0.007265	2.278889	0.0319
LINNOVATION	0.036718	0.008518	4.310755	0.0002
C	-0.601814	1.496072	-0.402263	0.6911
R-squared	0.987743	Mean dependent var		14.06260
Adjusted R-squared	0.984679	S.D. dependent var		0.228211
S.E. of regression	0.028247	Sum squared resid		0.019150
Durbin-Watson stat	1.898893	Long-run variance		0.000454

The estimated regression line fits the data quite well. The value of R^2 is 0.98, which is very high; this high value of R^2 is due to time series data. The values of R^2 shows that 85 percent variation in natural log of GDP is explained by the natural log of employment rate, natural log of capital,

natural log of education expenditure, natural log of enrolment in higher education and natural log of innovation, while the remaining variations are due to some other factors.

A similar reasoning applies to the rest of the single equations discussed below. The theoretical discussions of chapter 2 confirm that economic growth is a function of the, labour, capital (proxied by the fixed capital formation) skills levels of labour (proxied by the tertiary enrolment rate), government investment on education and intellectual property (measured by innovations or patents).

5.5.3 Dynamic Least Squares (DOLS)

The results of estimated model are reported in table 6. The estimated regression line is as presented bellow;

$$LGDP = -10.44 + 1.20LL + 0.12LK + 0.22LEnrolment + 0.04LExpenditure + 0.06LInnovation \quad (32)$$

The results of estimated model show that natural log of employment, natural log of capital, natural log of enrolment in higher education, natural log of education expenditure and natural log of innovation inputs are statistical different from zero at 1% level of significance. The positive sign of coefficients shows that there is a positive relation between estimated variables. A rational of this positive sign is that LGDP increase due to increase in employment, capital enrolment, expenditure and innovation.

Table 6: Dynamic Least Squares (DOLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LL	1.202240	0.095658	12.56805	0.0000
LK	0.120077	0.024527	4.895681	0.0018
LENROLMENT	0.215873	0.021029	10.26544	0.0000
LEXPENDITURE	0.040951	0.007104	5.764864	0.0007
LINNOVATION	0.062877	0.011955	5.259582	0.0012
C	-10.43899	1.456826	-7.165574	0.0002
R-squared	0.999535	Mean dependent var		14.05752
Adjusted R-squared	0.998139	S.D. dependent var		0.217209

S.E. of regression	0.009370	Sum squared resid	0.000615
Durbin-Watson stat	3.065568	Long-run variance	2.32E-05

Adding all GDP elasticities we come up with the value 1.64, which indicates that the function exhibits the property of increasing returns to scale i.e. doubling the inputs (employment, capital, enrolment, education expenditure and innovation) will yields a more than doubled increase in the output (DGP).

The estimated regression line fits the data quite well. The value of R^2 is 0.99, which is very high; this high value of $R^2$is due to time series data. The values of R^2 shows that 99 percent variation natural log of employment, natural log of capital, natural log of enrolment in higher education, natural log of education expenditure and natural log of innovation, while the remaining variations are due to some other factors.

5.5.4 Canonical Cointegrating Regression (CCR)

The results of estimated model are reported in table 7. The estimated regression line is as presented bellow;

$$LGDP = -1.15 + 0.58LL + 0.25LK + 0.18LEnrolment + 0.02LExpenditure + 0.04LInnovation \quad (33)$$

The results of estimated model show that natural log of employment, natural log of capital, natural log of enrolment in higher education, natural log of education expenditure and natural log of innovation inputs are statistical different from zero at 1%, 5% and 10 % level of significance respectively. The positive sign of estimated coefficients shows that there is a positive relationship amongst the variables. A rational of this positive sign is that GDP increase due to increase in employment, capital, enrolment in higher education, expenditure in education and innovation.

Table 7: Canonical Cointegrating Regression (CCR)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LL	0.575102	0.146239	3.932605	0.0006
LK	0.245973	0.025792	9.536944	0.0000
LENROLMENT	0.180359	0.015871	11.36415	0.0000
LEXPENDITURE	0.019570	0.008696	2.250445	0.0339
LINNOVATION	0.037895	0.011021	3.438384	0.0021
C	-1.149782	2.047565	-0.561536	0.5796
R-squared	0.987283	Mean dependent var		14.06260
Adjusted R-squared	0.984104	S.D. dependent var		0.228211
S.E. of regression	0.028773	Sum squared resid		0.019869
Durbin-Watson stat	1.964579	Long-run variance		0.000454

The similar conclusion can be drawn to all the above models, the above on table 5,6 and 7 shows that the innovation doesn't not contribute much percentage in the economic growth of South Africa; this can be supported with the current state of our economy. South African economy is not knowledge intensive but it more labour intensive, it even verified by the data as you can see on the above table that the employment coefficient much more higher that the other coefficients.

5.6 Summary of the result

The core objective of this study was to provide an in-depth assessment of the impact of labour, capital, education expenditure, tertiary enrolment and innovation on economic growth in South Africa. Embedded within objective was the need to ascertain firstly, the magnitude at which economic and it determinants affect growth both in the short and long run.

The table below presents the summary of the entire estimated equations in order to achieve the objective of this study;

Table 8: Summary long and short Run β_i coefficient of cointegration relationships: Dependent variable GDP

Sample period 1983 to 2012							
Variables	**VAR/VECM**		**ARDL**		**FMOLS**	**DOLS**	**CCR**
	LR	**SR**	**LR**	**SR**			
LGDP	-	-0.09 [-0.39]		-0.38*** (-3.51)			
LL	-	0.05 [0.39]	0.10 [0.23]	0.21*** [3.607]	0.25*** [5.11]	1.2*** [12.57]	0.58*** [3.93]
LK	-	-0.004 [-0.05]	0.41* [4.11]	0.129*** [2.994]	0.18*** [10.67]	0.12*** [4.9]	0.25*** [9.54]
LExpenditure	0.28*** [4.09]	-0.01* [-1.77]	-0.005 [-0.25]	-0.13*** [-2.46]	0.02*** [2.79]	0.04*** [5.76]	0.02** [2.25]
LEnrolment	0.49*** [4.47]	0.03 [0.95]	0.17*** [5.52]	-0.36* [-1.92]	0.18*** [11.61]	0.22*** [10.27]	0.18*** [11.36]
LInnovation	0.27*** [3.31]	0.003 [0.39]	0.0002*** [2.70]	0.0002*** [4.159]	0.04*** [4.31]	0.06*** [5.26]	0.04*** [3.44]

Note: t-statistics are represented by [ ]

*, ** and *** represents significance at 10%, 5% and 1% levels, respectively,

The short run coefficients represents the magnitude of the change in the Δlagged variable (ie., change of the lagged variable).

The ECM coefficients for the VECM and ARDL model are not included.

From the previous presentation of results, we found that the VECM, FMOLS, CCR, DOLS and ARDL methods strongly suggest the existence of a long run cointegrating relationship between economic growth, labour, capital, enrolment, expenditure and innovation that is consistent with economic theory in all cases except for the ARDL model. The ARDL model generated a negative long run coefficient capturing the effect of education expenditure on economic growth; while the remainder of the models all concurs that there is a positive relationship. Moreover all the single equation models agree that labour, capital, education expenditure, enrolment and patents all have a statistically positive impact on economic growth. The VECM agrees with the single equation models in respect of expenditure, patents and enrolment. However, the magnitudes of the coefficients tend to vary widely between the VECM multi-equation approach and the single equation methods. The VECM approach tends to generate long run impact coefficients with larger magnitudes compared to the single equation methods. Although the multi-equation methods might capture the dynamics of the economy more accurately their long run impact elasticities appear to be implausibly high for education expenditure, enrolment and innovation, while the single equation methods appear more plausible, however, the literature tends to report similar variations.

In the long run, tertiary enrolment's role towards growth is highly significant and carries elasticities that range between 0.17 and 0.49. Hence, tertiary enrolment has a positive impact and statistically significant impact on economic growth in the long run and it has a high impact compared to the other variable excluding the coefficients of the control variable or natural variable of production function (labour and capital), this finding is consistent with most empirical literature on the subject matter. The elasticity coefficients also found to be of similar magnitudes with those of Fernando (2004) and Zahid and Tayyaba (2013).

There is strong evidence that innovation has a positive impact on economic growth in long run with magnitudes of 0.0002 to 0.27 respectively. This shows that the South African is moving slowly but surely to the knowledge based economy as most of the emerging economy are considering this part as a crucial element of economic growth. This find seems to be consistent with that of Goh (2013)

While the ARDL suggests that an inverse relationship exists between economic growth and education expenditure in the long run, VECM, DOLS, FMOLS and CCR equation methods find that the latter in fact favourably influences economic growth. Results from the single equation methods show that if education investment was to rise by 1 percent, then the economy would expand by 0.02 to 0.28 percent in the long run. In the short run, the unrestricted VAR system showed that economic growth responds negatively to education investment. Moreover, coefficients of the ARDL suggest the negative relationship among the mentioned variable in the short run adjustment.

In regard to the short run coefficients both VECM and ARDL agree that short run one period lagged GDP changes have negative adjustment impact on GDP in the next period however their magnitudes differ. Likewise, both approaches agree that the one period lagged increases in labour and innovation have positive impacts on GDP growth in the next period, here again their magnitudes differ. Both approaches also concur that short run positive changes in expenditure on education in the previous period have negative adjustment effects on GDP in the next period, here again magnitudes differ. Finally, both approaches differ in regard to the direction and magnitudes of the adjustment effects of capital and enrolment.

Conclusion

After choosing an appropriate subset of data that included structural dummy and separating them out I(1) and I(0) variables the study selected an unrestricted intercept no trend (Model B) VAR model of order one or two, that were selected on the basis of the AIC and SIC . Thereafter based on economic theory and experiences of South African economy the study chose to identify three long run cointegrating vectors viz., DGP and it determinants vectors (CV1), employment vector (CV2) and the capital vector (CV3). These vectors were identified using appropriate identifying restrictions on each of cointegrating vectors whenever the circumstances arose. However one of the main foci of the study was to estimates the long run relationship economic growth and it determinants involving five I(1) variables, (employment, capital, higher education enrolment, education expenditure, innovation and growth) in South Africa through the application of the Johansen cointegration technique and the vector error correction methodology. The results of the cointegrating technique suggest that there is long run relationship between amongst the estimated variables.

The last section of this chapter was based on the verification off the result that was produced by the VAR/VECM, the verification models seems to be consistent as the one of the VECM, indeed the long run relationship and the positive relationship exist with the estimated variables.

The last section of this chapter was based on the verification off the result that was produced by the VAR/VECM, through the use of single equation methods. The single equation verification models confirm the long run findings of the VAR/VECM methodology, that indeed the long run relationship and the positive relationship exist with the estimated variables. However the magnitudes of the long run coefficients vary between the single and multi-equation approaches.

Chapter 6: Overall Study Summary, Policy Recommendation and Strength and Weakness

6.0 Introduction

This chapter summarises the overall study and gives policy recommendations based on the finding as well as the strengths and weaknesses and offers suggestions for future research endeavours. The chapter consists of three sections. Section 6.1 presents the summary of the study and empirical findings are discussed. Policy implications and recommendations are given in section 6.2. While section 6.3 provides the study's strengths and weaknesses (limitations of study), section 6.4 outlines recommendations for future research.

6.1 Summary of the Study

This research paper set out to employ the Johansen procedure to estimate the long run and the short run dynamic relationships between GDP and it main determinants, viz., labour, capital, tertiary enrolment, education expenditure and innovation, for the purposes of developing a growth system that will be useful in managing a economic growth policies. The central focus of this empirical investigation was to derive a plausible production function that was consistent with the endogenous growth model perspective as discussed in chapter two.

After examining a large array of variables the study selected a smaller subset, which included GDP to serve as a measurement of economic growth; labour and capital (as they are the fundamental inputs into most production processes and are the key requirements of the Cob-Douglas production function); tertiary enrolment served as a proxy for human capital; education expenditure was interpreted as an indicator of state investment on education; and innovation was viewed as the economy's overall technical capacity. These variables were selected in accordance with the various economic growth theories discussed in chapter two and the literature review involving the South African economy, as well as, the emerging market and developed economies. However the central justification for this study is based on the endogenous growth models which fully supported the use of all the selected variables.

To achieve the study's objective and address the respective hypotheses, preliminary examinations of the data were conducted through the use of visual and unit root tests which

confirmed that all the variables were non-stationary in levels and stationary in their first differences (i.e., $I(1)$). Both the unrestricted VAR and VECM techniques were estimated

The results presented in the previous chapter showed that indeed three long run cointegrating relationships exist among the variables. The study identified the three cointegrating vectors in such a manner that economic growth (GDP), labour and capital served as the three respective dependent variables while government education expenditure, tertiary enrolment rates and innovations (registered patents) were the independent variables in all three cointegrating vectors. Interestingly in the long run expenditure, enrolment and innovations all have a significant positive impact on economic growth, labour and capital. The study then employed the single equation methodologies comprising FMOLS, DOLS, CCR and ARDL to confirm the central hypothesis of this study. The first three single equation cointegrating vectors confirmed that expenditure, enrolment and innovation have a significant positive relationship with economic growth thus confirming the main hypothesis of this paper and the conceptual perspectives of the endogenous growth models. However the magnitudes of the coefficients were much smaller than those of the Johansen VAR/VECM cointegrating vectors. However this could be due to the fact the VAR/VECM cointegrating vectors did not have capital and labour entering the long run equations as the independent variables while in the single equation methods all variables were included in the cointegrating vector with economic growth serving as the dependent variable. The ARDL model appears to support the mentioned single equation approaches in that labour, capital, enrolment and innovation share a positive relationship with economic growth. However, the ARDL finding contradicts both the VAR/VECM and the other single equation models in regard to the long run impact of education expenditure, where it was found to be statistically insignificant and negative in magnitude this result is consistent the finds of De Pleijt (2011). Since the majority of approaches support a positive association between long run economic growth and expenditure, enrolment and innovations (as well as capital and labour for the single equation models) this study is satisfied that the relationship explicated by the endogenous growth model is confirmed.

In respect of the short run adjustment when economic growth overshoots its long run equilibrium, the error correction adjustment coefficient (α_{11}) estimated by the VAR/VECM model suggests that output growth does not revert back to its long run equilibrium with the variables contained in the cointegrating vectors. Additionally, most of the other adjustment coefficients estimated by the VAR/VECM approach were found to be statistically insignificant.

This makes sense from an economic perspective especially since, it takes a long while for most of the variables to adjust to disequilibria in the system for example it takes a long while for university students to graduate, enter the job market and become highly productive, likewise political and administrative processes that determine education spending are slow to respond to situations that arose in the previous year; similarly, registration of patents is a long process involving inspiration, experimentation and long-winding registration processes. However the VECM short run adjustment coefficients suggested that education spending and patent registrations adjust quickly and by large magnitudes in the short run to compensate for excessive increases in GDP in the previous year. It is the conjecture of this study that those magnitudes are too high (recall, from the previous chapter expenditure and patent registrations respond positively by 10% and 9.5%, respectively to a 1% overshooting of GDP in the previous period). Further research needs to be carried out confirm this result.

The study employed the ARDL single equation model to confirm that the short run adjustment of GDP in the VECM (α_{11}) is similar to that of the ARDL ECM coefficient. To the surprise of this study the ARDL generated a statistically significant coefficient which contradicts the findings of the VECM results. Furthermore, the ARDL model showed that labour has a short run positive impact while expenditure does not seem to have a short or long run impact on GDP.

In order to make sense of the above disparate findings especially for the short run adjustment coefficients the study asserts that the VAR/VECM approach is perhaps a more reliable approach, compared to the ARDL, since it is based on the comprehensive Johansen VAR/ VECM methodology which incorporates I(1) variables in a closed system of equations involved in the VAR/VECM model, that captures all the possible interactions between these variables via lagged changes in a differenced I(1) variables and the error correction terms based cointegrating vectors describing the structural relations in the economy. The VECM model captures both long run and short run interactions while the effects of cross equation simultaneities and contemporaneous adjustments are accommodated for, by allowing their effects to be distributed throughout the system via the adjustment of the short run parameters. However the method is sensitive to size of the data set typically time series analyses require huge data sets which has been a serious weakness of this study.

6.2 Policy recommendations

The three identified cointegrating vectors suggest that output, labour and capital all benefit from state spending on education, tertiary enrolment and innovations in the economy. All the coefficients were positive and of high magnitudes. As mentioned above, in the main, the result pertaining to output growth was supported by single equation cointegrating methods. Thus the more obvious policy recommendation is that the public and private sectors must continue to vigorously support investment in education, increase tertiary enrolment rates and incentivise the innovations in the economy on the whole. As these endeavours result in synergistic effects between labour, capital and output thereby increasing the productivity of both capital and labour and thus promoting competiveness and economic growth.

It is gratifying to note that the Department of Higher Education and Training has made strident efforts to making more funds available via NSFAS (National Student Financial Aid Scheme) and provided inducements to universities in the form of more lecture rooms and laboratories to the extent that as at January 2015, there were 204,000 places available at universities this is an increase from 2013 which was at 170,000. Additionally in 2013 about 172,000 graduates obtained bachelor degrees, while in 2014 the figure was about 150,000. Moreover, for the first time in decades the number of places available to new students exceeds the number of students who achieved matriculation exemptions. However, notwithstanding these remarkable achievements NSFAS is underfunded and tens of thousands of students do not possess access to resources to fund their studies, hence more has to be done by the authorities (Bozzoli, 2015).

The NDP (2012) assertion that South Africa's hope for improved competitiveness, economic growth and higher living standards rely, to a great extent on science and technology and knowledge creation is considered to be the primary driver of technological growth implies that the authorities are acutely aware of the need for the creation of incentives that lead to an innovation-enabling environment, to this end the National Research Fund (NRF) have risen to the challenge and put many policies and incentive schemes in place, however universities suffer from dire skills shortages and strategies need to be put in place to grow home timber including in high-end skills necessary to sustain a future knowledge economy. Moreover, according to the National Advisory Council on Innovation (2013) reported that compared to its BRIC peers, South Africa has been dropping in innovations output, which may be attributed to the slide in: private sector spending on research and development, university-industry collaboration in research and development and Patent Co-operation Treaty patent applications. This state of affairs

prompts the need to investigate why companies are not taking advantage of the existing tax incentives and strategies to enhance university-industry collaboration.

Van Jaarsveld (2015) noted that a major hindrance in South Africa's capacity to unleash the full power of innovation is our basic education; countries that have succeeded in assimilating innovations optimally into their economies have focused on improving the quality and reach of their primary and secondary education. Especially innovation typically requires large number of intelligent and highly skilled individuals involved in small backyard operations or through focused private sector investment which then impacts dramatically on a country's economy and living standards.

Van Jaarsveld (2015), Jansen (2015) have vociferously advocated that poor school education affects the both the quantity and quality of candidates who can gain tertiary qualifications and university acceptance. Substandard education also affects the level of job complexity that a South African matriculant can handle compared to their foreign counterparts. They argue that the solution does not lie with throwing more resources at the problem but in a societal commitment. Learners must commit to doing what it takes to master the material. Teachers must commit to showing up at school and using all the allocated time to teaching the material and ensuring that learners master it.

6.3 Strength and weakness

As noted above, the overall long run results from both the VAR/VECM and single equation methods confirm the policy prescription of the South African authorities that skills and education is the key ingredient of economic growth and so too is innovation and the reduction in the unemployment rate. Hence the emphasis on government, labour and the private sector working together to steer the economy on a high growth trajectory has merit.

The available data and some cutting edge state of the art techniques were employed to confirm the endogenous growth model and it is pleasing to note that a convincing account was produced. Initially the study set out to use primary and secondary school enrolment rates as a proxy for the level of education in the economy, however the dataset was too small and there were many missing variables between the 1980s and early 1990s. Thus the study was forced to confine its analysis to employing solely the tertiary enrolment rates as a sole indicator of human capital since it was a data set that extended to 1983 and had no missing values. This meant that

the level of education in the economy was measured indirectly via the tertiary rate based on the assumption that the quality and quantity of tertiary enrolment is directly proportional to that of primary and secondary school enrolment rates. This is a relatively strong assumption especially since race, class and political factors determined access to tertiary education pre-1994 and in post-1994 class and political factors (albeit of a different flavour) still determine access to tertiary institutions which might not correlate exactly with the developments of access to primary are secondary education over the pre-and post-democratic era.

The third limitation of this study was the limited focus of this study. Recall that the VECM/VAR approach which considered three long run cointegrating vectors, where output, labour and capital served as respective dependent variables while education expenditure, tertiary enrolment and patent registrations served as the dependent variables in all three equations. However, since the main focus of the study was the impact of education expenditure, tertiary enrolment and innovations on economic growth when the study estimated single equation models for comparison purposes it only focused on economic growth as the dependent variable and neglected to consider the other two equations which perhaps would have provided richer insights.

6.4 Recommendations for Future Research

Future studies ought to search the archives for much larger data sets in order to carry out VAR/VECM type models which work best with large sample sizes, due to stationarity and cointegration tests being more robust in the context of large samples. Moreover, future studies ought to use alternative multi-equation methodologies for example dynamic stochastic general equilibrium models whose assumptions are based on strong microeconomic foundations. Alternatively one could use VAR/VECM panel data models for BRICS or a cohort of emerging market economies, all of which have not been published in the literature as yet.

Future studies ought to consider the dynamic interactions between capital, labour and economic growth and the manner in which education expenditure, enrolment and innovations affect these interactions perhaps through rectifying the omissions of this study as explained in section 6.3.

Additionally future research ought to identify alternative proxies for innovation such as proxies of technological progress or perhaps use time varying estimates of total factor productivity estimated via the Kalman filter approach.

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Appendix A

Table 1: Vector Autoregression Estimates

	LGDP	LL	LK	EROLLOMENT	EXPENDITUR	LP
LGDP(-1)	0.799645	0.172707	0.046358	2.377690	4.031284	4.045014
	(0.15501)	(0.27846)	(0.57978)	(0.83449)	(3.40451)	(3.23823)
	[5.15869]	[0.62022]	[0.07996]	[2.84928]	[1.18410]	[1.24914]
LL(-1)	0.111886	0.935249	-0.025862	-1.311268	-1.857215	-1.218723
	(0.08237)	(0.14796)	(0.30807)	(0.44341)	(1.80902)	(1.72067)
	[1.35840]	[6.32080]	[-0.08395]	[-2.95721]	[-1.02664]	[-0.70828]
LK(-1)	0.015236	-0.090189	0.893821	-0.501790	-1.267875	-1.138327
	(0.04423)	(0.07945)	(0.16542)	(0.23810)	(0.97138)	(0.92394)
	[0.34449]	[-1.13515]	[5.40318]	[-2.10750]	[-1.30523]	[-1.23204]
EROLLOMENT(-1)	0.055114	-0.006133	0.054243	0.600702	-0.779185	-1.144335
	(0.02732)	(0.04908)	(0.10218)	(0.14707)	(0.60000)	(0.57070)
	[2.01746]	[-0.12497]	[0.53086]	[4.08453]	[-1.29864]	[-2.00515]
EXPENDITUR(-1)	-0.009139	-0.006960	-0.016055	0.002834	0.637628	-0.388607
	(0.00673)	(0.01208)	(0.02516)	(0.03621)	(0.14772)	(0.14050)
	[-1.35883]	[-0.57605]	[-0.63821]	[0.07828]	[4.31652]	[-2.76581]
LP(-1)	0.013529	-0.018300	0.042565	-0.056352	0.198746	0.370217
	(0.01008)	(0.01810)	(0.03769)	(0.05425)	(0.22134)	(0.21053)
	[1.34241]	[-1.01082]	[1.12923]	[-1.03867]	[0.89791]	[1.75848]
D1	0.013511	-0.041739	0.093041	-0.029710	0.751598	-0.094042
	(0.02324)	(0.04174)	(0.08692)	(0.12510)	(0.51037)	(0.48544)
	[0.58144]	[-0.99987]	[1.07047]	[-0.23750]	[1.47265]	[-0.19372]
R-squared	0.993840	0.853546	0.965825	0.983730	0.709640	0.830411
Adj. R-squared	0.992300	0.816933	0.957282	0.979662	0.637050	0.788014
Sum sq. resids	0.009624	0.031059	0.134643	0.278926	4.642579	4.200163
S.E. equation	0.020025	0.035974	0.074901	0.107805	0.439819	0.418338
F-statistic	645.3678	23.31238	113.0458	241.8499	9.775995	19.58649
Log likelihood	81.21356	63.05386	40.31921	29.03023	-14.55698	-13.00470
Akaike AIC	-4.787972	-3.616378	-2.149627	-1.421305	1.390773	1.290626
Schwarz SC	-4.464168	-3.292574	-1.825823	-1.097501	1.714576	1.614430
Mean dependent	14.06260	15.95818	12.19268	14.78453	5.620739	7.054406
S.D. dependent	0.228211	0.084078	0.362392	0.755943	0.730046	0.908603

Determinant resid covariance (dof adj.)	2.89E-13
Determinant resid covariance	6.23E-14
Log likelihood	207.3870
Akaike information criterion	-10.67013
Schwarz criterion	-8.727306

Table 2: Error Correction Estimates

Cointegrating Eq:	CointEq1	CointEq2	CointEq3
LGDP(-1)	1.000000	0.000000	0.000000
LL(-1)	0.000000	1.000000	0.000000
LK(-1)	0.000000	0.000000	1.000000
EROLLOMENT(-1)	-0.485180	-0.129421	-0.826580
	(0.10850)	(0.07397)	(0.22669)
	[-4.47163]	[-1.74975]	[-3.64631]
EXPENDITUR(-1)	-0.276365	-0.158176	-0.464774
	(0.06751)	(0.04602)	(0.14105)
	[-4.09361]	[-3.43693]	[-3.29511]
LP(-1)	-0.274488	-0.106769	-0.587549
	(0.08296)	(0.05655)	(0.17333)
	[-3.30868]	[-1.88792]	[-3.38984]
C	-2.957407	-12.08893	7.686476
	(2.30930)	(1.57424)	(4.82475)
	[-1.28065]	[-7.67920]	[1.59313]

Error Correction:	D(LGDP)	D(LL)	D(LK)	D(EROLLOMENT)	D(EXPENDITUR)	D(LP)
CointEq1	-0.171899	0.495059	-0.241842	0.619291	10.07140	9.464662
	(0.16845)	(0.31700)	(0.52419)	(0.81577)	(3.47045)	(3.57408)
	[-1.02050]	[1.56172]	[-0.46137]	[0.75915]	[2.90205]	[2.64814]
CointEq2	0.306956	-0.441484	0.485990	-0.820354	-4.530298	-7.310292
	(0.14512)	(0.27310)	(0.45161)	(0.70282)	(2.98992)	(3.07920)
	[2.11515]	[-1.61654]	[1.07614]	[-1.16723]	[-1.51519]	[-2.37409]
CointEq3	4.54E-05	-0.102509	-0.059011	-0.006726	-3.473410	-2.000977
	(0.04592)	(0.08642)	(0.14290)	(0.22239)	(0.94610)	(0.97435)
	[0.00099]	[-1.18620]	[-0.41294]	[-0.03024]	[-3.67129]	[-2.05365]
D(LGDP(-1))	-0.090840	0.360629	1.113915	2.474637	-2.633896	-7.351447
	(0.29892)	(0.56252)	(0.93019)	(1.44763)	(6.15846)	(6.34236)
	[-0.30390]	[0.64109]	[1.19751]	[1.70945]	[-0.42769]	[-1.15910]
D(LL(-1))	0.056914	0.090714	0.295222	-2.214539	1.468304	7.519996
	(0.14290)	(0.26891)	(0.44468)	(0.69204)	(2.94405)	(3.03196)
	[0.39829]	[0.33733]	[0.66390]	[-3.20003]	[0.49874]	[2.48024]
D(LK(-1))	-0.004559	0.042913	0.162549	0.011466	1.692222	0.396413
	(0.07857)	(0.14787)	(0.24452)	(0.38053)	(1.61884)	(1.66718)
	[-0.05802]	[0.29021]	[0.66478]	[0.03013]	[1.04533]	[0.23777]

D(EROLLOMENT(-1))	0.032407	0.081680	-0.050601	0.297524	1.190478	0.084235
	(0.03379)	(0.06358)	(0.10514)	(0.16363)	(0.69610)	(0.71688)
	[0.95917]	[1.28463]	[-0.48127]	[1.81832]	[1.71022]	[0.11750]
D(EXPENDITUR(-1))	-0.018941	0.016797	-0.034009	0.049339	0.292833	0.069599
	(0.01064)	(0.02003)	(0.03312)	(0.05155)	(0.21929)	(0.22583)
	[-1.77959]	[0.83862]	[-1.02678]	[0.95718]	[1.33539]	[0.30818]
D(LP(-1))	0.003408	0.006170	-0.012689	0.053756	-0.165035	0.134252
	(0.00852)	(0.01604)	(0.02653)	(0.04129)	(0.17564)	(0.18088)
	[0.39977]	[0.38458]	[-0.47830]	[1.30206]	[-0.93964]	[0.74221]
R-squared	0.444340	0.164706	0.567852	0.507873	0.450543	0.476405
Adj. R-squared	0.232660	-0.153501	0.403225	0.320396	0.241227	0.276941
Sum sq. resids	0.008320	0.029466	0.080571	0.195140	3.531657	3.745721
S.E. equation	0.019905	0.037458	0.061941	0.096397	0.410090	0.422336
F-statistic	2.099114	0.517606	3.449313	2.708991	2.152447	2.388420
Log likelihood	80.28592	61.31773	46.22898	32.96038	-10.47670	-11.35941
Akaike AIC	-4.752395	-3.487849	-2.481932	-1.597359	1.298447	1.357294
Schwarz SC	-4.332036	-3.067489	-2.061573	-1.176999	1.718806	1.777653
Mean dependent	0.022597	0.004948	0.023096	0.085293	-0.017933	-0.051015
S.D. dependent	0.022723	0.034877	0.080182	0.116933	0.470786	0.496674

Determinant resid covariance (dof adj.)	1.99E-14
Determinant resid covariance	2.34E-15
Log likelihood	249.9468
Akaike information criterion	-11.66312
Schwarz criterion	-8.160127

Appendix B

Table 1: ARDL Long Run Coefficient Estimates

Estimated Long Run Coefficients using the ARDL Approach
ARDL(2,2,0,1,2,2) selected based on Akaike Information Criterion

```
*******************************************************************************
 Dependent variable is LGDP
 29 observations used for estimation from 1983 to 2011
*******************************************************************************
 Regressor        Coefficient     Standard Error        T-Ratio      [Prob]
 LL                  .10358        .45475               .22778       [.823]
 LK                  .41425        .10079               4.1101       [.001]
 LInnovation         .1647E-3      .5239E-4             3.1438       [.008]
 LExpenditure       -.00517        .02070               -.25015      [.806]
 LEnrolment          .16723        .030303              5.5186       [.000]
 c                   4.3113        6.0701               .71025       [.490]
*******************************************************************************
```

Testing for existence of a level relationship among the variables in the ARDL model

```
*******************************************************************************
 F-statistic  95% Lower Bound  95% Upper Bound  90% Lower Bound  90% Upper Bound
   10.8265          3.6209          5.0375          2.9917          4.1873
 W-statistic  95% Lower Bound  95% Upper Bound  90% Lower Bound  90% Upper Bound
   64.9591         21.7255         30.2247         17.9500         25.1239
*******************************************************************************
```

If the statistic lies between the bounds, the test is inconclusive. If it is above the upper bound, the null hypothesis of no level effect is rejected. If it is below the lower bound, the null hypothesis of no level effect can't be rejected. The critical value bounds are computed by stochastic simulations using 20000 replications.

Table 2: ARDL Short Run Coefficient Estimates

Error Correction Representation for the Selected ARDL Model
ARDL(2,2,0,1,2,2) selected based on Akaike Information Criterion

```
*******************************************************************************
 Dependent variable is dLGDP
 29 observations used for estimation from 1983 to 2011
*******************************************************************************
 Regressor           Coefficient    Standard Error       T-Ratio    [Prob]
 dLGDP1                -.38764            .11024         -3.5162    [.003]
 dLL                   .2141              .059358         3.607     [.002]
 dLL1                  .28979             .096786         2.9941    [.008]
 dLK                   .12980             .029994         4.3274    [.000]
 dLInnovation          .1080E-            .2595E-5        4.1596    [.001]
 dLExpenditure        -.0081410           .0053118       -1.5326    [.144]
 dLExpenditure1       -.013030            .0052767       -2.4693    [.024]
 dLEnrolment           .023802            .023519         1.0120    [.326]
 dLEnrolment 1        -.036035            .018674        -1.9297    [.071]
 dD1                   .17308             .029915         5.7858    [.000]
 ecm(-1)              -.31333             .09722         -3.2228    [.005]
*******************************************************************************
```

List of additional temporary variables created:

```
 dLGDP = LGDP-LGDP(-1)
 dLGDP1 = LGDP(-1)-LGDP(-2)
 dLL = LL-LL(-1)
 dLL1 = LL(-1)-LL(-2)
```

```
 dLK = LK-LK(-1)
 dLInnovation = LInnovation-LInnovation (-1)
 dLExpenditure = LExpenditure-LExpenditure (-1)
 dLExpenditure1 = LExpenditure (-1)- LExpenditure (-2)
 dLEnrolment = LEnrolment - LEnrolment (-1)
 dLEnrolment1 =LEnrolment(-1)- LEnrolment(-2)
ecm = LGDP   -.10358*LL   -.41425*LK -.1647E-3*PAT + .0051783*SPEND   -.16723*
 ENROL   -4.3113*c
*******************************************************************************
 R-Squared                      .95070   R-Bar-Squared                   .89381
 S.E. of Regression           .0075115   F-Stat.    F(11,17)    22.7895[.000]
 Mean of Dependent Variable    .022929   S.D. of Dependent Variable      .023051
 Residual Sum of Squares      .7335E-3   Equation Log-likelihood        112.3333
 Akaike Info. Criterion        96.3333   Schwarz Bayesian Criterion      85.3949
 DW-statistic                   2.6159
*******************************************************************************
 R-Squared and R-Bar-Squared measures refer to the dependent variable dLGDP and in
cases where the error correction model is highly restricted, these measures could
become negative.
```

Testing for existence of a level relationship among the variables in the ARDL model

```
*******************************************************************************
 F-statistic  95% Lower Bound  95% Upper Bound  90% Lower Bound  90% Upper Bound
   10.8265          3.6209          5.0375          2.9917          4.1873
 W-statistic  95% Lower Bound  95% Upper Bound  90% Lower Bound  90% Upper Bound
   64.9591         21.7255         30.2247         17.9500         25.1239
*******************************************************************************
```

If the statistic lies between the bounds, the test is inconclusive. If it is above the upper bound, the null hypothesis of no level effect is rejected. If it is below the lower bound, the null hypothesis of no level effect can't be rejected. The critical value bounds are computed by stochastic simulations using 20000 replications.

Figure 2

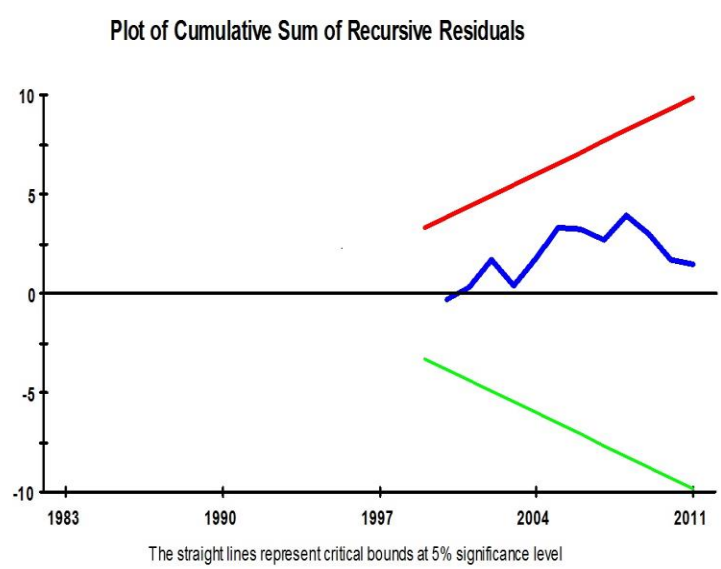
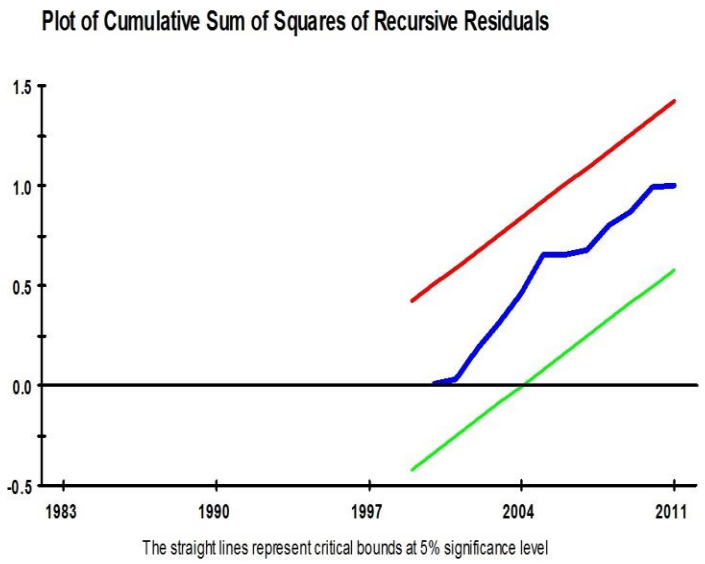


Figure 3


Plot of Cumulative Sum of Squares of Recursive Residuals
1.5
1.0
0.5
0.0
-0.5
1983
1990
1997
2004
2011
The straight lines represent critical bounds at 5% significance level