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Essays on Decomposition of Output Growth and Total Factor Productivity (TFP) in Sub-Saharan Africa and South Africa's Nine Provinces

By

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Abstract

International experience has revealed that countries (national level) and the regions in a country (sub-national level) grow at different rates. Explaining the difference in these growth rates and identifying the sources of this growth have been the focus of growth theory, i.e., neoclassical (exogenous) growth theory advanced by Solow (1956) and Swan (1956) and new (endogenous) growth theory introduced by Romer (1986) and Lucas (1988). Underpinned by these two growth theories, numerous economic studies have established that the difference in growth rates at a national and sub-national level can be attributed to factors such as institutional quality, financial development and human capital (health), while the sources of growth are physical capital, human capital (education), labour, and Total Factor Productivity (TFP). However, the standard growth accounting and cross-country analyses, the empirical techniques of neoclassical and new growth theories do not adequately clarify the sources of growth and their relative impact. The three essays of this PhD thesis use Stochastic Frontier Analysis (SFA), as an alternative empirical technique, to address these limitations. This PhD thesis thus contributes to the growth literature on the importance of the different factors [specifically, institutional quality, financial development and human capital (health)] to the growth rate and the relative importance of the different sources of growth at a national and sub-national level. The growth elements in Sub-Saharan Africa (SSA) (national level) and South Africa's nine provinces (sub-national level) are decomposed through the use of SFA to establish: (i) in Essay 1, that Financial Development (FD) impacts on Technical Efficiency (TE) through Institutions (I), with banking development more important than stock market development in contributing to financial development and consequently increases in productive efficiency, in SSA; (ii) in Essay 2, that in contrast to the established growth literature, physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces and (iii) in Essay 3, that consistently with the literature, health (public health expenditure) has a significant impact on the Technical Efficiency (TE) of South Africa's nine provinces. To allow the financial sector (banks and stock exchanges) to play its catalytic role in facilitating productive efficiency and economic growth in SSA, policy makers should ensure an appropriate institutional environment (e.g., addressing issues of property rights and government effectiveness). For growth to be sustainable in South Africa's nine provinces, each provincial government should increase the relevant capital investments [e.g., public sector Gross Fix Capital Formation (GFCF)] and invest in productivity enhancing factors (e.g., human capital, both education and health) that would enrich its growth potential based on its unique requirements.

Declaration

I declare that this thesis is my own unaided work. It is submitted in fulfilment of the requirement for the award of Doctor of Philosophy (Ph.D.) in Economics at the School of Economics and Finance of the University of the Witwatersrand. It has not been submitted before for any degree or examination to this or any other university.

Student: Christian Floris Green (Number – 878027)

Signed:  Date: 07 October 2022

Preface

With an initial interest in the importance of institutions - specifically the financial system and in particular the importance of stock exchanges - to economic growth, I started my journey in preparing this PhD thesis.

My journey started with Professor Yasmina Rim Limam that assisted me in narrowing down the institutional and financial variables of focus in Sub-Saharan Africa. She also provided the necessary guidance that assisted me in transitioning between writing reports in a professional environment versus academic writing. I am especially appreciative of Professor Giampaolo Garzarelli, my current supervisor, that agreed to take over as my supervisor. He assisted me to further develop and crystallise the importance of institutions and financial development, as well as human capital (health) within the context of growth theory and guided my thinking on my topic at both a national and sub-national level.

I am thankful for the role my parents, John and Hilda Green, have played in instilling in me the values of integrity and a sense of duty that have been indispensable in my journey to complete this project. I am also immensely grateful to my wife Irma for her encouragement and support during this project, while my two children, Markus and Noah were ever patient in their demands for more playtime.

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Chapter 1

Introduction

1.1. Background

International experience has revealed a wide disparity in economic growth rates and levels across countries. The result is reflected in the huge difference in standards of living among countries, which has led countries to be classified (at a basic level) as either developed or developing. According to the United Nations (UN), this classification is a measure of a country's basic economic conditions that includes its level of Gross Domestic Product (GDP) and per capita GDP. All African countries, including South Africa, are classified as developing according to this classification. At a sub-national level, the regions of countries also grow at different rates. The difference in growth rates among countries (national level) and among the regions of countries (sub-national level) can be attributed to factors such as institutional quality, financial development and human capital (health), while the sources of growth, as identified by the neoclassical and endogenous growth theories, are ascribed to physical capital, human capital (education), labour, and Total Factor Productivity (TFP).

This PhD thesis addresses the importance of the different factors [institutional quality, financial development and human capital (health)] to the growth rate, while also identifying the relative importance of the different sources of growth at a national and sub-national level and is structured as follows. In Chapter 2, Essay 1 establishes whether financial development positively affects the technical efficiency in Sub-Saharan Africa (SSA) through the channel of institutions. In Chapter 3, Essay 2 addresses the question of whether physical capital accumulation is more important than Total Factor Productivity (TFP) in driving the growth in South Africa's nine provinces. In Chapter 4, Essay 3 identifies whether health care positively affects the technical efficiency of South Africa's nine provinces. Chapter 5 concludes.

In addressing the importance of the different factors to growth, authors such as Acemoglu, Johnson and Robinson (2004: 1) and Lal (1998: 5) indicate that institutions set the rules for the workings of a society, work on the basis of incentives and reduce the costs associated with the interaction among people. In relation to the importance of institutions to economic growth, Acemoglu, Johnson and Robinson (2004) propose a dynamic political economy framework (the economic institutions hypothesis) in which economic differences in economic institutions are

the fundamental cause of differences in economic development. Thus, according to Acemoglu, Johnson and Robinson (2004: 1), the economic institutions in society, such as the structure of property rights and the presence and quality of markets, are of primary importance to economic outcomes.

Authors such as Kuncic (2012) asserts that social institutions can be classified as formal (legal, political and economic) or informal (norms, traditions, customs). The focus of this PhD thesis is on formal institutions. Knack and Keefer (1995) study the impact of property rights (economic institutions) on economic growth by using indicators such as expropriation risk, quality of bureaucracy, contract enforceability, and infrastructure quality. They established that institutions that protect property rights are crucial to economic growth and to investment and that property rights affects not only the magnitude of investment, but also the efficiency with which inputs are allocated.

Institutions are thus central to economic life, such as in the case of the financial system, as studied in Essay 1 (Chapter 2). Although economists (e.g., Robinson 1952 and Lucas 1988) believe that finance is a relatively unimportant factor in economic development, King and Levine (1993: 719) and others found that higher levels of financial development are positively associated with faster rates of economic growth, physical capital accumulation and economic efficiency improvements. In line with this view, theoretical models show that financial sector development (i.e., financial instruments, markets and intermediaries) arise to mitigate the effects of market frictions (i.e., acquiring information, enforcing contracts and making transactions). In emerging to enhance market frictions, the financial sector changes the incentives and constraints facing economic agents in ways that influence savings rates, investment decisions, technological innovation, and ultimately economic growth. Financial development follows when transaction and information costs continue to decrease through clustering of excellence and expertise in economic and financial services, as well as through the creation of new financial or investment products, services, or processes, i.e., financial innovation.

In this regard, the City of London (2011: 12) pointed out that Financial Centres (FCs) are at the vanguard or apex of innovation within the financial sector. Tschoegl (2000: 3) identified that the Financial Centres literature indicates that FCs contribute towards financial innovation as they traditionally represent the primary markets where finance capital and currency are collected, switched, disbursed, and exchanged. Reed (1980: 20) further pointed out that the

efficiency of a centralised location is thought to stem from the economies-of-scale of such functions as quick and easy access to the knowledge and services of complementary and competitive institutions. According to Sharman (2009: 1), FCs are also characterised by highly positive governance environments in terms of the transparency, impartiality and durability of their institutions, i.e., FCs provide good institutions necessary to drive growth. According to Lannoo (2007: 1), FCs are places where the financial sector plays a dominant role in the local economy, defined, amongst others, by the share of GDP or national income derived from financial services and/or total employment. However, there are differing views on which type of financial services (i.e., banking or stock exchanges) are more important to be used in identifying a FC. Levine and Zervos (1998) focus on stock exchanges as the cornerstone of a FC, while also incorporating banking. In line with Levine and Zervos (1998), Essay 1 identifies countries in Sub-Saharan Africa (SSA) with a stock exchange as a FC and then also focuses on their banking development. Following this outline, 20 countries in SSA were identified as host to a FC, i.e., to have a stock exchange.

As noted, the disparities in economic growth rates and levels among countries are also evident within countries, i.e., there are regional differences in growth rates and levels among the regions of countries. This is quite evident in South Africa's nine provinces, where STATS SA identified the province of Gauteng as having the highest growth rate, at 1.2 percent, while the North West province as having the lowest growth rate, at -3.6 percent, in 2016. The implication of this difference can be seen in the difference in Gross Domestic Product (GDP) per capita between the two provinces in 2016: R77,149 in Gauteng, and R47,222 in North West. Furthermore, Gauteng made the largest contribution to South Africa's economy in 2018, with R1,10 trillion, amounting to 34.9 percent of total GDP, followed by Kwazulu-Natal with R504 billion, amounting to 16 percent, the Western Cape with R436 billion, amounting to 13.9 percent, and the Northern Cape making the least contribution at R69 billion, amounting to 2.2 percent. The economic dominance of Gauteng, Kwazulu-Natal and the Western Cape is not surprising, as tertiary and secondary sector activities, which dominate the national economy, are concentrated in the economies of these three provinces. The primary sector is the smallest in South Africa, with mining contributing to GDP growth in the smaller provinces of Limpopo, Mpumalanga, the Northern Cape, and North West.[1] Considering that each province has its own unique industrial makeup, with different sectors dominating in specific provinces, it is not implausible to assume that there might be a divergence of sources of growth in South Africa's nine provinces, i.e., capital accumulation might dominate in one province, while Total Factor

[1] STATS SA, (2017), Your job, your economy, your province, http://www.statssa.gov.za/?p=9794

Productivity (TFP) in another. Essay 2 sheds light on the importance of the various sources of growth in South Africa's nine provinces.

As is the case on a national level, the differences in growth rates at a sub-national level can also be attributed to certain factors, e.g., quality institutions, financial development and human capital (health) per province, as is the case in South Africa. This forms the basis for Essay 3 (Chapter 4) that looks at the impact of health care (public health expenditure) on the economic growth of South Africa's nine provinces.

According to authors such as Tompa (2002), human capital (which has traditionally been interpreted as education and skills) has been identified as a key determinant of productivity growth that assists with economic growth. She and other authors have however indicated that there is increasing attention directed to health as a form of human capital that is key in augmenting growth and wealth accumulation. In this regard, Alexa, Pop-Silagh and Cismas (2016) noted that "health has been recognised as an important factor in growth dating back to Grossman (1972) who modelled optimal investment in increasing longevity." The catalytic role health can play in augmenting the drivers of economic development (trade openness, financial development, institutional quality, etc.) has been highlighted in the literature by authors such as Bloom, Canning and Sevilla (2001 & 2004); Bloom, Canning, Kotschy, Prettner, and Schünemann (2019) and Barro (2013). They indicated that health has a sizable impact and is a better predictor than education and skills for the subsequant pace of economic growth.

In providing a selection of papers that used health as a determinant of economic growth, Bloom et al. (2004) identified life expectancy as the most widely used indicator of health, establishing that life expectancy has a significant positive effect on the rate of economic growth. Finlay (2007) indicated that life expectancy will expand the time horizon over which returns to education and savings for retirement can be earned, thus encouraging investment as the present value of lifetime earnings increases. As a further measure of health, Barro (2013) established a negative relationship between fertility rate and economic growth, suggesting that a drop in the fertility rate would raise the growth rate of per capita output. In contrast to studies that focused on the direct impact of health on economic growth, Finlay (2007) jointly determined economic growth, education and fertility and determined that the indirect effect of health on economic growth is positive and significant, i.e., a decrease in mortality will decrease fertility that will raise total years of schooling, which in turn increases GDP. This is in line with Venkataramani, Shanmugam and Ruger (2006) that indicated that the empirical studies have generally specified

health as an input in the production function, which is not desirable since health (as an input) in general is viewed as indirectly augmenting the production process. Based on this gap in the literature, Essay 3 establishes the indirect impact of health on output growth. Tompa (2002) identified health expenditure as a further measure to capture health. Authors such as Aboubacar and Xu (2017), Piabuo and Tieguhong (2017) and Baldacci, Clements, Gupta, Cui (2004) found that health expenditure has a significant impact on economic growth. In this regard, Ogungbenle, Olawumi and Obasuyi (2013) found that a positive relationship exists among gross domestic product, public health expenditure and life expectancy in Nigeria. They established that since there is no causal linkage between life expectancy and public health expenditure, public health spending should increase to improve life expectancy. Furthermore, as there is no causal linkage between life expectancy and economic growth, sustainable economic growth is dependent on measures to boost life expectancy. In addition, as there is a causal linkage between public health expenditure and economic growth, an increase in public health expenditure will boost economic growth. Accordingly, Essay 3 focuses on public health expenditure, as a health measure to establish its impact in South Africa's nine provinces. Only a few studies have found no positive effect of health improvements on economic growth (Acemoglu and Johnson, 2006). However, the overwhelming evidence from the literature is that improved health increases the quality of the workforce, enhances productivity and improves knowledge absorption.

Explaining the difference in growth rates among countries and identifying the sources of growth have been the focus of numerous economic studies, underpinned by the two main growth theories, i.e., neoclassical (exogenous) growth theory advanced by Solow (1956) and Swan (1956) and new (endogenous) growth theory introduced by Romer (1986) and Lucas (1988). Based on these two growth theories, the established growth literature attributes (i.e., decomposes) output growth to physical capital (machinery and equipment) and human capital (education), labour and knowledge [Total Factor Productivity (TFP)]. However, the essence of the exogenous and endogenous growth theories is that, in the long-run, the rate of economic growth depends on the growth rate of TFP, which is determined by the rate of technological progress, i.e., economic growth is mainly attrubuted to TFP.

The empirical studies underpinning these two growth theories (namely, growth accouting and cross-country analysis), have however: (i) Been inconclusive in pinpointing the relative importance of the various sources of growth, which consist of capital, labour and Total Factor Productivity (TFP). Limam and Miller (2004: 2) and Limam, Miller and Garzarelli (2019) for

instance note that dispute still exists concerning the most important determinants of economic growth. (ii) Not allowed for the decomposition of TFP to adequately reflect the contribution of other factors to output growth, as it leaves a lumpy factor in output growth other than capital and labour (Garzarelli, Limam and Rossi 2014). TFP represents the efficiency with which the factors of production (capital and labour) are used and is a fusion of all other factors other than physical capital and labour that impacts on productivity. Quality institutions, financial development and human capital (health) are examples of factors that can improve TFP. In addition, Venkataramani, Shanmugam and Ruger (2006) noted that empirical studies have generally specified health (human capital) as an input in the production function process, rather than as part of TFP, which does not detail how exactly health accomplishes output growth.

In an effort to overcome the limitations of these empirical studies, authors such as Koop, Osiewalski and Steel (1995) proposed a stochastic frontier framework [i.e., Stochactic Forntier Analysis (SFA)]; that is, an empirical approach to more acurately decompose the elements of growth to identify the most important determinants of economic growth. Frontier Analysis establishes the optimum benchmark against which deviations are calculated, with SFA developed (independently) by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) to estimate the frontier with statistical methods and imposes an explicit functional form for both the frontier and deviations from it that is inefficiency. The general stochastic production frontier model focusses on the decomposition of TFP to obtain an estimator for one of its constituent parts, i.e., Technical Efficiency (TE) in an effort to take account of factors such as quality institutions, financial development and health for economic growth. The other component of TFP is Technical Change (TC), which is depicted by a time trend and interactions of the regressors with time.

The general stochastic production frontier model [developed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977)] that is used by this PhD thesis is as follows:

$$Y_{it} = X_{it}\beta + v_{it} - u_{it}. \qquad \textbf{(1.1)}$$

Assuming a transformation of model 1.1 to a translog production function, with the 17 Sub-Saharan Africa (SSA) countries that are hosts to Financial Centres (FCs) and South Africa's

nine provinces producing three production factors, namely physical capital, labour and human capital, the new model can be expressed in the following way:

$$InY_{it} = \alpha_0 + \alpha_1 InK_{it} + \alpha_2 InL_{it} + \alpha_3 InHC_{it} + \alpha_4 TInK_{it} + \alpha_5 TInL_{it} + \alpha_6 TInHC_{it} + \alpha_7 T + \alpha_8 T^2 + v_{it} - u_{it} \quad \textbf{(1.2)}$$

where for country or province i at time t, *Y* is output, *K* is capital, *L* is labour, *HC* is human capital, *T* is a time trend to account for Technical Change (TC), v is a random error that accounts for statistical noise, and u is a non-negative random variable associated with technical inefficiency, which is associated in the case of Essay 1 with institutions and financial development and for Essay 3 with health.

1.2. Contribution and Link among the Essays

Given the limitations of the empirical studies of the established growth literature that decomposes output growth into capital, labour and grouping all other factors (including institutions, financial development and health) in the lumpy factor of TFP, this PhD thesis contributes to the economic growth literature by using SFA to explore: (i) in Essay 1 the decomposition of TFP to account for the role of Institutions and Financial Development in the Technical Efficiency (TE) of Sub-Saharan Africa (SSA), (ii) in Essay 2 the relative importance of the various sources of growth by focusing on the decomposition of output growth at a sub-national level in South Africa's nine provinces, and (iii) in Essay 3 the decomposition of TFP to account for the role of health care in the Technical Efficiency (TE) of South Africa's nine provinces. This PhD thesis thus fills this gap in the growth literature by using SFA, an alternative to the standard growth accounting and cross-country analyses that have been the main empirical techniques employed by neoclassical and new growth theories. The objective is to identify the relative importance of the various sources of growth, i.e., capital, labour and TFP, as well as decomposing TFP to reflect the contribution of other factors to output growth, i.e., quality institutions, financial development and health. Stochactic Forntier Analysis, as the prefered empirical technique, and thus provides the link between the three essays of this PhD thesis, to fill the gap in the growth literature on the importance of the vatious sources of growth and the contribution of other factors to output growth.

1.3. Research Objectives, Hypotheses and Data

Essay 1 explores whether financial development (epitomised by Financial Centres as the apex in innovation in the financial sector) operate through the channel of Institutions (I) to impact Technical Efficiency (TE) in Sub-Saharan Africa. Essay 1 argues that financial development positively affects the technical efficiency in SSA through the channel of institutions, captured by financial centres as the highest form of financial innovation in the financial sector. In addressing this hypothesis, the essay addresses the question: What is the impact of financial development and institutions on technical efficiency in Sub-Saharan Africa? The data used in this essay is for 17 SSA countries over the period 2002 to 2017 that are host to Financial Centres (FCs), with data on *Y* (output), *K* (capital), *L* (labour), and *HC* (Human Capital) obtained from the Penn World Table 9.1 (Feenstra, Inklaar and Timmer 2015). Data for Banking Development (BD) and Stock Market Development (SMD) were obtained by using the Financial Institutions Index (FII) and Financial Markets Index (FMI) of the International Monetary Fund (IMF), which are relative rankings of countries on the depth, access and efficiency of their financial institutions and financial markets. Variables on institutional quality, Property Rights (PR) is obtained from the Heritage Foundation and Government Effectiveness (GE), Political Stability and Absence from Violence and Terrorism (PSAVT) and Regulatory Quality (RQ) are obtained from the World Governance Indicators.

Considering that each province has its own unique industrial makeup, with different sectors dominating in specific provinces, it is not implausible to assume that there might be a divergence of sources of growth in South Africa's nine provinces, i.e., capital accumulation might dominate in one province, while TFP in another. Essay 2 considers that, in contrast to the established growth literature, physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces. In addressing this hypothesis, this essay answers the following question: what is the relative importance of physical capital and TFP in contributing to the economic growth of South Africa's nine provinces? This essay differs from earlier studies, as it focuses on the sub-national level as opposed to the national level. The data used in this essay is for South Africa's nine provinces for the period 2009 to 2018, with data on *Y* (output), *L* (labour), and *HC* (Human Capital) from STATS SA. Human Capital (HC) is proxied by the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education. Educational attainment is used instead of average years of schooling or enrolment rates, in line with authors such as Rivera and Currais (1999), Barro (2013) and Caselli (2005). Data on capital (K) is obtained from Quantec (2022) and is proxied

by Gross Fix Capital Formation (GFCF), which is a proxy for physical capital accumulation, in line with Barro (1989) and Benhabib and Spiegel (1994).

Essay 3 hypothesises that health care positively affects the technical efficiency of South Africa's nine provinces. In addressing this hypothesis, this essay answers the question: What is the impact of health care on the technical efficiency of South Africa's nine provinces? This essay differs from earlier studies, as it focuses on the sub-national level as opposed to the national level. It also differs from previous studies in establishing the indirect impact of health through TFP on economic growth. Data on *Y* (output), *K* (capital), *L* (labour), *HC* (Human Capital), and *PHE* (Public Health Expenditure) is from STATS SA, while data on capital (K) is obtained from Quantec (2022) and is for South Africa's nine provinces for the period 2009 to 2018. Similar to Essay 2, human capital (HC) is proxied by the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education and capital (K) is proxied by Gross Fix Capital Formation (GFCF).

1.4. Summary of Results

The results of Essay 1 confirm that Financial Development (FD) impacts on Technical Efficiency (TE) through Institutions (I), in line with King and Levine (1993) that identify a positive relationship between financial development and growth and Acemoglu, Johnson and Robinson (2004) that idenify that economic institutions are the fundamental cause of long run growth. Institutinal quality (IQ) seems to increase the technical efficiency of banks, while it does not seem to increase the technical efficiency of stock markets. Thus, against expectations, banking development is more important than stock market development in contributing to financial development and consequently increases in productive efficiency, in SSA.

Essay 2 establishes that labour growth is the main driver of economic growth in South Africa's nine provinces, followed by physical capital and human capital accumulation, with TFP being the least important factor of growth. This essay thus confirms that, in contrast to the established growth literature, e.g., Solow (1957) and Chenery (1986), physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces. In addition, this essay identifies that the source of growth for each individual province differs based on (i) the achievements of each province with regards to factor accumulation and (ii) its economic structure. Thus, in terms of economic structure, Gauteng, which is dominated by the tertiary and secondary sectors that are more capital intensive and require higher skilled human capital,

physical and human capital accumulation are more important to growth, while growth in the North West, which is dominated by the primary sector, is driven by labour growth.

As consistent with the literature, Aboubacar and Xuv (2017) and Piabuo and Tieguhong (2017), it was established in Essay 3 that health (public health expenditure) has a significant impact on the Technical Efficiency (TE) of South Africa's nine provinces.

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Chapter 2 : Essay 1

The Role of Institutions and Financial Development in the Technical Efficiency (TE) of Sub-Saharan Africa

Abstract

This essay establishes whether financial development (epitomised by financial centres) positively affects the technical efficiency in Sub-Saharan Africa (SSA) through the channel of institutions. The growth elements in SSA are decomposed through the use of Stochastic Frontier Analysis (SFA) to establish the impact of financial development and institutions on the technical efficiency in SSA. The contribution this essay makes to the literature is to further enhance the understanding of the impact of financial development on economic growth, specifically within the context of the level of banking development and stock market development in SSA, by addressing the limitations of the standard growth accounting and cross-country analyses of neoclassical and new growth theories that do not adequately clarify the sources of growth and their relative impact. The results confirm that Financial Development (FD) impacts on Technical Efficiency (TE) through Institutions (I). The implication is that, against expectations, banking development is more important than stock market development in contributing to financial development and consequently increases in productive efficiency, in SSA. Policy makers in SSA should thus ensure an appropriate institutional environment (e.g., addressing issues of property rights and government effectiveness) in their countries to allow the financial sector (banks and stock exchanges) to play its catalytic role in facilitating productive efficiency and economic growth. However, legal origin, e.g., British (common law) and French (civil law) law traditions influences the appropriate institutions available in a country. Future research should thus consider legal origin in establishing the impact of financial development and institutions on the technical efficiency in SSA.

2.1. Introduction

Authors such as Acemoglu, Johnson and Robinson (2004: 1) and Lal (1998: 5) indicate that institutions set the rules for the workings of a society, work on the basis of incentives and reduce the costs associated with the interaction among people. Institutions are thus central to economic life, such as in the case of the financial system that consists of financial instruments, markets and intermediaries. These elements of the financial system develop to alleviate the effects of market frictions (i.e., acquiring information, enforcing contracts and making transactions). In performing these functions, Levine (2004: 5) indicates that the financial sector changes the incentives and constraints facing economic agents in ways that influence savings rates, investment decisions, technological innovation, and ultimately economic growth. Financial development follows when transaction and information costs continue to decrease through clustering of excellence and expertise in economic and financial services, as well as through the creation of new financial or investment products, services, or processes, i.e., financial innovation.

In this regard, the City of London (2011: 12) pointed out that Financial Centres (FCs) are at the vanguard or apex of innovation within the financial sector. Tschoegl (2000: 3) identified that the financial centres literature indicates that FCs contribute towards financial innovation as they traditionally represent the primary markets where finance capital and currency are collected, switched, disbursed and exchanged. Reed (1980: 20) further pointed out that the efficiency of a centralised location is thought to stem from the economies-of-scale of such functions as quick and easy access to the knowledge and services of complementary and competitive institutions. According to Sharman (2009: 1), FCs are also characterised by highly positive governance environments in terms of the transparency, impartiality and durability of their institutions, i.e., FCs provide good institutions necessary to drive growth.

Although institutions and financial development are associated with faster rates of economic growth, the majority of the empirical studies underpinned by the two main growth theories – i.e., neoclassical (exogenous) growth theory advanced by Solow (1956) and Swan (1956) and new (endogenous) growth theory introduced by Romer (1986) and Lucas (1988) – attributes output growth to two production inputs (capital and labour) and Total Factor Productivity (TFP). TFP represents the efficiency with which the factors of production (capital and labour) are used and is a fusion of all other factors, other than physical capital and labour, that impacts on productivity. Quality institutions and financial development are examples of factors that can

improve TFP. However, as Garzarelli, Limam, and Rossi (2014) have noticed, the established growth literature does not allow for the decomposition of TFP to adequately reflect the contribution of other factors to output growth, as it leaves a lumpy factor in output growth other than capital and labour. In an effort to overcome the limitations of these empirical studies, authors such as Koop, Osiewalski and Steel (1995) proposed a stochastic frontier framework, i.e., using Stochastic Frontier Analysis (SFA) to more acurately decompose the elements of growth, specifically TFP that can be further decomposed into Technical Efficiency (TE) and Technology Change (TC).

Thus, given the limitations of the empirical studies of the established growth literature that decomposes output growth into capital, labour and grouping all other factors (including institutions and financial development) in the lumpy factor of TFP, this essay will use SFA to explore whether financial development (epitomised by Financial Centres as the apex in innovation in the financial sector) operate through the channel of Institutions (I) to impact Technical Efficiency (TE) in Sub-Saharan Africa.

The relevance of focusing on the technical efficiency in Sub-Saharan Africa (SSA) is informed by the view of authors such as Garzarelli, Limam, and Rossi (2014) that indicated that previous literature, in general, agrees that bad institutions explain the poor economic performance in SSA. However, the positive growth stories in the region have also been associated with good institutions, with the Commission for Africa (CFA) (2005) indicating that the recent drivers of economic growth in Africa have been related to institutions, which, amongst others, includes governance relating to peace and security. The economic framework relating to financial sector development and infrastructure development were also identified as drivers of growth. According to Papaioannou (2007: 6), using the neoclassical growth accounting framework, the evidence has hinted that financial development fosters growth through two mechanisms: (i) a spur in investment (a capital accumulation channel) and (ii) an efficiency/productivity channel, which should be of specific interest to SSA countries.

The important role institutions and financial development can play in economic development is especially relevant within the context of SSA's development needs, which provide the main motivation for conducting the current research. In 2001, 46.4 percent of the population in SSA were living in households with incomes per person of less than US$1 a day (the previous international poverty line), while the situation has not changed substantially, as the Millennium Development Goal (MDG) 2015 Report of the United Nations (UN) revealed that the

proportion of people living on less than US$1.25 a day (the revised international poverty line) were nearly the same at around 48 percent in 2015. Growth is required for countries to reduce poverty and, in this regard, the Commission for Africa (CFA), indicated that a number of economists have attempted to quantify this positive impact, with the finding that for a one percent rise in economic growth, the number of people living below the old poverty line (of US$1 a day) should fall by between two and three percent. However, while many African countries have historically managed to generate periods of rapid growth, few have been able to sustain it for long periods (CFA, 2005).

Substantial infrastructure investment, estimated according to the World Bank to be around US$93 billion a year and accounting for 15 percent of Africa's GDP, were identified as one of the major hindrances to unlocking SSA's growth potential, i.e., financial development is a key enabler for economic growth in SSA. In this regard, Levine and Zervos (1998) found that financial development – the initial level of stock market development (liquidity – value of the trades of domestic shares as a share of market capitalisation) and the initial level of banking development (Bank Credit – credit to the private sector divided by GDP) – are positively and significantly correlated with future rates of economic growth, capital accumulation and productivity growth. They further argue that, in line with the growth accounting framework, the link between financial development (stock markets and banks) and growth runs most robustly through productivity growth.

In the African context, however, financial development is lagging those of advanced and emerging markets, with the continent comparing to low income and developing countries, i.e., in 2017, Africa had a Financial Development Index (FDI)[2] of 0.16, while the FDI for advanced and emerging markets and low income and developing countries were 0.65, 0.33 and 0.14, respectively, as reflected in Table 2.1. Africa's FDI, however, masks a wide disparity in the financial development of the continent, specifically in SSA, as Table 2A.1 in the Appendix reveals. South Africa, with a FDI of 0.64 in 2017 compared to advanced markets, while Mauritius with a FDI of 0.49 compared to European markets that had a FDI of 0.53. At the other extreme, the Democratic Republic of Congo (DRC) and the Central African Republic both had a FDI of 0.05 in 2017, which is even lower than low income and developing countries.

[2] Developed by the International Monetary Fund (IMF) as a measure of overall financial development that includes a measure of banking development [Financial Institutions Index (FII)] and stock market development [Financial Market Index (FMI)], available at https://data.imf.org/?sk=F8032E80-B36C-43B1-AC26-493C5B1CD33B.

A similar picture is evident in relation to banking development [Financial Institutional Index (FII)], where South Africa with a FII of 0.73 and Namibia with a FII of 0.68, compared to advanced markets that had a FII of 0.72 in 2017, while the majority of SSA countries, compared to low income and developing countries that had a FII of 0.26 in 2017.

Table 2.1: Financial Development (FD) of Major Countries and Regions

		2012	2013	2014	2015	2016	2017
Brazil	Financial Development Index	0.61	0.61	0.62	0.63	0.60	0.61
	Financial Institutions Index	0.66	0.66	0.65	0.67	0.63	0.63
	Financial Markets Index	0.54	0.54	0.56	0.58	0.55	0.57
China, P.R.: Mainland	Financial Development Index	0.55	0.57	0.60	0.63	0.65	0.64
	Financial Institutions Index	0.49	0.51	0.53	0.59	0.60	0.62
	Financial Markets Index	0.60	0.60	0.64	0.65	0.67	0.64
India	Financial Development Index	0.40	0.40	0.41	0.42	0.42	0.43
	Financial Institutions Index	0.36	0.36	0.37	0.37	0.38	0.38
	Financial Markets Index	0.43	0.42	0.44	0.45	0.44	0.47
Japan	Financial Development Index	0.81	0.84	0.84	0.86	0.86	0.89
	Financial Institutions Index	0.87	0.89	0.90	0.91	0.91	0.93
	Financial Markets Index	0.71	0.75	0.75	0.77	0.78	0.83
United States	Financial Development Index	0.88	0.88	0.89	0.90	0.89	0.89
	Financial Institutions Index	0.85	0.84	0.85	0.87	0.86	0.86
	Financial Markets Index	0.88	0.89	0.89	0.89	0.88	0.89
Advanced Markets	Financial Development Index	0.64	0.64	0.64	0.64	0.64	0.65
	Financial Institutions Index	0.73	0.72	0.73	0.72	0.72	0.72
	Financial Markets Index	0.53	0.53	0.53	0.54	0.53	0.55
Africa	Financial Development Index	0.14	0.15	0.15	0.15	0.15	0.16
	Financial Institutions Index	0.25	0.25	0.25	0.25	0.26	0.26
	Financial Markets Index	0.04	0.04	0.04	0.04	0.04	0.05
Emerging Markets	Financial Development Index	0.31	0.32	0.32	0.33	0.33	0.33
	Financial Institutions Index	0.43	0.44	0.44	0.45	0.45	0.45
	Financial Markets Index	0.19	0.19	0.19	0.19	0.19	0.20
Europe	Financial Development Index	0.53	0.53	0.53	0.53	0.52	0.53
	Financial Institutions Index	0.64	0.64	0.64	0.63	0.63	0.63
	Financial Markets Index	0.40	0.40	0.40	0.40	0.39	0.41
Low-Income and Developing Countries	Financial Development Index	0.14	0.14	0.14	0.14	0.14	0.14
	Financial Institutions Index	0.24	0.25	0.25	0.25	0.25	0.25
	Financial Markets Index	0.02	0.02	0.02	0.02	0.02	0.03

Note: Financial Development Index (FDI) is a relative ranking, ranging between 1 (high) and 0 (low), of countries on the depth, access, and efficiency of their financial institutions and financial markets. Financial Institutions Index (FII) is a relative ranking, ranging between 1 (high) and 0 (low), of countries on the depth, access, and efficiency of their financial institutions. Financial Markets Index (FMI) is a relative ranking, ranging between 1 (high) and 0 (low), of countries on the depth, access, and efficiency of their financial markets.

Source: IMF

In terms of stock market development [Financial Market Index (FMI)], there were only three SSA countries, South Africa (0.55), Mauritius (0.46) and Nigeria (0.21), in 2017 that had a FMI that could compare to advanced economies that had a FMI of 0.55 and emerging markets that had a FMI of 0.20. The rest of SSA had a FMI of 0.09 or less, in line with those of low income and developing countries. The size and liquidity of SSA stock exchanges is reflected in Table

2A.2 in the Appendix. This provides a further indication that except for the major stock markets in SSA, such as in South Africa, with a market capitalisation ratio (size) of 229 percent of GDP and turnover ratio (liquidity) of 41 percent, financial market development in the region is quite limited.

However, for the financial sector (banks and stock exchanges) to play its catalytic role in driving economic growth in SSA, it should be underpinned by the appropriate (i.e., good in terms of incentive alignment and coordination of actions and expectations) institutional environment. In the context of Africa's infrastructure needs, this is quite relevant, as Zergawu, Walle and Giménez-Gómez (2020) found that the interaction of infrastructure capital and institutional quality shows a positive and significant impact on economic growth.

This essay thus argues that financial development positively affects the technical efficiency in SSA through the channel of institutions, captured by financial centres as the highest form of financial innovation in the financial sector. In addressing this hypothesis, the essay addressed the question: What is the impact of financial development and institutions on the technical efficiency in Sub-Saharan Africa?

This essay differs from earlier studies by decomposing the growth elements in SSA through the use of Stochastic Frontier Analysis (SFA) as an alternative to the standard growth accounting and cross-country analyses that have been the main empirical techniques employed by neoclassical and new growth theories. SFA is applied to 17 SSA countries, over the period 2002 to 2017. The motivation to select these countries is that they host Financial Centres (FCs).

The results confirm that in SSA, Financial Development (FD) impacts on Technical Efficiency (TE) through Institutions (I). When interacted with institutional quality (IQ), banking development seems to increase technical efficiency, while stock market development does not seem to increase technical efficiency. Against expectation, banking development is more important than stock market development in contributing to FD in SSA.

This paper is structured as follows. The next section provides the theoretical and empirical literature review on the two growth theories that constitute the basis of this paper, as well as the impact of financial development and institutions on productivity and growth. This is followed by the methodology section that specifies the general stochastic production frontier model as

the basis for the preferred empirical specification and research technique, as well as the data used. The section on empirical results follows, while the last section concludes.

2.2. Literature Review

2.2.1. Theoretical Overview

Explaining the difference in growth rates between countries has been the focus of numerous economic studies, underpinned by the two main growth theories, i.e., neoclassical (exogenous) growth theory advanced by Solow (1956) and Swan (1956) and new (endogenous) growth theory introduced by Romer (1986) and Lucas (1988). Based on these two growth theories, the established growth literature attributes (i.e., decomposes) output growth to physical capital (machinery and equipment) and human capital (education), labour and knowledge [Total Factor Productivity (TFP)]. However, the essence of the exogenous and endogenous growth theories is that, in the long-run, the rate of economic growth depends on the growth rate of TFP, which is determined by the rate of technological progress, i.e., economic growth is mainly attrubuted to TFP.

TFP represents the efficiency with which factors of production (capital and labour) are used and is a fusion of all other factors, other than physical capital and labour, that impacts on productivity, i.e., these other factors improve the level of output produced per unit of input. Quality institutions (e.g., property rights, government effectiveness, etc.) and the level of financial development, which is the focus of this paper, are examples of factors that can affect TFP.

Although numerous influential economists (e.g., Robinson 1952 and Lucas 1988) believe that finance is a relatively unimportant factor in economic development, King and Levine (1993: 719) and others found that higher levels of financial development are positively associated with faster rates of economic growth, physical capital accumulation and economic efficiency improvements. In addition, they found that the predetermined component of financial development is a good predictor of long-run growth, which means that when countries have relatively high levels of financial development, economic growth tends to be relatively fast over the subsequent 10 to 30 years.

In line with this view, theoretical models further show that financial sector development (i.e., financial instruments, markets and intermediaries) arise to mitigate the effects of market

frictions (i.e., acquiring information, enforcing contracts and making transactions). In emerging to enhance market frictions, the financial sector changes the incentives and constraints facing economic agents in ways that influence savings rates, investment decisions, technological innovation, and ultimately economic growth. Financial development occurs when the financial sector emerges to enhance market frictions and do a correspondingly better job at providing the five broad economic functions[3] provided by the financial system. These economic functions influence savings and investment decisions and hence economic growth (Levine, 2004: 5).

Using the neoclassical growth accounting framework, the mechanisms through which financial sector development (i.e., the five broad economic functions of the financial sector) influences economic growth are identified as the capital accumulation and efficiency/productivity mechanisms, as reflected in Figure 2.1 in the Appendix (Levine, 2004). In terms of the capital accumulation channel, Thiel (2001: 18) indicates that the more efficient the transformation of savings into investment, the lower the loss of resources through transaction costs and the more savings can be used for productive investment. Thus, with the reduction in transaction costs associated with the functions of pooling of savings and the easing of exchange, more savings are available for investment, i.e., capital accumulation. Thiel (2001: 18) identifies the efficiency/productivity channel as (i) the selection of the most profitable investment projects that relates to producing information and allocating capital, as well as monitoring firms and exerting corporate governance, (ii) the provision of liquidity and (iii) the allocation of risks.

This paper uses Financial Centres (FCs) as the reference point for financial development, which according to Lannoo (2007: 1) is used for places where the financial sector plays a dominant role in the local economy, defined, amongst others, by the share of GDP or national income derived from financial services and/or total employment. However, there are differing views on which type of financial services (i.e., banking or stock exchanges) are more important to be used in identifying a FC. Quennouëlle-Corre (2011: 2) identified two main points of view in this regard; one that emphasises banking as the cornerstone of a financial centre and another that stresses the importance of stock exchanges. This research will focus on stock exchanges as the cornerstone of a FC, i.e., identifying those countries in SSA with stock exchanges as FCs (Levine and Zervos, 1998). However, banking will be used as a further measure to establish the development of the financial system in those FCs in SSA. Using both the banking system and the presence of a stock exchange and using the geographic typology of Jao (2003: 4), FCs can

[3] (i) Produce information ex ante about possible investments and allocate capital, (ii) monitor investments and exert corporate governance after providing finance, (iii) facilitate the trading, diversification and management of risk, (iv) mobilise and pool savings, and (v) ease the exchange of goods and services.

be classified into national or domestic centres (their activities are confined to the boundaries of a country), regional centres (when a financial centre outgrows its national boundaries to serve its neighbouring countries) and global (international) centres (their activities extend all over the globe). For the purpose of this research, the geographical typology will be national and regional FCs.

On institutions, Acemoglu, Johnson and Robinson (2004: 1) indicate that North (1990: 3) offers the following definition: "Institutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction." According to Lal (1998:5), implicit in this is the notion that institutions reduce the transaction costs associated with the interaction/relations among individuals. Authors such as Kuncic (2012) assert that institutions can be classified as formal (legal, political and economic) or informal (social), with more than thirty institutional indicators that can be clustered into the three homogenous groups of formal institutions. The focus of this essay is on formal institutions, i.e., legal, political and economic institutions, as it is these institutions that have a more direct influence on the efficiency of exchanges in our financial context.

In relation to the importance of institutions to economic growth, Acemoglu, Johnson and Robinson (2004), proposes a dynamic political economy framework (the economic institutions hypothesis) in which economic differences in economic institutions are the fundamental cause of differences in economic development. Economic institutions, which determine the incentives and constraints of economic agents, are social decisions that are chosen for their consequences (Baltagi, Demitriades and Law, 2007: 3). Thus, according to Acemoglu, Johnson and Robinson (2004: 1), the economic institutions in society, such as the structure of property rights and the presence and perfection of markets are of primary importance to economic outcomes. However, the economic institutions of a society depend on the nature of political institutions and the distribution of political power in society. Political institutions and income distribution are thus the dynamic forces that combine to shape economic institutions and outcomes. According to Baltagi, Demitriades and Law (2007: 3), it is argued that growth promoting economic institutions emerge when political institutions (i) allocate power to groups with interests in broad based property rights enforcement, (ii) create effective constraints on power holders and when there are few rents to be captured by power holders. Furthermore, the economic institutions hypothesis suggests that even though complex political mechanisms may be at work (including social conflict emanating from changing political forces such as the rise of mass

democracy and the changes in the distribution of income), economic institutions provide a useful summary statistic that helps to shape economic development at any point in time.

Thus, the mechanism through which the elements of TFP (e.g., quality institutions and financial development) impact on growth is through productivity that creates new profit opportunities; firms produce greater output for the same level of input and earn higher revenues, which increases investment demand, inducing a level of saving and investment that makes capital per hour of labour grow and ultimately generate higher growth (Gross Domestic Product). However, as Garzarelli, Limam, and Rossi (2014) have noticed, the established growth literature does not allow for the decomposition of TFP to adequately reflect the contribution of other factors to output growth (including quality institutions and financial development), as it leaves a lumpy factor in output growth other than capital and labour.

2.2.2. Empirical Overview

Levine (2004: 38) indicates that a substantial body of empirical work exist on the relationship between finance and growth and that the studies can be organised around the following econometric approaches: (i) cross-country studies, (ii) panel studies, (iii) pure time-series investigations, (iv) country case-studies, (v) industry analyses, and (vi) firm level analyses.

The pioneering study on finance and growth, using cross-country analysis, was conducted by Goldsmith (1969) that sought to assess whether finance exerts a causal influence on growth and whether the mixture of markets (stock exchanges) and intermediaries (banks) operating in an economy influences economic growth. He found that: (i) financial intermediary size relative to the size of the economy rises as countries develop and (ii) a positive correlation exist between financial development and the level of economic activity. However, Goldsmith was unable to provide much cross-country evidence because of the absence of data on securities market development for a broad range of countries and his work raises several problems (Levine, 2004: 39&40).

In building on Goldsmith's work (to account for these problems), King and Levine (1993) studied 77 countries over the period 1960–1989 and systematically control for other factors affecting long-run growth, examine the capital accumulation and productivity growth channels (based on the growth accounting framework), construct additional measures of the level of financial development, and analyse whether the level of financial development predicts long-

run economic growth, capital accumulation and productivity growth. They examine three growth indicators, averaged over the 1960-1989 period: (i) the average rate of real per capita GDP growth, (ii) the average rate of growth in the capital stock per person and (iii) total productivity growth. Furthermore, they constructed additional measures of the level of financial development: (i) DEPTH, which equals liquid liabilities of the financial system (currency plus demand and interest-bearing liabilities of banks and nonbank financial intermediaries) divided by GDP, i.e., measuring the size of financial intermediaries; (ii) BANK, which equals the ratio of bank credit divided by bank credit plus central bank domestic assets, measuring the relative degree to which the central bank and commercial banks allocate credit and (iii) PRIVY, which equals credit to private enterprises divided by GDP. King and Levine (1993) finds that there is a strong positive relationship between each of the financial development indicators and the three growth indicators. In continuing with this work, they furher find that financial depth in 1960 is a good predictor of subsequent rates of economic growth, physical capital accumulation, and economic efficiency improvements over the next 30 years, even after controlling for income, education and measures of monetary, trade and fiscal policy. In line with King and Levine (1993), this essay uses PRIVY as a measure of banking development.

However, Levine (2004: 44) points out two areas of limitations with the research by King and Levine (1993): (i) cross-country growth regressions do not deal formally with the issue of causality and it only focus on one segment of the financial system, banks. In order to address the limitation of focusing on one segment of the financial system, Levine and Zervos (1998) construct numerous measures of stock market development to assess the relationship between stock market development and economic growth (real per capita GDP growth), capital accumulation and productivity growth in a sample of 42 countries over the period 1976–1993. These measures are Size (Capitalisation), the value of domestic shares as a share of GDP; Liquidity (Value Traded), the value of the trades of domestic shares as a share of GDP; Liquidity (Turnover), the value of the trades of domestic shares as a share of market capitalisation; and Volatility, a measure of stock return volatility. They use credit to the private sector (Bank Credit) divided by GDP, as a banking development indicator and find that the initial level of stock market liquidity and the initial level of banking development (Bank Credit) are positively and significantly correlated with future rates of economic growth, capital accumulation and productivity growth. They further argue that, in line with the growth accounting framework, the link between stock markets, banks and growth runs most robustly through productivity growth (i.e., TFP), rather than physical capital accumulation. In line with the work by Levine and Zervos (1998), this essay focuses more on stock market development

as the basis of a Financial Centre (FC) and use variables relating to size, liquidity and volatity as measures of stock market development.

However, Levine (2004: 49) indicates that despite the results by King and Levine (1993) and Levine and Zervos (1998) it does not settle the issue of causality, with Papaioannou (2007: 14) and others identifying a number of reasons why this is the case: (i) it is difficult to account for all possible factors that may foster growth, with multicollinearity impacting on isolating the individual effect among the various regressors on growth; (ii) financial development may be quite heterogeneous across countries; (iii) potential reverse causation; (iv) non-trivial data issues, e.g., the coarse nature of proxies that are not theory-driven; (v) all countries are pooled (industrial, emerging and underdeveloped) in the estimation. In addition, authors such as Beck, Levine and Loayza (2000) indicated that cross-country regression estimates (i) do not exploit the time-series dimension of the data, (ii) it may be biased by the omission of country-specific effects and (iii) they do not control for the endogeneity of all the regressors.

Levine (2004: 53), Papaioannou (2007: 14) and others indicated that recent research has tried to address these caveats and push for the causal interpretation of the finance-growth association. In this regard, Levine, Loayza and Beck (2000) and Beck, Levine and Loayza (2000) construct a panel dataset (focusing on financial intermediaries) for 71 countries with data averaged over each of the seven 5-year periods between 1960 and 1995 and use a dynamic panel General Methods of Moments (GMM) estimator that improves upon pure cross-country work, with the regression equation in levels.

As with their cross-country estimators, Levine, Loayza and Beck (2000), Beck, Levine and Loayza (2000) and Levine (1999) use instrumental variables with panel estimators to accomplish their task to control for the simultaneity bias that may arise from the joint determination of financial intermediary development and the sources of growth. In this regard, Levine (2004: 49) suggests that to assess whether the finance-growth relationship is driven by simultaneity bias, one need instrumental variables that explain cross-country differences in financial development, but that they should be uncorrelated with economic growth beyond their link with financial development and other growth determinants. Levine, Loayza and Beck (2000) and others use La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1998) measures' of legal origin as instrumental variables, i.e., whether a country's Commercial/Company law derives from British, French, German, or Scandinavian law tradition. La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1998) show that differences in the legal treatment of creditors,

legal system efficiency and the comprehensiveness and quality of information disclosed in corporate annual reports are systematically linked to a country's legal origin. Importantly, legal origin shapes national approaches to laws concerning creditors and the efficiency with which those laws are enforced. Therefore, since most countries obtained their legal systems through occupation and colonisation, the legal origin variables may be plausibly treated as exogenous.

Using these instrument variables, Levine, Loayza and Beck (2000) analyses 71 countries over the 1960-1995 period and established (i) a very strong connection between the exogenous component of financial intermediary development and long-run economic growth and (ii) an economically large impact of financial development on growth. Using the same econometric methods and data, Rioja and Valev (2004) find that finance boosts growth in rich countries primarily by speeding-up productivity growth, while finance encourages growth in poorer countries primarily by accelerating capital accumulation. Using only a panel estimator and not a system estimator, Benhabib and Spiegel (2000) find that the indicators of financial development are correlated with both total factor productivity growth and the accumulation of both physical and human capital. Their findings indicate that different indicators of financial development are linked with different components of growth (total factor productivity, physical capital accumulation and human capital accumulation). As a variation on legal origin as an instrumental variable, Levine (1999) uses the legal variables identified by La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1998), legal treatment of creditors, legal system efficiency and the comprehensiveness and quality of information disclosed in corporate annual reports as variables to establish that there is a positive link between these variables and financial development and ultimately economic growth.

Jeanneney, Hua and Liang (2006) uses a panel dataset for 29 Chinese provinces over the period 1993 to 2001 and applying Generalized Method of Moment (GMM) system estimation to investigate the impact of financial development on productivity growth in China and found that financial development has significantly contributed to China's productivity growth, mainly through efficiency.

I terms of time-series studies, Neusser and Kugler (1998) used measures of the value-added provided by the financial system instead of simple measures of the size of the financial system to find that finance boosts growth. With regards to industry level studies, Rajan and Zingales (1998) find that an increase in financial development disproportionately boosts the growth of industries that are naturally heavy users of external finance. Similarly Demirgüç-Kunt and

Maksimovic (1998) show that industries that are naturally composed of smaller firms grow faster in countries with better-developed financial systems. Arizala, Cavallo and Galindo (2009) estimates the impact of financial development on industry-level TFP growth using a panel of 77 countries with data for 26 manufacturing industries for the years 1963 to 2003 and found a significant relationship between financial development and industry-level TFP, i.e., TFP growth can accelerate up to 0.6 percent per year, depending on the external finance requirement of industries. Firm-level studies by Demirgüç-Kunt and Maksimovic (1998) show that the proportion of firms that grow at rates exceeding the rate at which each firm can grow with only retained earnings and short-term borrowing is positively associated with stock market liquidity and banking system size. Finally, in examining the individual regions of Italy, as part of a case study, Guiso, Sapienza and Zingales (2002) find that local financial development (i) enhances the probability that an individual starts a business, (ii) increases industrial competition and (iii) promotes the growth of firms.

However, for the financial sector to play its catalytic role in econoic growth, it should be underpinned by the appropriate institutional environment. In this reagrd, the central element of the Acemoglu, Johnson and Robinson (2004) thesis is that economic institutions are the fundamental cause of long run growth. Many other authors have used this thesis to concentrate on emphasising the importance of institutions for economic growth and the development of financial markets. Most notably, Knack and Keefer (1995) study the impact of property rights on economic growth by using indicators provided by two country risk evaluators [International Country Risk Guide (ICRG) and Business Environmental Risk Intelligence (BERI)] to potential foreign investors. The indicators used from the ICRG (expropriation risk, quality of bureaucracy, rule of law, and repudiation of contracts by government) and the indicators used from the BERI (contract enforceability, infrastructure quality, nationalisation potential, and bureaucratic delays), include evaluations of contract enforceability and risk of expropriation. Because of strong correlations among the separate indicators of the two evaluators, with the consequent risk of multicollinearity and in order to avoid omitting any of them from the equation, the ICRG variables and the BERI variables have been aggregated to form an ICRG index and BERI index of security of contractual and property rights. Knack and Keefer (1995) used the two indices to provide additional insights into the sources of growth and their ability to explain investment. Focusing on growth between 1974 and 1989 and using growth regressions and Ordinary Least Squares (OLS), they find that the two indices are statistically and economically more significant is explaining growth and investment. This is in contrast to earlier proxies for institutions such as frequencies of revolution, coups, political assassinations,

or political violence. Furthermore, it was established that institutions that protect property rights are crucial to economic growth and to investment and that property rights affects not only the magnitude of investment, but also the efficiency with which inputs are allocated.

In addition, other authors such as Johnson, McMillian and Woodruff (2002) use the recent experience in Eastern Europe and the former Soviet Union as an experiment, i.e., country case studies find that weak property rights discourage firms from reinvesting their profits, even when bank loans are available. Their data is secured from a 1997 survey of recently formed and relatively small manufacturing firms in five transition countries: Poland, Romania, Slovakia, Ukraine, and Russia. As an outcome variable they focus on the amount entrepreneurs chose to reinvest out of their profits. They find that those entrepreneurs with the least secure property rights invest nearly 40 percent less of their profits than those with the most secure property rights. Furthermore, Classens and Laeven (2003) use industry-specific and country-specific data for 45 countries, with their growth regression done for the period 1980 to 1989 to indicate that in countries with more secure property rights, firms might allocate resources better and consequentially grow faster as the returns on different types of assets are more protected against competitors' actions. This essay therefore uses Property Rights as an important proxy for quality institutions, while also using Government Effectiveness, Political Stability and Absence from Violence and Terrorism and Regulatory Quality.

To allow quality institutions and financial development to be estimated as part of TFP in establishing its impact on the TE in SSA (given their impact on economic growth), this study uses Stochastic Frontier Analysis (SFA). This empirical technique evolved as a further methodology to decompose TFP to adequately reflect the contribution of other factors to output growth that includes quality institutions and financial development. In this regard, Makiela (2014) indicates that the established growth literature uses a one-stage decomposition of output growth. The more advanced methodology that emerged, i.e., Frontier Analysis (FA), subsequently used a two-stage decomposition of output growth. Thus, in addition to the traditional production factors (e.g., physical capital and labour), FA further decomposes TFP into Technical Efficiency (TE) and Technical Change (TC) or progress. This two-stage decomposition of output growth assists to further enhance the understanding of which components are relatively more important in determining output growth.

This framework was first used in the context of a frontier analysis by Färe, Grosskopf, Norris, and Zhang (1994), who use Data Envelopment Analysis (DEA) to analyse economic growth of

selected countries. Given the perceived limitation of DEA due to the linear function which significantly constraints the analysis, Koop, Osiewalski and Steel (1995) developed a stochastic frontier framework, i.e., using Stochastic Frontier Analysis (SFA) to derive the components of output growth. This essay will follow more recent contributions in using SFA as the prefered method for decomposing output growth to estabish the technical efficiency in Sub-Saharan Africa.

2.3. Methodology

2.3.1. Empirical Specification and Research Technique

The use of SFA as the preferred methodology for this essay brings with it a confusion around the different concepts it entails, i.e., productivity (TFP) vs. efficiency. In this regard, Coelli, Prasada Rao, O'Donnell, and Battese (2005) indicate that, although they are not precisely the same, productivity and efficiency have often been used interchangeably. To avoid any confusion, the two concepts can be differentiated by using a production frontier, which represents the maximum output that a firm can generate from each level of input. It should be noted that "firm" is usually a proxy for any production unit, e.g., it may be a country, as is the case here (17 SSA countries). Thus, firms in a particular industry operate either on the frontier, if they are Technically Efficient (TE), or beneath the frontier, if they are not.

According to Farrell (1957), TE reflects the ability of a firm to minimize input use to produce a given amount of output. On the Cartesian plane, productivity is measured by a ray (with a slope of y/x) through the origin and a particular data point on or below the production frontier. If a firm operating at a point below the production frontier were to move to a technically efficient point on the production frontier – i.e., to a point with the same input, but higher output – the slope of the ray would be greater, implying higher productivity at the point on the frontier. If a firm were to move further to a point where the slope of the ray is tangent to the production frontier – the slope of the ray would be greater and defines a point of maximum possible productivity. The implication is that a firm may be technically efficient, but may still be able to improve its productivity by exploiting scale economies, as reflected in Figure 2.2 in the Appendix.

Farrell (1957) introduces the basic framework for studying and measuring inefficiency, which is defined as the deviations of actual from "optimum behaviour." Frontier Analysis establishes the optimum benchmark against which deviations are calculated. The estimation of efficiency

can be categorised according to the assumptions and techniques used to construct the efficient frontier. Accordingly, the literature distinguishes between two major concepts used for measuring this frontier function: non-parametric and parametric approaches. Fiorentino, Karmann and Koeter (2006), Kiyota (2011) and Kaparakis, Miller and Noulas (1994), and others, outline the two approaches as follows.

The non-parametric approach, i.e., Data Envelopment Analysis (DEA), was introduced by Charnes, Coopers and Rhodes (1978) and consists of estimating the frontier by using linear programming to calculate piecewise linear segments of the efficient frontier, as reflected in Figure 2.3 in the Appendix. It neither imposes any assumptions about functional form of the frontier nor any distributional assumptions about inefficiency. Its main disadvantage lies in the fact that it is unable to decompose the deviations of a certain firm from the efficient production frontier into components: inefficiency and random error parts. This entirely deterministic construction of the frontier attributes the entire difference between an inefficient observed firm and an efficient reference firm on the frontier exclusively to inefficiency.

The parametric approach, i.e., Stochastic Frontier Analysis (SFA), was developed (independently) by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) and estimates the frontier with statistical methods, as reflected in Figure 2.4 in the Appendix. It imposes an explicit functional form for both the frontier and deviations from it that is inefficiency. SFA is considered to be more sophisticated compared to DEA, as the estimation of efficiency is based on economic optimisation, given the underlying assumption of a stochastic optimal frontier. It allows for incorporating technical efficiencies and decomposes random error terms and the inefficiency of the production unit and takes into account the existence of exogenous shocks or statistical noise. As mentioned earlier, this is the preferred method of this essay, given its advantages over DEA.

The general stochastic production frontier model used by this essay has as its main focus the decomposition of TFP to obtain an estimator for one of its constituent parts, i.e., Technical Efficiency (TE). The other component of TFP is Technical Change (TC), which is depicted by a time trend and interactions of the regressors with time. The early studies on SFA used cross-section data, with later studies employing panel data. Coelli, Prasada, O'Donnell, and Battese (2005) indicate that the use of panel data allowed authors such as Kumbhakar (1990) and Battese and Coelli (1992) to include time-varying inefficiency.

In line with these later authors, this essay uses panel data to construct the frontier production function as

$$Y_{it} = X_{it}\beta + v_{it} - u_{it}, \quad \textbf{(2.1)}$$

where Y_{it} presents the output of country i at time t; X_{it} is a vector containing the production inputs; β is a vector of unknown parameters; v_{it} is a symmetric random error to account for statistical noise; and u_{it} is a non-negative random variable associated with technical inefficiency.

Coelli, Prasada Rao, O'Donnell, and Battese (2005) indicate that the model defined by (2.1) is called a stochastic frontier production function because the output values are bounded from above by the stochastic (i.e., random) variable $\exp(X_{it}\beta + v_{it})$. The random error v_{it} can be positive or negative and so the stochastic frontier outputs vary about the deterministic part of the model, i.e., $\exp(X_{it}\beta)$, as reflected in Figure 2.4 in the Appendix.

Thus, if there are no inefficiency effects (i.e., if $u_{it} = 0$) the frontier output of a country can lie above the deterministic part of the production frontier if the noise effect is positive (i.e., $v_{it} > 0$) (i.e., $Y_{it} > \exp(X_{it}\beta)\ iff\ \varepsilon_{it} \equiv v_{it} - u_{it} > 0$), while the frontier output of a country can lie below the deterministic part of the frontier if the noise effect is negative (i.e. $v_{it} < 0$) (i.e. $Y_{it} < \exp(X_{it}\beta)\ iff\ \varepsilon_{it} \equiv v_{it} - u_{it} < 0$). Furthermore, Technical Efficiency (TE), which is the ratio of observed output to the corresponding stochastic frontier output, is denoted by $\exp(-u_{it})$ and is derived as follows:

$$TE_{it} = \frac{Y_{it}}{\exp(X_{it}\beta + v_{it})} = \frac{\exp(X_{it}\beta + v_{it} - u_{it})}{\exp(X_{it}\beta + v_{it})} = \exp(-u_{it}). \quad \textbf{(2.2)}$$

This measure of TE takes a value between zero and one and measures the output of country i at time t relative to the output that could be produced by a fully-efficient country using the same input vector. In order to estimate the parameters of the stochastic production frontier model (2.1), given the two random terms, Aigner, Lovell and Schmidt (1977) obtained Maximum Likelihood (ML) estimates under the assumptions of:

$$v_i \sim iidN(0, \sigma_v^2) \text{ (normal random), and} \quad \textbf{(2.3)}$$

$$u_i \sim iidN^{+}(0, \sigma_u^2) \text{ (half-normal random).} \quad \textbf{(2.4)}$$

It is assumed that the countries in SSA produce output using physical capital, labour and human capital according to a simplified translog production function, i.e., the transformation of model (2.1) to a translog production function:

$$InY_{it} = \alpha_0 + \alpha_1 InK_{it} + \alpha_2 InL_{it} + \alpha_3 InHC_{it} + \alpha_4 TInK_{it} + \alpha_5 TInL_{it} + \alpha_6 TInHC_{it} + \alpha_7 T + \alpha_8 T^2 + \alpha_9 D + v_{it} - u_{it}, \quad \textbf{(2.5)}$$

where for country i at time t, Y is output, K is capital, L is labour, HC is human capital, T is a time trend to account for Technical Change TC, D is a dummy variable (2009^{+}) to account for the financial crisis in 2008, v is a random error that accounts for statistical noise, and u is a non-negative random variable associated with technical inefficiency.

This essay assumes that a SSA country's distance to the best practice output level is a function of its level of financial development and quality of institutions. Financial development is reflected by a measure of Banking Development (BD) captured by Private Capital (PC) and Stock Market Development (SMD) captured by Market Capitalisation Ratio (MCR), Shares Traded Ratio (STR) and Turnover Ratio (TR). Institutional Quality (IQ) is captured by Property Rights (PR), Government Effectiveness (GE), Political Stability and Absence of Violence and Terrorism (PSAVT), and Regulatory Quality (RQ) that reflects legal, political and economic institutions. The hypothesis is that financial development (i.e., BD and SMD), captured by financial centres as the highest form of financial innovation in the financial sector, positively affects the technical efficiency in SSA through the channel of institutions (i.e., PR, GE, PSAVT, and RQ).

However, based on data availability, two indexes [Financial Institutions Index (FII)] and [Financial Markets Index (FMI)], developed by the International Monetary Fund (IMF), are used to capture Banking Development (BD) and Stock Market Development (SMD), respectively for the SSA countries that are host to Financial Centres (FC). These indexes capture BD (using Private Capital as a variable) as part of the FII and SMD (using Market Capitalisation Ratio, Shares Traded Ratio and Turnover Ratio) as part of the FMI.

The two sets of Financial Development (FD) indicators (BD and SMD) used by this essay are in line with empirical studies relating to, amongst others, the economic institutions theory. It should be noted that the majority of the cross-country and panel data studies focus on financial intermediaries (banking) as representative of the financial system. It is only Levine and Zervos (1998) that incorporates financial markets (stock exchanges), in addition to banking, as representative of the financial system. As this essay focuses on Financial Centres (FCs), i.e.,

hosts to stock exchanges, the two sets of FD indicators (BD and SMD) are used in the analyses, in line with Levine and Zervos (1998).

Banking Development (BD), denoted by Private Capital (PC), is credit to private enterprises divided by GDP. Although Baltagi, Demitriades and Law (2007), Law and Demitriades (2005) and others use liquid liabilities and domestic credit as additional indicators of BD, this essay focuses on PC, as the relevance of the two other variables is questioned. In this regard, Baltagi, Demitriades and Law (2007) indicate that liquid liabilities measure the ability of banks to mobilise funds or the size of the banking system relative to the economy, but the funds are not always used to finance new entrepreneurs, while domestic credit comprises private credit as well as credit to government; thus, it is probably the least well suited to capture financial development.

Stock Market Development (SMD) is captured by three proxies: (i) Market Capitalisation Ratio (MCR), which equals the value of listed domestic shares on domestic exchanges divided by GDP. It measures the size of the stock market, with the assumption that overall market size is positively correlated with the ability to mobilise capital and diversify risk on an economy-wide basis. Thus, according to Schmiedel (2001) and others, as larger exchanges have a better ability to manage exchanges operations, a negative relationship between exchange size and inefficiency would be intuitive. (ii) Shares Traded Ratio (STR), which equals the value of shares traded on domestic stock exchanges divided by GDP. It measures trading volume as a share of national output and should therefore positively reflect liquidity on an economy-wide basis, i.e., it captures trading relative to the size of the economy (Law and Demetriades, 2005). (iii) Turnover Ratio (TR), which equals the value of total shares traded, divided by market capitalisation. It measures trading relative to the size of the stock market, i.e., reflecting liquidity of the stock market (Chinn and Ito, 2005). Table 2A.3 in the Appendix provides an overview of the descriptions of the variables that underpin financial development.

The institutional quality variable PR is the property rights component, which is an assessment of the ability of individuals to accumulate private property, secured by clear laws that are fully enforced by the state and is positively associated with financial development (Beck, Demirgüç-Kunt and Levine, 2003). PSAVT measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism, with a positive correlation found between political stability and financial development (Law and Azwan-Saini, 2008). GE captures perceptions of the quality of public services, the quality of the civil service and the

degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. It has been shown that GE has the highest correlation with private sector credit and stock market capitalisation (Baltagi, Demitriades and Law, 2007). In terms of RQ, competition in the financial system is often a desirable feature because it normally leads to increased institutional efficiency, lower costs for clients, and improvements in the quality and range of financial services provided. An expansion in available financial market instruments will increase competition by expanding the available sources of financial services that consumers can access. Ease of entry into the system could be judged by looking at the regulatory and policy requirements, i.e., Regulatory Quality (RQ) (Chinn and Ito, 2005). Table 2A.3 in the Appendix provides an overview of the descriptions of the institutional quality variables.

Based on the variables identified above, the essay estimates a stochastic frontier where the technical inefficiency component u_{it} of equation (2.5) is modelled according to four specifications relating to the financial development variables, FII and FMI, entered individually and in interaction with each of the four institutional quality variables, PR, GE, PSAVT, and RQ, as reflected as follows:

$$u_{it} = \delta_0 + \delta_1 FII + \delta_2 FMI + \delta_3 PR + \delta_4 FII.PR + \delta_5 FMI.PR + \omega_{it} \quad \textbf{(2.6)}$$

$$u_{it} = \delta_0 + \delta_1 FII + \delta_2 FMI + \delta_3 GE + \delta_4 FII.GE + \delta_5 FMI.GE + \omega_{it} \quad \textbf{(2.7)}$$

$$u_{it} = \delta_0 + \delta_1 FII + \delta_2 FMI + \delta_3 PSAVT + \delta_4 FII.PSAVT + \delta_5 FMI.PSAVT + \omega_{it} \quad \textbf{(2.8)}$$

$$u_{it} = \delta_0 + \delta_1 FII + \delta_2 FMI + \delta_3 RQ + \delta_4 FII.RQ + \delta_5 FMI.RQ + \omega_{it} \quad \textbf{(2.9)}$$

This is similar to Garzarelli, Limam and Rossi (2014) that use a stochastic frontier to estimate the technical efficiency in SSA in relation to three economic variables (i.e., education, government spending and trade openness) and three governance variables (i.e., government effectiveness, political stability and requlatory quality).

Four versions of equation (2.5) were estimated for the 17 SSA countries that are host to FCs over the 2002-2017 period. The initial identified period was 1999-2013, but data availability required a revision of the period. Data availability has also resulted in Cabo Verde, Sudan and Zimbabwe being removed from the list of 20 SSA countries that are host to FCs, which is reflected in Table 2.2. Technical inefficiency was accordingly modelled as reflected in equations (2.6), (2.7), (2.8), and (2.9).

Table 2.2: SSA - Financial Centres (FC)

No.	Country Name	Country Code
1	Botswana	BWA
2	Cote d'Ivoire	CIV
3	Cameroon	CMR
4	Ghana	GHA
5	Kenya	KEN
6	Mozambique	MOZ
7	Mauritius	MUS
8	Malawi	MWI
9	Namibia	NAM
10	Nigeria	NGA
11	Rwanda	RWA
12	Sudan	SDN
13	Eswatini	SWZ
14	Tanzania	TZA
15	Uganda	UGA
16	South Africa	ZAF
17	Zambia	ZMB

All the unknown parameters in model (2.5) are estimated in a single-stage Maximum-Likelihood (ML) procedure, promoted by Coelli, Prasada Rao, O'Donnell, and Battese (2005) and using FRONTIER, a computer programme for SFA, developed by Coelli (1996), specifically for the measurement of efficiency and/or productivity. Coelli (1996) indicated that FRONTIER considers two primary model specifications (i) an error components specification with time-varying efficiencies permitted, proposed by Battese and Coelli (1992) and (ii) a model specification in which the firm (country) effects are directly influenced by a number of variables (i.e., institution and financial development), proposed by Battese and Coelli (1995).

This essay considers the latter model specification of Battese and Coelli (1995) that is expressed as:

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it}) \qquad ,i = 1, \dots, N, t = 1, \dots, T, \tag{2.10}$$

where Y_{it} is the logarithm of the production of country i at time t; X_{it} is a $kx1$ vector of input quantities (capital, labour and human capital) of country i at time t; β is a vector of unknown parameters; the V_{it} are random variables assumed to be $iid.N(0, \sigma_{V^2})$ and independent of the U_{it} which are non-negative random variables (e.g., financial development for the current essay)

assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the $N(M_{it}, \sigma_{U^2})$ distribution; where:

$$M_{it} = Z_{it}\delta, \tag{2.11}$$

where Z_{it} is a $px1$ vector of variables (institutions and financial development in the current essay) which may influence the efficiency of a country; and δ is a $1xp$ vector of parameters to be estimated (Coelli, 1996).

2.3.2. Data

Data on *Y* (output), *K* (capital), *L* (labour), and *HC* (Human Capital) is obtained from the Penn World Table 9.1 (Feenstra, Inklaar and Timmer, 2015), which is proxied by *rgdpna* [real GDP at constant 2011 national prices (in mil. 2011US$)], *rnna* (Capital stock at constant 2011 national prices (in mil. 2011US$)], *emp* [number of persons engaged (in millions)], and *hc* [human capital index, based on years of schooling and returns to education]. This is in line with the study by Garzarelli, Limam and Rossi (2014) that focused on public governance in relation to the technical efficiency in SSA. Eswatini is ranked the lowest with regards to GDP and labour, while Rwanda is ranked lowest for capital and Mozambique for human capital. Nigeria is ranked highest with regards to GDP and labour, while South Africa is ranked highest for capital and Botswana for human capital.

As mentioned earlier, data for BD and SMD were obtained by using the Financial Institutions Index (FII) and Financial Markets Index (FMI) of the IMF, which are relative rankings of countries (between 0 for lowest and 1 for highest) on the depth, access and efficiency of their financial institutions and financial markets. Thus, for the FII, data on credit to the private sector in percent of GDP [Private Capital (PC)] is used for the depth of banking development. In the case of the FMI, stock market capitalisation to GDP [Market Capitalisation Ratio (MCR)] and stocks traded to GDP [Shares Traded Ratio (STR)] are used as an indication of the depth of a country's financial market and data on stock market turnover ratio (stocks traded to capitalisation) [Turnover Ratio (TR)], is used as an indication of the efficiency of a financial market. As is expected, South Africa is ranked highest for both banking development (FII) and stock market development (FMI), while Malawi is ranked lowest for banking development and Sudan for stock market development.

Variables on institutional quality, PR is obtained from the Heritage Foundation and GE, PSAVT and RQ are obtained from the World Governance Indicators. The score for PR ranges between 100 (high) to 0 (low), while it ranges from approximately -2.5 (weak) to 2.5 (strong) for GE, PSAVT and RQ. Cote d'Ivore is ranked the lowest with regards to PR, while Sudan is ranked lowest for GE, PSAVT and RQ. Botswana is ranked highest for PR, Mauritius for GE and RQ and Namibia for PSAVT. Table 2.3 summarises the statistics for all the variables.

Table 2.3: Data Description - Financial Development

Variable	Minimum		Maximum		Mean	Median	Standard Deviation
Y	Eswatini	6.28	Nigeria	1.014	125	47	214
K	Rwanda	11.18	South Africa	2.592	393	155	586
L	Eswatini	0.25	Nigeria	65.16	10.10	7.06	11.89
HC	Mozambique	1.14	Botswana	2.89	1.94	1.88	0.42
FII	Malawi	0.11	South Africa	0.74	0.29	0.22	0.16
FMI	Sudan	0.000	South Africa	0.501	0.085	0.034	0.117
PR	Cote d'Ivore	20.00	Botswana	75.00	40.61	30.00	13.63
GE	Sudan	-1.53	Mauritius	1.06	-0.40	-0.55	0.60
PSAVT	Sudan	-2.67	Namibia	1.20	-0.39	-0.22	0.96
RQ	Sudan	-1.56	Mauritius	1.13	-0.31	-0.42	0.57

Notes: Y and K are in US$ billions. L is the labour force in millions. HC is Human Capital Index, based on years of schooling and returns to education. Financial Institutions Index (FII), ranging between 1 (high) and 0 (low), on the depth, access and efficiency of a country's financial institutions. Financial Markets Index (FMI), ranging between 1 (high) and 0 (low), on the depth, access and efficiency of a country's financial market. PR is the property rights component, ranging between 100 (high) to 0 (low). GE, PSAVT, and RQ ranges from approximately -2.5 (weak) to 2.5 (strong) for Government Effectiveness, Political Stability and Absence from Violence and Terrorism and Regulatory Quality. Number of countries N = 17

2.4. Results

2.4.1. Hypothesis Testing

As stochastic frontier analysis requires a series of statistical tests, two hypothesis tests were performed to establish the appropriateness of some of the test procedures. First, based on the existence of the inefficiency component, u_{it}, it was tested whether an OLS rather than stochastic frontier estimation better represent the data. This entailed testing the null hypothesis that the frontier coefficients are jointly insignificant against the alternative hypothesis that at least one of the coefficients is significant, i.e., testing $H_0: \gamma = u = 0$. The results show that the H_0 is strongly rejected in all four specifications, which specify that frontier is a better estimation technique than OLS.

Second, it was checked whether a translog production function fits the data better than a Cobb-Douglas production function, i.e., testing whether we can reject $H_0: \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$. The results in Table 2.4 denote that in all four specifications, the null hypothesis is rejected, which indicates that the translog specification is a better fit than the Cobb-Douglas specification.

Table 2.4: Hypothesis Testing - Financial Development

Specification	Null Hypothesis Testing		LR	Critical Value	Degrees of Freedom	Decision at 5% Significance
I	SF versus OLS:	$H_0: \gamma = u = 0$	259.47	14.067	7	Reject
	Cobb Douglas versus Translog:	$H_0: \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$	123.79	11.070	5	Reject
II	SF versus OLS:	$H_0: \gamma = u = 0$	315.86	14.067	7	Reject
	Cobb Douglas versus Translog:	$H_0: \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$	75.01	11.070	5	Reject
III	SF versus OLS:	$H_0: \gamma = u = 0$	358.48	14.067	7	Reject
	Cobb Douglas versus Translog:	$H_0: \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$	51.66	11.070	5	Reject
IV	SF versus OLS:	$H_0: \gamma = u = 0$	355.43	14.067	7	Reject
	Cobb Douglas versus Translog:	$H_0: \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$	90.07	11.070	5	Reject

Notes: LR, Likelihood Ratio; SF, Stochastic Frontier; OLS, Ordinary Least Squares

2.4.2. Empirical Results

Table 2.5 summarises the technical efficiency scores obtained from the four specifications. The scores for the top two and bottom two countries are reflected, with more detailed results on per country technical efficiency reflected in Table 2A.4 in the Appendix. Results show that the average technical efficiency for the 17 SSA countries from the four specifications is of the order 0.66, indicating that on average countries register more than 65 percent of the efficiency of the most efficient country. The mean and standard deviation (20 percent deviation from the mean) reflects stable efficiency scores for the countries and across the four specifications. Ghana, Malawi and Tanzania are consistently ranked the least efficient, while South Africa, Mauritius and Namibia are the highest ranked. It should be noted that although both the low and top countries' efficiencies widely deviate from the mean, the skewness is in favour of the top performing countries.

Table 2.5: Technical Efficiency Ranking 2002-2017 – Financial Development

Specification	Two Lowest Efficiencies		Two Highest Efficiencies		Mean	Standard Deviation
I	Tanzania	0.4185	Mauritius	0.9325	0.6751	0.1936
	Ghana	0.3621	South Africa	0.9303		
II	Tanzania	0.4274	South Africa	0.9605	0.6569	0.2149
	Ghana	0.3601	Namibia	0.9465		
III	Malawi	0.4231	South Africa	0.9505	0.6902	0.2094
	Ghana	0.3647	Namibia	0.9339		
IV	Tanzania	0.4348	South Africa	0.9701	0.7084	0.2166
	Ghana	0.3654	Namibia	0.9522		

In the group of 17 SSA countries that are host to a FC, macroeconomic indicators seem to validate the efficiency scores of Ghana, Malawi and Tanzania (lowest efficiency) being consistently ranked lower than South Africa, Mauritius and Namibia (highest efficiency).

In the case of Tanzania, poverty, inequality and youth unemployment is persisting, despite recent robust growth, which averaged 6 to 7 percent a year over the last decade. In this regard, the key challenges facing Tanzania that impact on its low efficiency score are low total factor productivity growth, a substantial infrastructure deficit, a lack of access to the development finance required to bridge this infrastructure gap, and a skills mismatch in the labour market.[4] This is reflected in its low ranking on the Human Development Index (FDI)[5] (159 out of 189 countries). In addition, the Worldwide Governance Indicators (WGI)[6] of the World Bank, highlight that Tanzania has either deteriorated or has been stagnant in all governance indicators between 2012 and 2017 (except for control of corruption), with the strongest decline in voice and accountability, political stability/violence and rule of law, i.e., weak institutional quality.

According to the World Bank, Malawi remains one of the poorest countries in the world despite making significant economic and structural reforms to sustain economic growth, which was 4.4 percent in 2019, a marked increase from 3.5 percent in 2018. A key challenge that impacts on its low efficiency score, is the corruption levels that remain high, with Transparency International ranking Malawi 123 out of 180 economies in 2019.[7] Further challenges are its low infrastructure development, low manufacturing base and low adoption of new technology. In addition, since 2016, fiscal slippages have exacerbated the fiscal deficit, with the debt-to-GDP ratio rising from 30 to 62 percent between 2013 and 2019.[8] This can be seen in its macroeconomic stability ranking of 122 out of 141 countries, a sub-index of the Global Competitiveness Index[9]. In addition, the lack of skilled workers in Malawi makes the labour market dysfunctional and can be seen in its low Human Development Index (HDI)[10] ranking of 172 out of 189 countries globally in 2018.

As with Tanzania and Malawi, Ghana's high growth momentum since 2017 has consistently placed it among Africa's 10 fastest-growing economies.[11] However, as with the two previous countries, Ghana's growth has recently become less inclusive, with high inequality and slower poverty reduction. The World Bank identified increased weaknesses in Ghana's financial sector, over the past years, as a major challenge to economic growth that has also informed its low efficiency ranking. In this regard, the heightened vulnerabilities in the financial sector has

[4] African Economic Outlook (AEO) (2020), available at https://www.afdb.org/en/documents/african-economic-outlook-2020.
[5] UNDP Human Development Report (2019), available at http://hdr.undp.org/sites/default/files/hdr2019.pdf.
[6] World Bank Worldwide Governance Indicators (WGI) available at https://info.worldbank.org/governance/wgi/.
[7] World Bank Malawi Economic Monitor (2019), available at https://openknowledge.worldbank.org/bitstream/handle/10986/31929/Malawi%20Economic%20Monitor%209.pdf?sequence=1&isAllowed=y.
[8] African Economic Outlook (AEO) (2020).
[9] Global Competitiveness Report (2019), available at https://www.weforum.org/reports/how-to-end-a-decade-of-lost-productivity-growth.
[10] UNDP Human Development Report (2019).
[11] African Economic Outlook (AEO) (2020).

resulted in the closure of nine domestically owned universal banks between 2017 and 2018, with low rural access to formal financial accounts.[12] Low human capital is a further challenge, where the IMF noted that despite higher school enrolment, learning outcomes remain below standard, with Ghana comparing poorly in the region on student performance, leading the World Bank to recommend that the education system be reformed and to make teaching more effective.[13] Infrastructure development is another challenge facing Ghana, where the Global Competitiveness Report ranks it 118 out of 141 countries, with the specific areas of concern being electricity access and quality, quality of road infrastructure and efficiency of air transport.[14]

In the case of Mauritius, real GDP growth was moderate yet steady, averaging 3.8 percent during 2015 to 2019, with GDP per capita trending upward, reaching an estimated $10,200 in 2019, the third highest in Africa. These positive growth numbers are attained on the basis of sound macroeconomic and structural policies, which are set to continue.[15] This is reflected in the Global Competitiveness Report where it was identified that Mauritius is well-positioned in terms of institutional quality (29 out of 141 countries), developed social capital (21 out of 141 countries), strong corporate governance (14 out of 141 countries), ICT adoption (43 out of 141 countries), and is one of the most open countries in the world (6 out of 141 countries). Furthermore, Mauritius' high efficiency score is also underpinned by its high level of financial development, where it is ranked 27 out of 141 countries by the Global Competitiveness Report.[16] As in the current study, Mauritius' high efficiency score is also reflected in a study by Garzarelli, Limam and Rossi (2014) on the interaction of public governance (institutional quality) and economic varibales, education, government spending and trade openness.

South Africa's real GDP grew at an estimated 0.7 percent in 2019, down from 0.8 percent in 2018.[17] Despite its low growth path, South Africa, an Upper Middle-Income Country (UMIC), has the highest efficiency score. This is underpinned by the fact that South Africa is a regional financial hub, with the Global Competitiveness Report ranking it at 19 out of 141 countries. South Africa is also identified as having developed one of the most advanced transport infrastructures in the region, with a rank of 45 out of 141 countries, while it is among the top

[12] World Bank Ghana Economic Update (2019), available at http://documents1.worldbank.org/curated/en/395721560318628665/pdf/Fourth-Ghana-Economic-Update-Enhancing-Financial-Inclusion-Africa-Region.pdf.
[13] IMF Ghana Selected Issues Paper (2019), available at https://www.imf.org/en/Publications/CR/Issues/2019/12/18/Ghana-Selected-Issues-Paper-48884.
[14] Global Competitiveness Report (2019).
[15] African Economic Outlook (AEO) (2020).
[16] Global Competitiveness Report (2019).
[17] African Economic Outlook (AEO) (2020).

countries in Africa for market size (ranked 35 out of 141 countries). A further distinguishing factor is South Africa's relatively strong institutional quality, where the country is ranked 55 out of 141 countries.[18] Similar to Mauritius, Garzarelli, Limam and Rossi (2014) also identify South Africa as one of the countries with the highest efficiency in SSA.

The IMF has pointed out that over the last two decades, despite being a small and commodity-dependent economy exposed to external shocks, Namibia's annual per capita GDP growth averaged 2.6 percent. This has been achieved on the basis of a strong institutional and governance framework, among the best-rated in Africa[19] that can be seen in Namibia's high ranking on the Corruption Perception Index in 2019. Namibia was ranked 56 out of 180 countries, stronger than the ranking for South Africa at 70 out of 180 countries.[20] In addition, Namibia has political stability, well-developed transport infrastructure and abundant and diverse natural resources. Furthermore, Namibia has a huge pool of institutional savings that could finance high-return investments to contribute to rapid, inclusive and sustainable growth, i.e., Namibia has a sound financial system.[21] This is reflected in the high ranking from the Global Competitiveness Report for Namibia on financial system (41 out of 141 countries).[22]

Table 2.6 presents the results of the stochastic frontier estimations. For each specification, the first ten lines show the coefficients of the estimated frontiers based on equation (2.5), while the next fifteen lines display the coefficients of the equations explaining technical inefficiency based on specification I, II, III, and IV. The last three rows report the two inefficiency statistics (the inefficiency variance, σ_u^2, and the inefficiency indicator, γ, which measures the percentage of the error term that is explained by inefficiency) and the log-likelihood.

Consistent with expectations, the coefficients of In*K* and In*L* for all four specifications are positive and highly significant, indicating that both physical capital and labour positively impact on output growth. However, the coefficients for In*HC* for the four specifications are negative and significant, against expectations. This may be explained by the fact that for the majority of countries in this sample of SSA countries, there are a lack of skilled workers that make their labour markets dysfunctional, as was highlighted earlier on the factors impacting on the low efficiency scores for Tanzania, Malawi and Ghana.

[18] Global Competitiveness Report (2019).
[19] IMF Namibia Article IV Report (2019, available at https://www.imf.org/en/Publications/CR/Issues/2019/09/12/Namibia-2019-Article-IV-Consultation-Press-Release-and-Staff-Report-48675.
[20] Transparency International Corruption Perception Index (2019), available at https://www.transparency.org/files/content/pages/2019_CPI_Report_EN.pdf.
[21] African Economic Outlook (AEO) (2020).
[22] Global Competitiveness Report (2019).

Table 2.6: Stochastic Frontier and Technical Efficiency Estimation - FD

		Specification			
Parameter	**Variable**	**I**	**II**	**III**	**IV**
α_0	Frontier Intercept	4.1413*	3.4134*	3.2791*	3.6149*
α_1	In*K*	0.5494*	0.6189*	0.6363*	0.5939*
α_2	In*L*	0.4387*	0.4036*	0.3701*	0.4204*
α_3	In*HC*	-0.0937***	-0.2873**	-0.3311*	-0.1849***
α_4	*T*In*K*	0.0146*	-0.0026	-0.0048**	-0.0001
α_5	*T*In*L*	-0.0096*	0.0030	0.0058*	0.0012
α_6	*T*InHC	-0.0135*	0.0367*	0.0443*	0.0280**
α_7	*T*	-0.1704*	0.0133	0.0292	-0.0098
α_8	T^2	0.0011*	-0.0009**	-0.0009**	-0.0010**
α_9	*2009+*	-0.0635*	-0.0219	-0.0110	-0.0082
δ_0	Inefficiency Intercept	3.6980*	2.2926*	0.6526**	2.6407*
δ_1	In*FII*	2.6089*	1.9451*	0.4141**	2.2175*
δ_2	In*FMI*	-0.0895	-0.0977***	-0.0237	-0.0585
δ_3	In*PR*	-1.1638*			
δ_3	In*GE*		-2.6268*		
δ_3	In*PSAVT*			-0.9561*	
δ_3	In*RQ*				-3.0034*
δ_4	In*FIIPR*	-0.9023*			
δ_4	In*FIIGE*		-2.5746*		
δ_4	In*FIIPSAVT*			-1.0553*	
δ_4	In*FIIRQ*				-2.7618*
δ_5	In*FMIPR*	0.0225			
δ_5	In*FMIGE*		0.1311**		
δ_5	In*FMIPSAVT*			0.0606*	
δ_5	In*FMIRQ*				0.0640
σ_u^2	Inefficiency Variance	0.0505*	0.0394*	0.0288*	0.0343*
γ	Inefficiency indicator	1.0000*	0.9318*	0.9025*	0.9173*
Log-Likelihood		91.6318	119.8242	141.1352	139.6119

Notes: * Significant at 1%; ** Significant at 5%; *** Significant at 10%. Number of countries N = 17. Number of periods T = 16.

Except for one that is negative and significant, all coefficients on *T* are not significant. For T^2, the coefficients are all significant, while being positive for specification I and negative for specifications II, III and IV. The indication is that for the coefficients on *T* and T^2 that are negative and significant, it seems to suggest that the technology change for African countries have a negative impact on output.

When interacted with In*K* and In*L*, contrasting results are obtained for the different specifications on the significance of technology, i.e., for both In*K* and In*L* there is one coefficient that is positive and significant, one that is negative and significant and two that are not significant. Thus, for *T*In*K*, technology change interacts with physical capital to generate output growth in specification I, while in specification III it is not capital augmenting. Similarly, for *T*In*L* technology change interacts with labour to generate output growth in specification III, while in specification I it is not labour augmenting.

It is, however, interesting to note that the coefficients for *T*In*HC*, are positive and significant in three of the four specifications. This may indicate that technology [which Garzarelli, Limam and Rossi (2014) identify as mainly imported in the context of developing countries] in combination with human capital has generated output growth. Given the lack of skilled workers that negatively impact on their labour markets, as identified earlier, it is surprising that human capital is able to generate additional output in combination with the imported technology for the sample of SSA countries. One explanation could be that technology in the form of Information and Communication Technology (ICT) plays a significant role in facilitating school enrolment (i.e., human capital development) in SSA countries (Oluwatobi, Olurinola and Taiwo, 2016). This is echoed on a pratical level by Jagannathan (2018)[23] that notes that the spread of new forms of technology-assisted learning and innovative pedagogies are making a real difference in the lives of many Africans. She made the example of agriculture, where mobile phones and other traditional forms of communication, such as radio, have made a big contribution to the spread of training and information about better forms of crop management and animal husbandry, resulting in significantly improved yields in many parts of Africa.

The variable 2009^{+} is a dummy variable to account for the 2008 financial crisis, with the expectation that GDP would be negatively effected during the period after 2008. In a study by Andrieș and Ursu (2016), on the impact of the 2008 financial crisis on the banking efficiency of European banks, the authors established that the financial crisis reduced the GDP in European economies that ultimately impacted on their banking efficiency. Although the coefficient on 2009^{+} is only significant for one of the four specifications, all have a negative sign, confirming the expectation that the 2008 financial crisis should have a negative impact on GDP in SSA countries, in line with the eperience in Euopean countries.

[23] https://blogs.worldbank.org/digital-development/africa-technology-and-human-capital-go-hand-hand

In relation to the coefficients of the technical efficiency components, the coefficients on the Financial Development (FD*)* variables, Financial Institutions Index (*FII*) and Financial Markets Index (*FMI*), show contrasting impacts on efficiency. For banking development (*FII*), all coefficients are positive and significant, implying that banks do not seem to increase efficiency[24], in contrast to the literature that indicates that there is a strong positive relationship between banking development and economic and productive growth (King and Levine, 1993). A possible explanation might be the low Insitutional Quality (IQ) of SSA countries that may prevent banks from mitigating the effects of market frictions (i.e. acquiring information, enforcing contracts and making transactions). In contrast, the coefficients on stock market development (*FMI*) are all negative, while only specification II is significant, indicating that *FMI* seems to increase efficiency. This is consistent with the literature that the initial level of financial market development is positively and significantly related to future rates of economic growth, capital accumulation and productivity growth (Levine and Zervos, 1998).

In order to further examine the effect of FD on technical efficiency, it is analysed whether FD affects technical inefficiency through its interaction with the IQ variables (PR, GE, PSAVT, and RQ). The impact of the IQ variables, on their own, are established first, with the expectation that it would impact positively on efficiency. This is confirmed, as the coefficients for all four specifications are negative and highly significant, supporting the view that IQ increases productive efficiency and supporting the view that the recent drivers of economic growth in Africa have been good institutions.

Given this outcome, it is further expected that the FD variables should perform better when interacted with the IQ variables. Again, the FD variables show a contrasting impact on efficiency. In the case of banking development (*FII*), the coefficients for all four specifications (i.e., the interactions with the four IQ variables) are negative and highly significant. Thus, while banking development (*FII*) seems not to increase efficiency, when interacted with IQ, it seems to increase productive efficiency. However, while stock market development (*FMI*) seems to contribute to efficiency, when interacted with IQ, it does not seem to increase efficiency, as specifications II and III are positive and significant. A possible explanation might be the low level of financial market development for the majority of SSA countries that are host to a stock market, as Tables 2A.1 and 2A.2 in the Appendix highlights.

[24] In SFA, a positive coefficient for an efficiency component indicates a negative effect and vice versa.

The implication is that in SSA countries, as expected, Financial Development (FD) impacts on Technical Efficiency (TE) through Institutions (I). This is in line with authors such as Goldsmith (1969), King and Levine (1993) and Levine and Zervos (1998) that find a positive correlation between financial development and the level of economic growth. Furthermore, as espoused by Acemoglu, Johnson and Robinson (2004) and validated by Knack and Keefer (1995), it is shown that insitutions are the bedrock for the financial sector to play its catalytic role in economic growth. With regards to the debate on which element is more important for financial development, as highlighted by Quennouëlle-Corre (2011: 2), the SSA context has revealed that financial development is underpinned by banking development, rather than stock market development. Thus, while financial market development is seen as at the forefront of innovation within the financial sector and is characterised by highly positive governance environments, it is banking development that is more important than stock market development in contributing to financial development and consequently increases in productive efficiency, in SSA. This is the case, as data from the African Securities Exchange Association (2012) indicated that except for the major stock markets in SSA, e.g., the Johannesburg Stock Exchange (JSE) in South Africa, financial market development in the region (based on size and liquidity) is quite limited.

2.5. Conclusion

This essay validates the hypothesis that financial development (epitomised by financial centres) positively affects the technical efficiency in Sub-Saharan Africa (SSA) through the channel of institutions. Financial centres are identified as host to a stock exchange, with banking as a further measure of financial development. It is recognised that financial centres (characterised by highly positive governance environments in terms of the transparency, impartiality and durability of their institutions) are the highest form of financial innovation in the financial sector. The growth elements in SSA are decomposed through the use of Stochastic Frontier Analysis (SFA) to establish the impact of financial development and institutions on the technical efficiency in SSA. This is to account for the limitations of the standard growth accounting and cross-country analyses of neoclassical and new growth theories that do not adequately clarify the sources of growth and their relative impact.

The data used in this essay is for 17 SSA countries over the period 2002 to 2017 that are host to Financial Centres (FCs). In line with Garzarelli, Limam and Rossi (2014) and others, data on *Y* (output), *K* (capital), *L* (labour), and *HC* (Human Capital) is obtained from the Penn World

Table 9.1. Variables on institutional quality, Property Rights (PR) is obtained from the Heritage Foundation and Government Effectiveness (GE), Political Stability and Absence from Violence and Terrorism (PSAVT) and Regulatory Quality (RQ) are obtained from the World Governance Indicators, in line with Beck, Demirgüç-Kunt and Levine (2003), Law and Azwan-Saini (2008), Baltagi, Demitriades and Law (2007, and Chinn and Ito (2005). However, a limitation of this essay is due to data constraints regarding data for banking development and stock market development as used by authors such as Levine and Zervos (1998). Data was obtained by using the Financial Institutions Index (FII) and Financial Markets Index (FMI) of the International Monetary Fund (IMF), which are relative rankings of countries (between 0 for lowest and 1 for highest) on the depth, access and efficiency of their financial institutions and financial markets. Furthermore, the initial identified period for this research was 1999-2013, but data availability required a revision of the period to 2002 to 2017. Data availability has also resulted in Cabo Verde, Sudan and Zimbabwe being removed from the list of 20 SSA countries that are host to FCs.

The contribution this essay makes to the literature is to further enhance the understanding of the impact of financial development on economic growth, specifically within the context of the banking development and stock market development in SSA. Furthermore, this essay differs from earlier studies by decomposing the growth elements in SSA through the use of Stochastic Frontier Analysis (SFA) as an alternative to the standard growth accounting and cross-country analyses that have been the main empirical techniques employed by neoclassical and new growth theories.

The results confirm that Financial Development (FD) impacts on Technical Efficiency (TE) through Institutions (I). This is in line with King and Levine (1993) that identify a positive relationship between financial development and growth. It also ties in with Acemoglu, Johnson and Robinson (2004) that idenify that economic institutions are the fundamental cause of long run growth. This essay further reveals that banking development (*FII*) does not seem to increase technical efficiency by itself, but when interacted with institutional quality (IQ) it seems to increase technical efficiency. In contrast, stock market development (*FMI*) seems to increase efficiency by itself, but when interacted with institutional quality (IQ) it does not seem to increase technical efficiency. The implication is that, against expectations, banking development is more important than stock market development in contributing to financial development and consequently increases in productive efficiency, in SSA.

Policy makers in SSA should thus ensure an appropriate institutional environment in their countries to allow the financial sector (banks and stock exchanges) to play its catalytic role in facilitating productive efficiency and economic growth. These countries should thus address issues around Property Rights (PR), Government Effectiveness (GE), Political Stability and Absence from Violence and Terrorism (PVAVT), and Regulatory Quality (RQ), as it has been shown that institutions reduce the transaction costs associated with the interaction/relations among individuals (Lal, 1998). Through appropriate institutions, the financial sector is able to reduce the effects of market frictions (i.e., acquiring information, enforcing contracts and making transactions) (Levine, 2004: 5).

However, legal origin, i.e., whether a country's commercial/company law derives from British, French, German, or Scandinavian law tradition shapes national approaches to laws concerning creditors and the efficiency with which those laws are enforced, i.e., legal origin influences the appropriate institutions available in a country (Levine, Loayza and Beck, 2000). Future research should thus consider legal origin in establishing the impact of financial development and institutions on the technical efficiency in SSA. Most African countries obtained their legal systems through occupation and colonisation, with British (common law) and French (civil law) law traditions most previlent.

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2.7. Appendix

Table 2A.1: Financial Development (FD) of Sub Sahara Africa

		2012	2013	2014	2015	2016	2017
Angola	Financial Development Index	0.14	0.15	0.14	0.15	0.16	0.15
	Financial Institutions Index	0.25	0.27	0.25	0.26	0.27	0.27
	Financial Markets Index	0.02	0.02	0.03	0.03	0.04	0.03
Benin	Financial Development Index	0.11	0.13	0.14	0.12	0.13	0.12
	Financial Institutions Index	0.22	0.25	0.27	0.24	0.25	0.23
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Botswana	Financial Development Index	0.27	0.27	0.26	0.27	0.26	0.26
	Financial Institutions Index	0.45	0.44	0.44	0.45	0.44	0.44
	Financial Markets Index	0.08	0.08	0.07	0.08	0.08	0.07
Burkina Faso	Financial Development Index	0.12	0.12	0.13	0.12	0.13	0.13
	Financial Institutions Index	0.23	0.23	0.25	0.24	0.26	0.25
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Burundi	Financial Development Index	0.12	0.13	0.13	0.13	0.14	0.15
	Financial Institutions Index	0.17	0.18	0.17	0.18	0.18	0.20
	Financial Markets Index	0.06	0.08	0.08	0.08	0.09	0.09
Cabo Verde	Financial Development Index	0.25	0.25	0.25	0.25	0.25	0.25
	Financial Institutions Index	0.50	0.50	0.49	0.49	0.49	0.48
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Cameroon	Financial Development Index	0.10	0.11	0.09	0.10	0.10	0.11
	Financial Institutions Index	0.18	0.21	0.18	0.19	0.20	0.21
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Central African Republic	Financial Development Index	0.06	0.06	0.05	0.05	0.05	0.05
	Financial Institutions Index	0.12	0.11	0.11	0.10	0.10	0.10
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Chad	Financial Development Index	0.10	0.10	0.09	0.08	0.09	0.10
	Financial Institutions Index	0.18	0.18	0.15	0.13	0.15	0.16
	Financial Markets Index	0.01	0.01	0.03	0.03	0.03	0.03
Comoros	Financial Development Index	0.05	0.05	0.05	0.05	0.05	0.05
	Financial Institutions Index	0.10	0.10	0.10	0.10	0.11	0.11
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Congo, Democratic Republic of	Financial Development Index	0.04	0.04	0.05	0.05	0.05	0.05
	Financial Institutions Index	0.08	0.08	0.10	0.10	0.09	0.10
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Congo, Republic of	Financial Development Index	0.12	0.12	0.13	0.16	0.16	0.15
	Financial Institutions Index	0.22	0.23	0.24	0.26	0.26	0.25
	Financial Markets Index	0.01	0.01	0.02	0.05	0.05	0.05
Cote d'Ivoire	Financial Development Index	0.14	0.15	0.15	0.16	0.16	0.16
	Financial Institutions Index	0.19	0.20	0.21	0.22	0.23	0.23
	Financial Markets Index	0.09	0.09	0.09	0.09	0.09	0.09
Djibouti	Financial Development Index	0.15	0.14	0.13	0.15	0.16	0.15
	Financial Institutions Index	0.26	0.25	0.24	0.26	0.28	0.29
	Financial Markets Index	0.03	0.03	0.03	0.03	0.02	0.00
Equatorial Guinea	Financial Development Index	0.10	0.10	0.10	0.10	0.11	0.11
	Financial Institutions Index	0.20	0.19	0.19	0.20	0.21	0.21
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Eritrea	Financial Development Index	0.09	0.08	0.08	0.08	0.08	0.08
	Financial Institutions Index	0.17	0.17	0.16	0.16	0.16	0.16
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Ethiopia	Financial Development Index	0.13	0.14	0.14	0.14	0.13	0.12
	Financial Institutions Index	0.25	0.27	0.27	0.26	0.25	0.23
	Financial Markets Index	0.02	0.02	0.02	0.01	0.01	0.01

		2012	2013	2014	2015	2016	2017
Gabon	Financial Development Index	0.11	0.12	0.12	0.13	0.13	0.12
	Financial Institutions Index	0.21	0.22	0.23	0.24	0.24	0.22
	Financial Markets Index	0.00	0.01	0.01	0.01	0.01	0.01
Gambia, The	Financial Development Index	0.10	0.10	0.10	0.10	0.08	0.09
	Financial Institutions Index	0.19	0.19	0.20	0.19	0.15	0.17
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Ghana	Financial Development Index	0.13	0.13	0.14	0.14	0.14	0.15
	Financial Institutions Index	0.20	0.21	0.21	0.21	0.21	0.22
	Financial Markets Index	0.05	0.05	0.06	0.06	0.07	0.06
Guinea	Financial Development Index	0.07	0.07	0.11	0.08	0.11	0.10
	Financial Institutions Index	0.14	0.14	0.21	0.16	0.18	0.18
	Financial Markets Index	0.00	0.00	0.00	0.00	0.03	0.02
Guinea-Bissau	Financial Development Index	0.06	0.07	0.07	0.07	0.10	0.10
	Financial Institutions Index	0.12	0.14	0.14	0.14	0.20	0.20
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Kenya	Financial Development Index	0.18	0.18	0.19	0.19	0.19	0.19
	Financial Institutions Index	0.28	0.28	0.30	0.30	0.29	0.30
	Financial Markets Index	0.07	0.07	0.07	0.07	0.07	0.07
Lesotho	Financial Development Index	0.16	0.17	0.16	0.16	0.14	0.14
	Financial Institutions Index	0.31	0.33	0.31	0.32	0.28	0.27
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Liberia	Financial Development Index	0.16	0.16	0.14	0.11	0.13	0.15
	Financial Institutions Index	0.23	0.26	0.23	0.19	0.22	0.21
	Financial Markets Index	0.09	0.06	0.04	0.03	0.04	0.09
Madagascar	Financial Development Index	0.09	0.09	0.10	0.10	0.10	0.10
	Financial Institutions Index	0.16	0.17	0.19	0.18	0.19	0.20
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Malawi	Financial Development Index	0.10	0.09	0.09	0.09	0.08	0.09
	Financial Institutions Index	0.20	0.18	0.17	0.18	0.16	0.17
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Mali	Financial Development Index	0.11	0.12	0.13	0.13	0.14	0.13
	Financial Institutions Index	0.22	0.23	0.25	0.26	0.28	0.26
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Mauritius	Financial Development Index	0.39	0.40	0.43	0.43	0.42	0.49
	Financial Institutions Index	0.53	0.55	0.56	0.54	0.53	0.51
	Financial Markets Index	0.24	0.24	0.29	0.31	0.29	0.46
Mozambique	Financial Development Index	0.13	0.14	0.14	0.15	0.14	0.12
	Financial Institutions Index	0.23	0.24	0.24	0.25	0.23	0.21
	Financial Markets Index	0.02	0.03	0.03	0.04	0.05	0.03
Namibia	Financial Development Index	0.36	0.36	0.38	0.39	0.40	0.39
	Financial Institutions Index	0.66	0.67	0.68	0.68	0.69	0.68
	Financial Markets Index	0.05	0.04	0.07	0.09	0.10	0.09
Niger	Financial Development Index	0.12	0.12	0.12	0.13	0.13	0.13
	Financial Institutions Index	0.22	0.22	0.22	0.24	0.24	0.24
	Financial Markets Index	0.01	0.01	0.01	0.01	0.01	0.01
Nigeria	Financial Development Index	0.22	0.23	0.23	0.23	0.23	0.23
	Financial Institutions Index	0.23	0.23	0.25	0.24	0.25	0.24
	Financial Markets Index	0.20	0.22	0.21	0.21	0.20	0.21
Rwanda	Financial Development Index	0.09	0.09	0.09	0.10	0.09	0.10
	Financial Institutions Index	0.17	0.17	0.18	0.18	0.18	0.20
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Sao Tome and Principe	Financial Development Index	0.14	0.14	0.14	0.13	0.12	0.12
	Financial Institutions Index	0.27	0.27	0.27	0.26	0.24	0.24
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00

		2012	2013	2014	2015	2016	2017
Senegal	Financial Development Index	0.10	0.10	0.10	0.10	0.11	0.12
	Financial Institutions Index	0.20	0.20	0.19	0.19	0.21	0.23
	Financial Markets Index	0.00	0.00	0.00	0.01	0.01	0.01
Seychelles	Financial Development Index	0.28	0.30	0.30	0.30	0.31	0.32
	Financial Institutions Index	0.55	0.57	0.58	0.58	0.60	0.62
	Financial Markets Index	0.01	0.01	0.01	0.01	0.01	0.01
Sierra Leone	Financial Development Index	0.07	0.05	0.07	0.06	0.07	0.05
	Financial Institutions Index	0.13	0.10	0.13	0.11	0.13	0.10
	Financial Markets Index	0.01	0.01	0.00	0.01	0.01	0.01
South Africa	Financial Development Index	0.57	0.58	0.59	0.61	0.63	0.64
	Financial Institutions Index	0.70	0.70	0.73	0.73	0.74	0.73
	Financial Markets Index	0.41	0.43	0.44	0.47	0.50	0.52
South Sudan	Financial Development Index	0.09	0.07	0.05	0.06	0.06	0.06
	Financial Institutions Index	0.17	0.14	0.10	0.11	0.12	0.12
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Sudan	Financial Development Index	0.09	0.10	0.10	0.11	0.11	0.11
	Financial Institutions Index	0.18	0.19	0.20	0.21	0.21	0.22
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Tanzania	Financial Development Index	0.12	0.12	0.11	0.11	0.11	0.10
	Financial Institutions Index	0.22	0.22	0.21	0.21	0.20	0.19
	Financial Markets Index	0.01	0.01	0.01	0.01	0.02	0.01
Togo	Financial Development Index	0.13	0.13	0.12	0.12	0.17	0.20
	Financial Institutions Index	0.25	0.24	0.21	0.19	0.28	0.30
	Financial Markets Index	0.01	0.01	0.03	0.04	0.06	0.09
Uganda	Financial Development Index	0.10	0.09	0.10	0.10	0.10	0.10
	Financial Institutions Index	0.19	0.18	0.20	0.19	0.20	0.19
	Financial Markets Index	0.00	0.00	0.00	0.00	0.00	0.00
Zambia	Financial Development Index	0.13	0.13	0.11	0.13	0.12	0.13
	Financial Institutions Index	0.22	0.23	0.20	0.22	0.20	0.23
	Financial Markets Index	0.02	0.02	0.02	0.03	0.03	0.03

Note: Financial Development Index (FDI) is a relative ranking, ranging between 1 (high) and 0 (low), of countries on the depth, access, and efficiency of their financial institutions and financial markets. Financial Institutions Index (FII) is a relative ranking, ranging between 1 (high) and 0 (low), of countries on the depth, access, and efficiency of their financial institutions. Financial Markets Index (FMI) is a relative ranking, ranging between 1 (high) and 0 (low), of countries on the depth, access, and efficiency of their financial markets.

Source: IMF

Table 2A.2: SSA - Stock Market Development (SMD) (2012)

Country Name	Country Code	Stock Exchange	Value traded on listed securities (US$) VT	Number of listed companies CL	Market Capitalisation as % of GDP MCR	Turnover Ratio (%) TR
Cabo Verde	CPV	Bolsa de Valores de Cabo Verde	271,933.69	4	3.98	0.71
Botswana	BWA	Botswana Stock Exchange	135,596,597.84	39	23.84	2.71
Cote d'Ivoire	CIV	BRVM	213,025,519.00	66	11.55	2.15
Tanzania	TZA	Dar es Salaam Stock Exchange	278,680,800.00	17	33.4	0.33
Cameroon	CMR	Douala Stock Exchange	135,596,597.84	39	23.84	2.71
Ghana	GHA	Ghana Stock Exchange	54,360,000.00	34	99.74	0.01
South Africa	ZAF	Johannesburg Stock Exchange	408,628,960,228.00	400	229.03	40.93
Sudan	SDN	Khartoum Stock Exchange	698,529,550.00	59	4	9.5
Zambia	ZMB	Lusaka Stock Exchange	68,321,712.93	20	52.79	0.73
Malawi	MWI	Malawi Stock Exchange	16,183,920.00	14	19.63	1.56
Mozambique	MOZ	Mozambique Stock Exchange	60,546,463.29	3	7.39	6
Kenya	KEN	Nairobi Securities Exchange	6,959,390,000.00	60	34.5	6.82
Namibia	NAM	Namibian Stock Exchange	552,264,200.00	32	9.99	1.38
Nigeria	NGA	Nigerian Stock Exchange	4,231,648,476.46	194	21.8	7.32
Rwanda	RWA	Rwanda Stock Exchange	22,783,994.00	4	26	2.2
Seychelles	SYC	Seychelles Securities Exchange	2,587,391.52	4	0.00	0.07
Sierra Leone	SLE	Sierra Leone Stock Exchange	212,020.02	1	5.48	0.06
Mauritius	MUS	Stock Exchange of Mauritius	352,831,646.73	88	63.66	4.97
Uganda	UGA	Uganda Securities Exchange	9,936,234.00	15	26.52	0.17
Zimbabwe	ZWE	Zimbabwe Stock Exchange	448,203,882.00	79	42.83	11.31

Note: VT - Value of listed securities trade. CL - The number of companies listed, reflecting the degree of access to the capital market by new companies. MCR - Measures the size of the stock market and equals the value of listed domestic shares on domestic exchanges divided by GDP. TR - Equals the value of total shares traded divided by market capitalisation, i.e., it measures the volume of domestic equities traded on domestic exchanges relative to the size of the market. The values for 2011 for MCR and TR for Cabo Verde was used as there was no values for 2012. This is also the case for Ghana and Rwanda. It should also be noted that although there were financial centres with data available for 2016, 2012 was selected as the year for comparison, as other financial centres only had data available up to 2012.

Source: African Securities Exchange Association (2012)

Table 2A.3: Variable Description

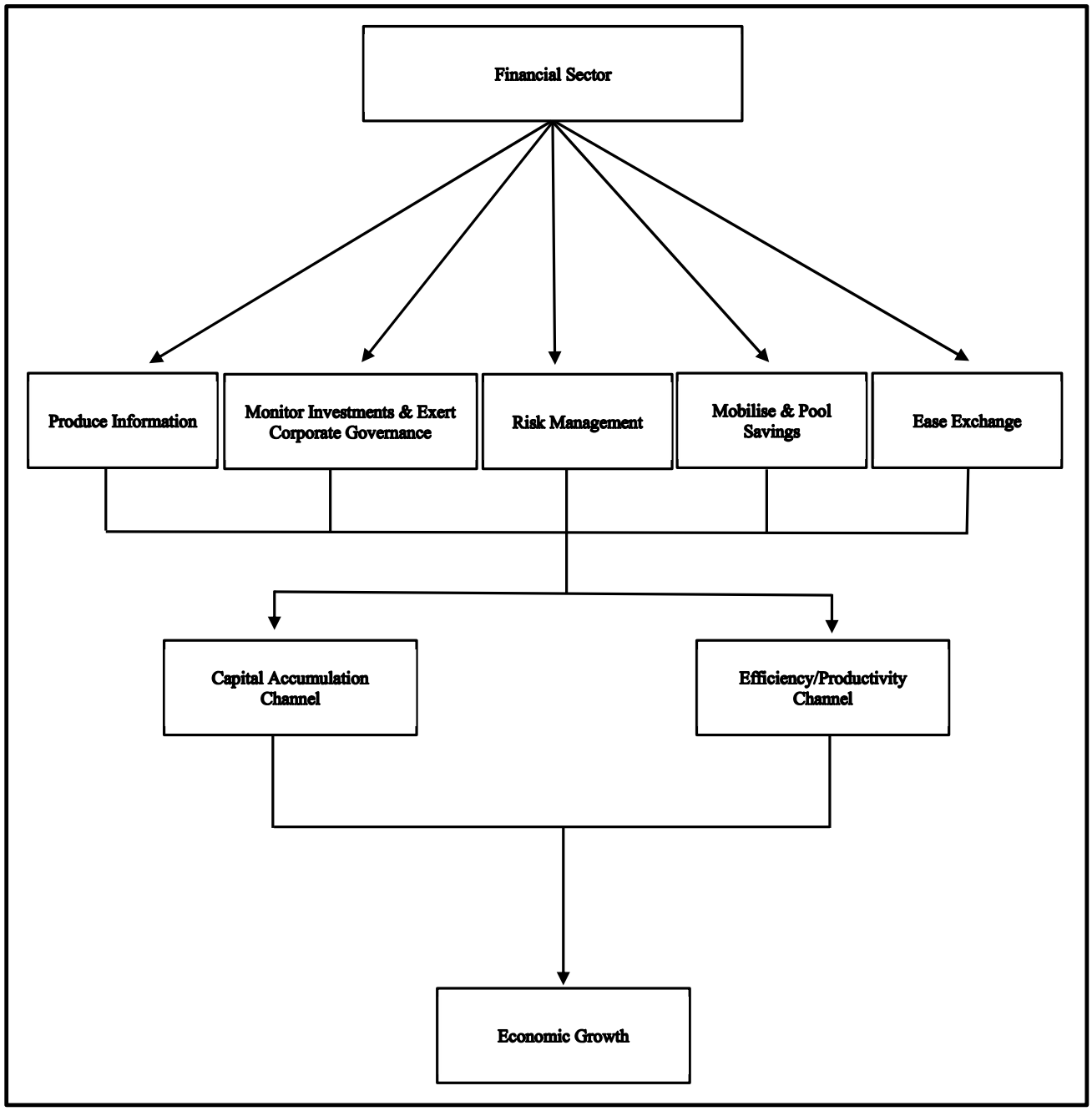
Acronym	Variable Name	Description	Authors	Source
FD	Financial Development	Represent both Banking Development (BD) and Stock Market Development (SMD).		
BD	Banking Development	Represents one banking development indicator.		
PC	Private Capital	Credit to private enterprises divided by GDP.	Beck, Levine and Loayza (2000), Rioja and Valev (2003), Levine (1999), Levine, Loayza and Beck (2000), Levine and Zervos (1998)	World Development Indicators (WDI)
SMD	Stock Market Development	Represents four stock market development indicators.		
MCR	Market Capitalization Ratio	**Size -** Measures the size of the stock market and equals the value of listed domestic shares on domestic exchanges divided by GDP. The assumption behind this measure is that overall market size is positively correlated with the ability to mobilize capital and diversify risk on an economy-wide basis.	Levine and Zervos (1998)	World Development Indicators (WDI)
STR	Shares Traded Ratio	**Liquidity -** Equals the value of shares traded on domestic stock exchanges divided by GDP. STR (Total Value Traded) measures trading volume as a share of national output and should therefore positively reflect liquidity on an economy-wide basis. While STR (Total Value Traded) captures trading relative to the size of the economy, Turnover measures trading relative to the size of the stock market. Thus, a small, liquid market will have high Turnover but small STR (Total Value Traded).	Levine and Zervos (1998)	World Development Indicators (WDI)
TR	Turnover Ratio	**Liquidity -** Equals the value of total shares traded divided by market capitalization, i.e., it equals the value of the trades of domestic shares on domestic exchanges divided by the value of listed domestic shares. Turnover measures the volume of domestic equities traded on domestic exchanges relative to the size of the market. High Turnover is often used as an indicator of low transactions costs. Importantly, a large stock market is not necessarily a liquid market: a large but inactive market will have large Capitalization but small Turnover.	Levine and Zervos (1998)	World Development Indicators (WDI)

Acronym	Variable Name	Description	Authors	Source
IQ	Institutional Quality	Include legal, political and economic institutions.		
PR	Property Rights	The property rights component is an assessment of the ability of individuals to accumulate private property, secured by clear laws that are fully enforced by the state. It measures the degree to which a country's laws protect private property rights and the degree to which its government enforces those laws. It also assesses the likelihood that private property will be expropriated and analyses the independence of the judiciary, the existence of corruption within the judiciary, and the ability of individuals and businesses to enforce contracts. The more certain the legal protection of property, the higher a country's score; similarly, the greater the chances of government expropriation of property, the lower a country's score. Countries that fall between two categories may receive an intermediate score.	Knack and Keefer (1995), Baltagi, Demitriades and Law (2007), Law and Demetriades (2005), and Claessens and Laeven (2003), Law and Azwan-Saini (2008), Law and Demetriades (2005), Claessens and Laeven (2003), Beck, Demirgüç-Kunt and Levine (2003)	The Heritage Foundation
GE	Government Effectiveness	Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e., ranging from approximately -2.5 to 2.5.	Knack and Keefer (1995), Baltagi, Demitriades and Law (2007), Law and Demetriades (2005), Law and Azwan-Saini (2008), Chinn and Ito (2005)	World Governance Indicators (World Bank)
PSAVT	Political Stability & Absence of Violence & Terrorism	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e., ranging from approximately -2.5 to 2.5.	Law and Demetriades (2005), Law and Azwan-Saini (2008), Chinn and Ito (2005)	World Governance Indicators (World Bank)
RQ	Regulatory Quality	Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e., ranging from approximately -2.5 to 2.5.	Law and Demetriades (2005), Law and Azwan-Saini (2008), Chinn and Ito (2005)	World Governance Indicators (World Bank)

Table 2A.4: Country and Technical Efficiency Averages - FD

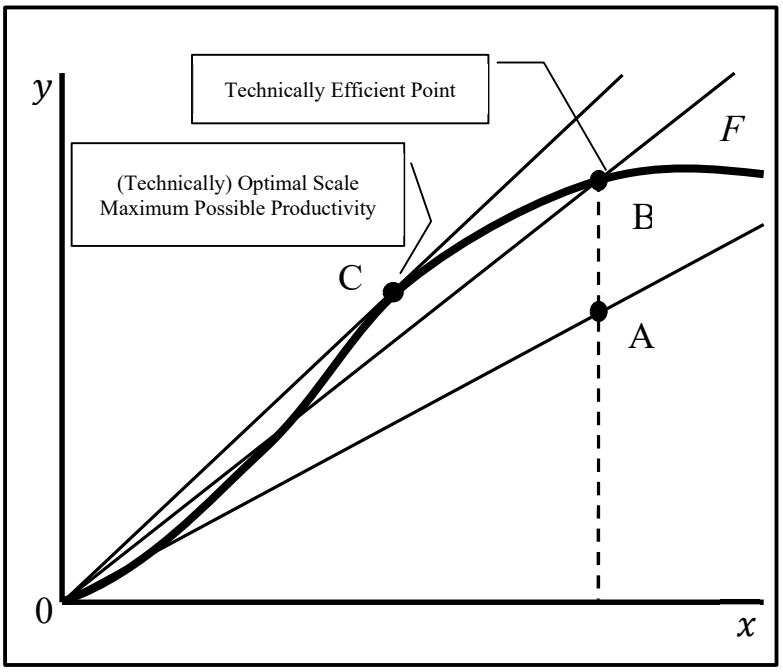
	Specification			
Country	**I**	**II**	**III**	**IV**
Botswana	0.9082	0.9207	0.8977	0.9280
Cote d'Ivoire	0.6542	0.6578	0.6631	0.6684
Cameroon	0.6196	0.5938	0.5927	0.6008
Ghana	0.3621	0.3601	0.3647	0.3654
Kenya	0.6731	0.6119	0.6196	0.6166
Mozambique	0.4932	0.4827	0.4881	0.4913
Mauritius	0.9325	0.9445	0.9211	0.9512
Malawi	0.5063	0.4310	0.4231	0.4385
Namibia	0.8871	0.9465	0.9339	0.9522
Nigeria	0.8810	0.8581	0.8759	0.8719
Rwanda	0.6442	0.5580	0.5624	0.5619
Sudan	0.7496	0.8160	0.8278	0.8318
Swaziland	0.7124	0.7801	0.7566	0.7901
Tanzania	0.4185	0.4274	0.4371	0.4348
Uganda	0.4842	0.4482	0.4582	0.4487
South Africa	0.9303	0.9605	0.9505	0.9701
Zambia	0.4405	0.4376	0.4275	0.4414
Total Average Efficiency	0.6645	0.6609	0.6588	0.6684

Figure 2.1: Channels Through which FD Influence Economic Growth



Source: Levine (2004)

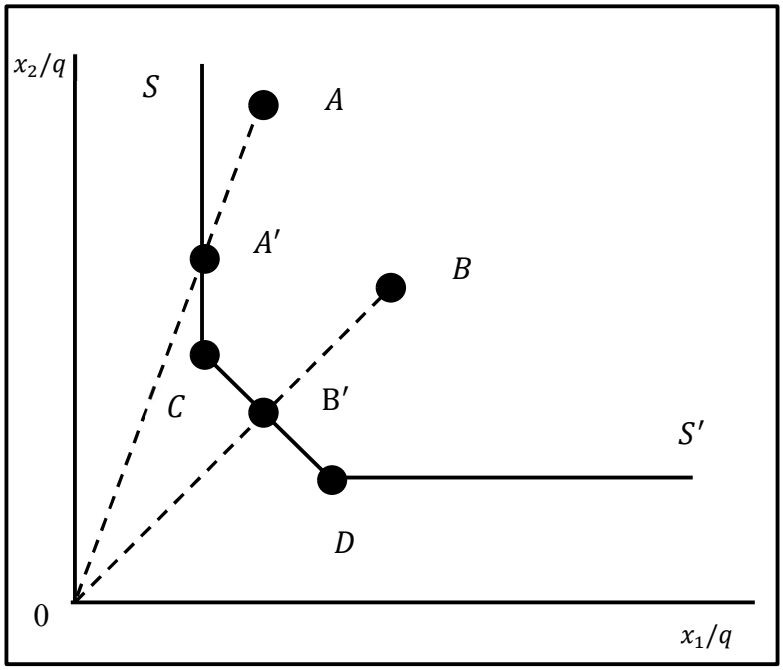
Figure 2.2: Efficiency Vs. Productivity



- Note - "firm" a proxy for any production unit, e.g., a country or province.
- Firms operate on frontier, if they are TE or beneath, if they are not.
- Farrell (1957) - TE the ability of a firm to minimize input use to produce given amount of output.
- On the Cartesian plane, productivity measured by a ray (with a slope of y/x) through the origin and a particular data point on or below the production frontier.

Source: Coelli, Prasada Rao, O'Donnell, and Battese (2005)

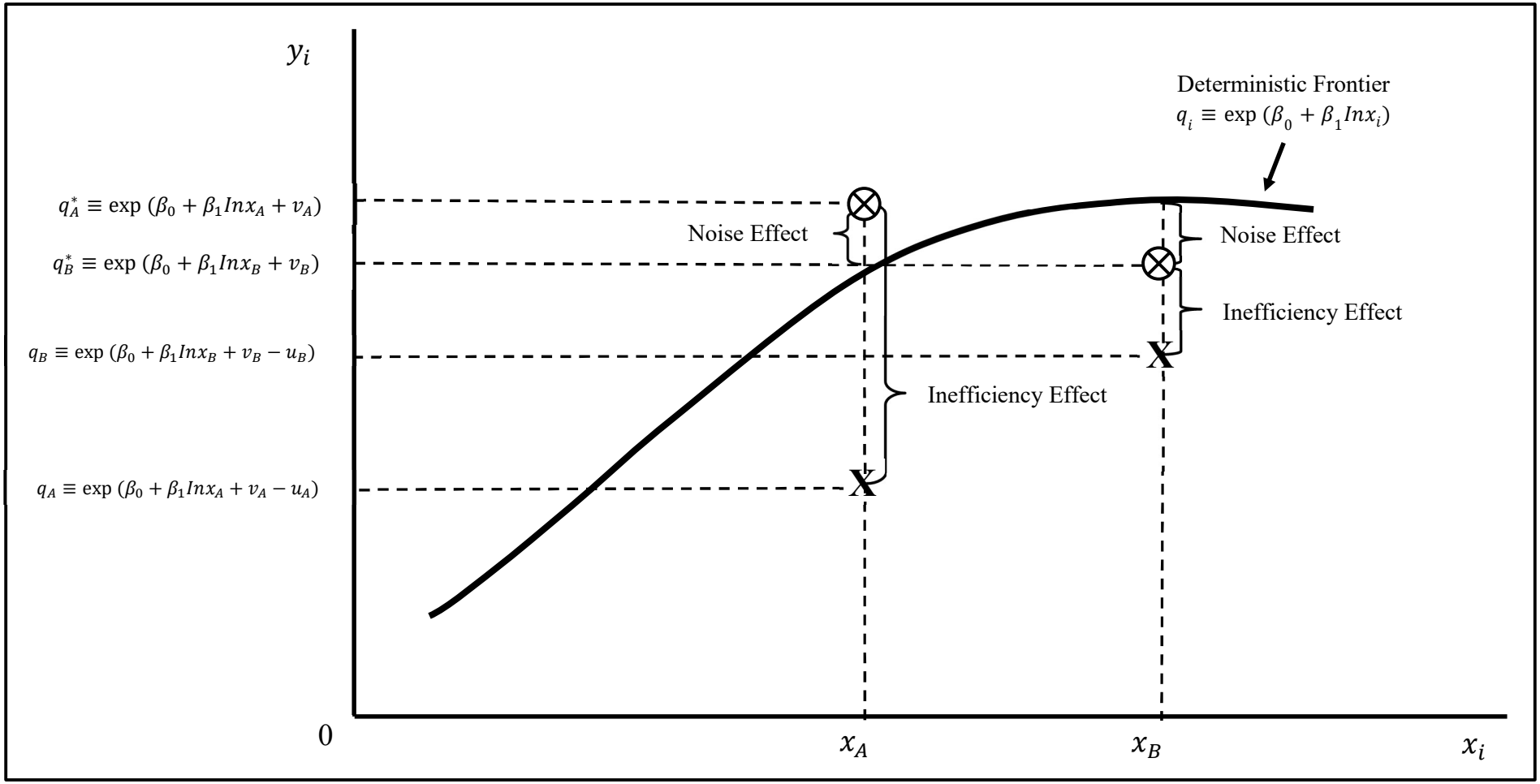
Figure 2.3: Data Envelopment Analysis (DEA)



- Estimating the frontier by linear programming to calculate piece wise linear segments of the efficient frontier.
- It neither imposes:
  - Any assumptions about functional form of the frontier nor
  - Any distributional assumptions about inefficiency.
- Disadvantage - unable to decompose deviations into components: inefficiency and random error parts.
- Attributes entire difference between an inefficient observed firm and an efficient reference firm to inefficiency.

Source: Coelli, Prasada Rao, O'Donnell, and Battese (2005)

Figure 2.4: Stochastic Frontier Analysis (SFA)



Source: Coelli, Prasada Rao, O'Donnell, and Battese (2005)

Chapter 3 : Essay 2

Decomposition of output growth in South Africa's nine provinces

Abstract

This essay determines whether physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces. The growth elements in South Africa's nine provinces are decomposed through the use of Stochastic Frontier Analysis (SFA) to establish the relative importance of the various sources of growth. This essay contributes to the literature, as it further enhances the understanding of which sources of growth are more important, i.e., physical capital or TFP, specifically focusing on the sub-national level as opposed to the national level that is the focus of most studies in the growth literature. In using SFA, this essay addresses the limitations of the standard growth accounting and cross-country analyses of neoclassical and new growth theories that do not adequately clarify the sources of growth and their relative impact. It is established that labour growth is the main driver of economic growth in South Africa's nine provinces, followed by physical capital and human capital accumulation, with TFP being the least important factor of growth, i.e., in contrast to the established growth literature, physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces. For growth to be sustainable, each provincial government should increase the relevant capital investments and invest in productivity enhancing factors that would enrich its growth potential based on its unique requirements. Provinces should therefore ensure that their public sector Gross Fix Capital Formation (GFCF) is adequate to sustain their economic growth and ensure a higher percentage of their populations aged 20 years and older complete grade 12 as highest level of education. Given the fact that public capital has been identified as forming the backbone on which the economy functions, future research should explore the importance of public capital versus private capital in the technical efficiency of South Africa's nine provinces.

3.1. Introduction

International experience has revealed a wide disparity in economic growth rates and levels across countries. The result is reflected in the huge difference in standards of living among countries, which has led countries to be classified (at a basic level) as either developed or developing. According to the United Nations (UN), this classification is a measure of a country's basic economic conditions that includes its level of Gross Domestic Product (GDP) and per capita GDP. All African countries, including South Africa, are classified as developing according to this classification. The disparities in economic growth rates and levels between countries are also evident within countries, i.e., there are regional differences in growth rates and levels among the regions of countries. This is quite evident in South Africa's nine provinces, where STATS SA identified the province of Gauteng as having the highest growth rate, at 1.2 percent, while the North West province as having the lowest growth rate, at -3.6 percent, in 2016. The implication of this difference can be seen in the difference in Gross Domestic Product (GDP) per capita between the two provinces in 2016: R77,149 in Gauteng, and R47,222 in North West.

Explaining the difference in growth rates between countries and identifying the sources of growth have been the focus of numerous economic studies, underpinned by the two main growth theories, i.e., neoclassical (or exogenous) growth theory (Solow 1956; Swan 1956) and new (or endogenous) growth theory (Romer 1986; Lucas 1988). However, the empirical studies underpinning these two growth theories (namely, growth accounting and cross-country analysis) have been inconclusive in pinpointing the relative importance of the various sources of growth, which consist of capital, labour and Total Factor Productivity (TFP). Limam and Miller (2004: 2) and Limam, Miller and Garzarelli (2019) for instance note that dispute still exists concerning the most important determinants of economic growth. In an effort to overcome the limitations of these empirical studies, authors such as Koop, Osiewalski and Steel (1995) proposed a Frontier Analysis (FA) approach to more acurately decompose the elements of growth and identify the most important determinants of economic growth.

The majority of the studies on economic growth focus on output growth at a national level and compare output growth across countries to establish the relative importance of the various sources of growth. However, growth rates at a national level mask the true extent of economic growth at a regional level within countries, i.e., at a sub-national level. The nine provinces of South Africa grow at different rates and exhibit different levels of GDP. This essay therefore

focuses on the sub-national level to establish the relative importance of physical capital accumulation and TFP in contributing to growth in each of South Africa's nine provinces. The studies by authors such as Limam and Miller (2004), Limam, Miller and Garzarelli (2019) and Garzarelli and Limam (2019) that address this issue at a national level, provide some first inspiration for this essay. The intent is to decompose provincial output growth and to thus establish the relative importance of the sources of growth at a sub-national level in South Africa.

The relevance of growth decomposition is particularly relevant within the context of the divergent growth rates of South Africa's nine provinces.[25] In this regard, it is important to understand what the drivers of growth in the various provinces might be, i.e., whether it is physical capital or TFP that has the most influence. This would aid tailor policymaking to each province, rather than adopting a one size fits all policy approach for the country as a whole.

South Africa's GDP for 2018 at constant prices, as reported in Table 3A.1 (a) and (b) in the Appendix, was R3,14 trillion, with Gauteng making the largest contribution, with R1,10 trillion, amounting to 34.9 percent of total GDP, followed by Kwazulu-Natal with R504 billion, amounting to 16 percent, the Western Cape with R436 billion, amounting to 13.9 percent, and the Northern Cape making the least contribution at R69 billion, amounting to 2.2 percent. The level of GDP is to some extent reflected in the growth rates for the provinces. Table 3A.1(c) in the Appendix indicates that Gauteng had the highest growth rate of 1.1 percent, followed by the Western Cape with 0.8 percent, Kwazulu-Natal with 0.7 percent, and the Free State (which was the eighth largest contributor to South Africa's GDP) with a negative growth rate of -0.2 percent in 2018.[26]

A factor, among others, that can explain the growth differential between the provinces is the historical apartheid policies of investing less in areas with a majority African population and where homelands[27] were present, i.e., apartheid geography significantly impacted on economic structures and access to economic opportunities. Homelands were mainly located in areas without substantial natural resources, while receiving less public investment and social services. The implication of these policies is still evident today, as provinces where a large share of the population lives in former homeland areas are typically characterised by lower household incomes, poverty and worse infrastructure. Thus, the Western Cape, the only province with a

[25] South Africa's nine provinces: Eastern Cape, Free State, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, the North West, Northern Cape, Western Cape.
[26] STATS SA, GDP (2019).
[27] In total, ten homelands were established: the Transkei, Bophuthatswana, Ciskei, Venda, Gazankulu, KaNgwane, KwaNdebele, KwaZulu, Lebowa, and QwaQwa.

minority African population and no homeland areas has fewer backlogs of government services and infrastructure than other provinces. Similarly, as Gauteng was established as an enclave around a few metropoles, the province has seen a substantial investment in public services and social services. In contrast, the Eastern Cape has a relatively higher share of former homeland areas compared to the other provinces, i.e., in 2015, 45 percent of the Eastern Cape's population were living in former homeland areas, compared to 27 percent for the country as a whole. This is reflected in its economic structure and key constraints to growth.[28]

The economic dominance of Gauteng, Kwazulu-Natal and the Western Cape is therefore not surprising, as Figure 3.1 in the Appendix indicates that the tertiary sector activities, which dominate the national economy, are concentrated in the economies of these three provinces. In addition, the same three provinces host the bulk of the secondary sector activities, which include manufacturing, construction and utilities. The primary sector is the smallest in South Africa, with mining contributing to GDP growth in the smaller provinces of Limpopo, Mpumalanga, the Northern Cape, and North West.[29] STATS SA therefore points out that since each province has its own unique industrial makeup, GDP per capita can be boosted if dominant industries in each province grow at a rate that outstrips population growth. Furthermore, geographic scale matters when making decisions about the economy: even though mining does not feature as one of the top four largest industries in South Africa, contributing only 8 percent to the national GDP, it is the dominant industry in four of the smallest provinces (according to GDP) and constitutes the lifeblood of many small towns. Thus, STATS SA (2017)[30] made the point that "shifts in the economic structure might not seem that important at a national level, but on a regional or local level they may have serious consequences for the livelihood of many people who depend on the affected industries".

Considering that each province has its own unique industrial makeup, with different sectors dominating in specific provinces, it is not implausible to assume that there might be a divergence of sources of growth in South Africa's nine provinces, i.e., capital accumulation might dominate in one province, while TFP in another. However, this essay considers that, in contrast to the established growth literature, physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces. In addressing this hypothesis, this essay answers the following question: what is the relative importance of physical capital and TFP in contributing to the economic growth of South Africa's nine provinces?

[28] Trade and Industrial Policy Strategies (TIPS) (2016), The Real Economy Bulletin, Provincial Review 2016.
[29] STATS SA, (2017), Your job, your economy, your province, http://www.statssa.gov.za/?p=9794
[30] STATS SA, (2017), Your job, your economy, your province, http://www.statssa.gov.za/?p=9794

This essay differs from earlier studies, as it focuses on the sub-national level as opposed to the national level. Furthermore, it employs Stochastic Frontier Analysis (SFA) as an alternative to the standard growth accounting and cross-country analysis that have been the main empirical techniques employed by neoclassical and new growth theories. SFA is applied to South Africa's nine provinces over the period 2009 to 2018 to decompose output growth at the sub-national level.

It is accepted that labour growth is the main driver of economic growth in the nine provinces over the 2009 to 2018 period. Physical capital and human capital accumulation follows, with TFP being the least important factor of growth. However, the source of growth for each individual province differs based on its economic structure, e.g., in Gauteng, dominated by the tertiary and secondary sectors that are more capital intensive and require higher skilled human capital, physical and human capital accumulation are more important to growth, while growth in the North West, which is dominated by the primary sector, is driven by labour growth. Thus, in contrast to the established growth literature, factor inputs (e.g., physical capital accumulation) are more important than TFP in driving growth in South Africa's nine provinces.

This essay is structured as follows. The next section provides the theoretical and empirical literature review on the two growth theories that constitute the basis of this essay. This is followed by the methodology section that specifies the general stochastic production frontier model as the basis for the preferred empirical specification and research technique, with the data used also specified. The section on empirical results follows, while the last section concludes.

3.2. Literature Review

3.2.1. Theoretical Overview

Economic growth theory addresses two general questions: (i) what are the determinants (sources) of long-run economic growth? and (ii) what accounts for the vast differences in growth rates across countries and time? As mentioned at the outset, there are essentially two growth theories that emerged to address these questions. The first, the neoclassical (or exogenous) growth theory, which is underpinned by the Solow (1956) and Swan (1956) growth model, identifies the three main sources of growth as capital (K), labour (L) and knowledge (A) that are combined to produce output (Y).

This is reflected by the following production function:

$$Y(t) = F\big(K(t), A(t)L(t)\big), \tag{3.1}$$

where *t* indicates time and implies that output changes over time only if (i) the inputs to production (capital and labour) change, and if (ii) the amount of knowledge increases on the condition that quantities of inputs (capital and labour) remain the same, as in the case of technological progress. Technological Change (TC) is thus the main channel through which output is increased. However, a shortcoming of this model is that it does not explain what determines TC (i.e., knowledge), and that technological change is exogenously imposed (Romer, 2011: 10 & 101).

In an effort to compensate for this shortcoming, the second, newer (endogenous) growth theory (Romer 1986 and Lucas 1988) postulates that technological progress takes place through innovation, as a result of economic activities; that is, economic growth is an endogenous outcome of an economy (Romer, 1994: 3). Innovation can be promoted through policies that, for example, stimulate research and development and increase the quality of education. However, one of the criticisms leveled towards endogenous growth theory is that it does not adequatly address the question of the vast difference in growth rates among countries based on the differences in knowledge accumulation (Romer, 2011: 144).

Despite the shortcomings and criticisms of the two growth theories, both have provided the basis for understanding economic growth and the decomposition of output growth, which is the main focus of this essay. Thus, based on these two growth theories, the established growth literature attributes – namely, decomposes – output growth into **physical capital** ***(machinery and equipment), labour and knowledge [Total Factor Productivity (TFP)]***. However, the essence of the exogenous and endogenous growth theories is that in the long-run the rate of economic growth depends on the growth rate of TFP, which is determined by the rate of technological progress, i.e., economic growth is mainly attrubuted to TFP.

TFP represents the efficiency with which factors of production (capital and labour) are used and is a fusion of all other factors, other than physical capital and labour, that impact productivity, i.e., those other factors that improve the level of output produced per unit of input. Quality institutions (property rights, government effectiveness, etc.), good policies (e.g., to encourage research and development that improve technology and thus lead to innovation),

financial development, and improvement in economic organisation, management, or systems are examples of factors that can improve TFP. The mechanism through which the elements of TFP impact growth is through productivity, which creates new profit opportunities; firms produce greater output for the same level of input and earn higher revenues, which increases investment demand, inducing a level of saving and investment that makes capital per hour of labour grow and ultimately generate higher growth (GDP increases).

3.2.2. Empirical Overview

As is the case with the theoretical literature, the empiral studies on growth theory are essentially underpinned by two research techniques. The first is growth accounting that was used to test the neoclassical (exogenous) growth theory of Solow (1956), which uses time-series data to decompose and assess the contribution to output growth of capital, labour and TFP. In earlier studies by Abramovitz (1956), Denison (1985) and Solow (1957) for the United States, these authors established that TFP is more important than factor inputs for output growth. Abramovitz (1956) found that between 1869 to 1878 and 1944 to 1953, 10 percent of output growth per person is associated with factor inputs and 90 percent is associated with TFP. Denison (1985) found that between 1929 to 1982, 32 percent of output growth per person is associated factor inputs, while 68 percent is associated with TFP. Solow (1957) found that between 1909 to 1949, physical capital accounts for about 12 percent of output growth per hour worked and 88 percent is attributed to TFP. However, Jorgenson, Gollop and Fraumeni (1987) found that quality-adjusted capital can explain a mojor portion of post-war growth (46 percent) in the United States, while TFP can be reduced to 23 percent of total growth. This is also evident in studies by Baier, Dwyer and Tamura (2006) and Young (1995). Using time series data for 145 countries between 1860 to 2000, Baier, Dwyer and Tamura (2006) found that for all countries, 14 percent of output growth is associated with TFP growth, while physical and human capital accounts for 86 percent. Young (1995) uses time series data between 1966 to 1991 for Hong Kong and between 1966 to 1990 for Singapore, South Korea and Taiwan to establish that TFP growth is only associated with 14 percent of output growth, while physical capital and labour accounts for 50 percent and 36 percent respectively of output growth in this group of Newly Industrialising Countries (NICs). However, according to a review by Chenery (1986) of a wide range of growth accounting studies, TFP accounted for 50 percent of total growth for developed countries and 30 percent for developing countries, with capital and labour accounting for less than 10 percent of growth combined in both categories of countries. A similar result is obtained by Easterly and Levine (2001) that notes that the fraction of output growth accounted for by

TFP growth is around 50 percent for OECD countries, while there is greater variation among Latin American countries, with the average accounted for by TFP growth being around 30 percent. This points to regional and country differences in the relative importance of physical capital and TFP to output growth. Table 3A.2 in the Appendix provides a selection of papers that identify the relative importance of factor inputs and TFP to output growth.

These are studies at a national level, with sub-national studies (at a provincial level) not that common. This is also the case in South Africa where similar growth accounting studies for the nine provinces are not that evident. However, in South Africa (at a national level), the importance of physical capital and TFP to output growth have been informed by policies, pre and post the democratic transition in 1994. Fedderke (2002) in a growth accounting study on South Africa, over the period 1970 to 1997 (focusing mostly on the pre democratic period), found that growth in the 1970s and 1980s was led by growth in physical capital and labour, with very little contribution from TFP. In a growth decomposition exercise on South Africa for the period 1996 to 2015 (post the democratic transition) Kumo (2017) noted that the first decade of democracy witnessed a rapid increase in employment and TFP, mainly driven by improved macroeconomic policies, reforms and strong institutions. However, the global financial crisis of 2008–09 and domestic structural weaknesses have resulted in a gradual deterioration in factor intensity, employment gains and TFP, with and increased influence of capital.

The second research technique emanates from the limitations of neoclassical growth theory and growth accounting. In this regard, Mankiw (1995) identify three practical empirical problems - the model cannot explain the observed differences in real income per capita across countries, the observed rate of convergence across countries, or the observed differences in real rates of return across countries. Furthermore, the limitations are identified as no explanation of the determinants of TFP; and, according to Renelt (1991), a precise measure of capital input and the lack of long-term time series data for a wide range of countries. This resulted in the use of cross-sectional data to perform cross-country analysis, starting with the basic neoclassical equation and then adding other explanatory variables to capture the effect of TFP, i.e., to consider a number of potential determinants of TFP. The additional variables include government spending, financial development, institutions, human capital (health), etc. In this regard, Barro (1989) uses cross-country data for 72 countries over the period 1960 to 1985 to establish that public investment tends to be positively correlated with growth and private investment. Similarly, Skinner (1987) using a pooled cross-section time-series data set for 27 Sub-Saharan African countries during 1965 to 1973 found that government investment is

estimated to be highly productive, with its marginal productivity estimated to be more than 50 percent. Easterly and Wetzel (1989) use cross-country data for 70 developing countries between 1960 to 1985 to indicate that financial markets have shown to raise a country's long-run rate of growth, with policies that lower distortions in resource allocation (in the financial sector) generally encourage growth. Examining cross-country evidence for 83 developing countries, Hicks (1980) found a clear and positive association between human capital and output growth. This is significant as he uses both literacy (the more traditional human capital approach that details primary or basic education) and life expectancy (a proxy for health that is not commonly used as a form of human capital). Institutons are also found to have a substantial impact on output growth. Using panel data for 89 developing countries, Grier and Tullock (1989) estalish that countries with stronger institutions (political freedom) grew at four percentage points faster than political repressive countries. Kormendi and Meguire (1985) use cross-country data for 47 countries for the period 1950 to 1977 and identified that although institutions (civil liberty) is found to have a marginal effect on growth, it has a dramatic effect on investment.

As with growth accounting studies, there are limited cross-section studies at a sub-national level, specifically focusing on South Africa's nine provinces, that establishes the impact of other explanatory variables to capture the effect of TFP. Most of these studies use data at a municipal or provincial level (sub-national level) to draw conclusions at an aggregate level regarding provinces, rather than comparing the performance of individual provinces. In this regard, Ngepah, Saba and Mabindisa (2021) find that higher levels of skilled employment is associated with higher total output and economic growth at a sub-national level. Their study uses the theoretical framework of the Cobb–Douglas production function, focusing on a balanced panel of 269 South African municipalities for the period 1993 to 2016 and using a panel causality test and Generalised Method of Moments Estimation (GMM). Coetzee and Kleynhans (2017) developed an endogenous growth model to assess the extent to which provincial capital expenditure (on infrastructure) may promote provincial economic growth using time series data of the KwaZulu-Natal province, as an example. They establish a positive relationship between provincial capital stock and economic growth in the long-term.

Caselli (2005) denotes the second research technique as ***development accounting*** and states that it does for cross-section analysis what growth accounting does for time series analysis, as it answers the question "how much of the cross-country income variance can be attributed to differences in (physical and human) capital, and how much to differences in the efficiency with which capital is used?".

According to authors such as Chenery (1986), Renelt (1991), and Garzarelli and Limam (2019) cross-country analysis appears to support capital growth as more important to output growth than TFP. In this regard, Mankiw, Romer and Weil (1992) use cross-country data for the period 1960 to 1985 for 98 countries employing Ordinary Least Squares (OLS) and conclude that physical capital accounts for 48 percent and human capital accounts for 23 percent of output growth, with TFP accounting for 29 percent. Although not as high, Miller and Upadhyay (2000) find a similar result. They use panel data for five-year intervals between 1960 and 1989 for 83 countries in six regions [Africa (19 countries), Caribbean, Central America, and North America (11), South America (11), Asia (16), Europe (20), and Oceania (4)] and found that the combined elasticity of output with respect to physical and human capital totals 58 percent, implying that TFP accounts for 42 percent of output growth. Benhabib and Spiegel (1994) use cross-country data for 121 countries for the period 1965 to 1985 and Ordinary Least Squares (OLS) to establish that physical capital account for around 50 percent and labour accounts for around 20 percent of output growth, while TFP accounts for the remaining 30 percent (refer to Table 3A.2 in the Appendix).

Renelt (1991) and León-Gonzalez and Montolio (2015) however identifies that since theory puts little restriction on possible relationships, many variables (as part of TFP) can be found to be correlated with growth because there may exist common causality, reverse causality, or simply spurious correlation, i.e., there are potential endogeneity in the regressors that leads to an inconsistent estimation.

Given the limitations of growth accounting and cross-country analysis to adequately clarify the sources of growth and their relative impact, the empirical literature evolved to develop further methodologies to more satisfactorily decompose output growth. In this regard, Makiela (2014) indicated that the established growth literature uses a one-stage decomposition of output growth. The more advanced methodology that emerged, i.e., Frontier Analysis (FA), subsequently used a two-stage decomposition of output growth. Thus, in addition to the traditional production factors (e.g., physical capital and labour), FA further decomposes TFP into Technical Efficiency (TE) and Technical Change (TC) or progress. This two-stage decomposition of output growth assisted to further enhance the understanding of which components are relatively more important in determining output growth.

Makiela (2014) notes that this framework was first used in the context of a frontier analysis by Färe, Grosskopf, Norris, and Zhang (1994), who used Data Envelopment Analysis (DEA) to

analyse economic growth in selected countries. Given the perceived limitation of DEA, due to the linear function which significantly constraints the analysis, Koop, Osiewalski and Steel (1995, 1999) developed a stochastic frontier framework; that is, they employed Stochastic Frontier Analysis to derive the components of output growth. Using SFA, authors such as Makiela (2014), Koop, Osiewalski, and Steel (1995, 1999) and Limam, Miller and Garzarelli (2019) showed that input factors (capital) are more important than TFP in explaining output growth. This essay follows the latter authors in using SFA as the prefered method for decomposing output growth.

3.3. Methodology

3.3.1. Empirical Specification and Research Technique

Farrell (1957) introduces the basic framework for studying and measuring inefficiency, which is defined as the deviations of actual from "optimum behaviour." Frontier Analysis establishes the optimum benchmark against which deviations are calculated. The literature distinguishes between non-parametric and parametric approaches to frontier analysis, with Fiorentino, Karmann and Koeter (2006), Kiyota (2011) and Kaparakis, Miller and Noulas (1994) outlining the two approaches as follows. The non-parametric approach, i.e., Data Envelopment Analysis (DEA), was introduced by Charnes, Coopers and Rhodes (1978) and consists of estimating the frontier by using linear programming to calculate piecewise linear segments of the efficient frontier. It neither imposes any assumptions about functional form of the frontier nor any distributional assumptions about inefficiency, while its main disadvantage lies in the fact that it is unable to decompose the deviations of a certain firm from the efficient production frontier into components: inefficiency and random error parts. The parametric approach, i.e., Stochastic Frontier Analysis (SFA), was developed (independently) by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) and estimates the frontier with statistical methods and imposes an explicit functional form for both the frontier and deviations from it that is inefficiency. SFA is considered to be more sophisticated compared to DEA, as it allows for incorporating technical efficiencies and the decomposition of random error terms and the inefficiency of the production unit and takes into account the existence of exogenous shocks or statistical noise. As mentioned earlier, this is the preferred method of this essay, given its advantages over DEA.

The general stochastic production frontier model used by this essay has as its main focus the decomposition of TFP to obtain an estimator for one of its constituent parts, i.e., Technical

Efficiency (TE). The other component of TFP is Technical Change (TC), which is depicted by a time trend and interactions of the regressors with time. The early studies on SFA used cross-section data, with later studies employing panel data. Coelli, Prasada, O'Donnell, and Battese (2005) indicate that the use of panel data allowed authors such as Kumbhakar (1990) and Battese and Coelli (1992) to include time-varying inefficiency.

In line with these later authors, this essay uses panel data to construct the frontier production function as

$$Y_{it} = X_{it}\beta + v_{it} - u_{it}, \tag{3.2}$$

where Y_{it} presents the output of province i at time t; X_{it} is a vector containing the production inputs; β is a vector of unknown parameters; v_{it} is a symmetric random error to account for statistical noise; and u_{it} is a non-negative random variable associated with technical inefficiency.

Technical Efficiency (TE), which is the ratio of observed output to the corresponding stochastic frontier output, is denoted by $\exp(-u_{it})$ and is derived as follows:

$$TE_{it} = \frac{Y_{it}}{\exp(X_{it}\beta + v_{it)}} = \frac{\exp(X_{it}\beta + v_{it} - u_{it})}{\exp(X_{it}\beta + v_{it)}} = \exp(-u_{it}). \tag{3.3}$$

This measure of TE takes a value between zero and one and measures the output of country i at time t relative to the output that could be produced by a fully-efficient province using the same input vector. In order to estimate the parameters of the stochastic production frontier model (3.2), given the two random terms, Aigner, Lovell and Schmidt (1977) obtained Maximum Likelihood (ML) estimates under the assumptions of:

$$v_i \sim iidN(0, \sigma_v^2) \text{ (normal random), and} \tag{3.4}$$

$$u_i \sim iidN^{+}(0, \sigma_u^2) \text{ (half-normal random).} \tag{3.5}$$

Furthermore, in terms of time-varying inefficiency, the model allowing for time-varying technical efficiency takes the form:

$$u_{it} = \exp[\eta(t-T)]\,.\,u_{it}, \qquad (t = 1,2,\ldots.,T, i = 1,2,\ldots.,N) \tag{3.6}$$

where η is an unknown parameter to be estimated and determines how technical efficiency varies over time.

Assuming a transformation of model (3.2) to a translog production function, with the provinces producing output using physical capital, labour and human capital, the new model can be expressed in the following way:

$$InY_{it} = \alpha_0 + \alpha_1 InK_{it} + \alpha_2 InL_{it} + \alpha_3 InHC_{it} + \alpha_4 TInK_{it} + \alpha_5 TInL_{it} + \alpha_6 TInHC_{it} + \alpha_7 T + \alpha_8 T^2 + v_{it} - u_{it}, \tag{3.7}$$

where for province i at time t, *Y* is output, *K* is capital*, L* is labour, *HC* is human capital, *T* is a time trend to account for Technical Change (TC), v *is* a random error that accounts for statistical noise, and u is a non-negative random variable associated with technical inefficiency. The interaction terms $TInK_{it}$, $TInL_{it}$ and $TInHC_{it}$ allow for possible non-neutral technological change, while T^2 reflects non-monotonic technological change (Garzarelli and Limam, 2019). The hypothesis is that physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces.

All the unknown parameters in model (3.7) were estimated in a single-stage Maximum-Likelihood (ML) procedure, introduced by Coelli, Prasada Rao, O'Donnell, and Battese (2005) and using FRONTIER, a computer programme for SFA, developed by Coelli (1996), specifically for the measurement of efficiency and/or productivity. Coelli (1996) indicated that FRONTIER considers two primary model specifications (i) an error components specification with time-varying efficiencies permitted, proposed by Battese and Coelli (1992) and (ii) a model specification in which the firm (provincial) effects are directly influenced by a number of variables, proposed by Battese and Coelli (1995). This essay considers the former model specification of Battese and Coelli (1992) that is expressed as:

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it}) \qquad , i = 1,\ldots.,N, t = 1,\ldots.,T, \tag{3.8}$$

where Y_{it} is the logarithm of the production of province i at time t; X_{it} is a $kx1$ vector of input quantities (capital, labour and human capital) of province i at time t; β is a vector of unknown

parameters; the V_{it} are random variables assumed to be $iid.N(0,\sigma_{V^2})$ and independent of the $U_{it} = \left(U_i \exp\left(-\eta(t-T)\right)\right)$, where the U_i are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be *iid* as truncations at zero of the $N(\mu,\sigma_{U^2})$ distribution; where η is a parameter to be estimated.

Having decomposed TFP for South Africa's nine provinces into its constituent parts, i.e., TE and TC, to establish their individual influence, this essay also determines the role of TFP, as a whole, in output growth. This relates to the growth literature's debate about the relative importance of output growth of production inputs (specifically physical capital) vs. TFP. In addressing this issue, this essay draws on contributions such as Garzarelli and Limam (2019), Limam and Miller (2004) and Limam, Miller and Garzarelli (2019) that use the definition by Jorgenson and Griliches (1967) to calculate the rate of growth of TFP. Their definition states that TFP is the difference between the rate of change of real product and the rate of growth of inputs. This definition is applied to equation (3.7), with the change in TFP calculated as follows:

$$\frac{\dot{TFP}}{TFP} = \frac{\dot{Y}}{Y} - \left(e_k \frac{\dot{K}}{K} + e_L \frac{\dot{L}}{L} + e_{HC} \frac{\dot{HC}}{HC}\right), \qquad \textbf{(3.9)}$$

with a variable denoted by a dot indicating the rate of change of the variable over time.

Using derivatives, the output elasticities with respect to *K, L* and *HC* can be obtained from model (3.7), and since a translog function is used, these elasticities are province and time specific.

- $e_k = \frac{\partial lnY_{it}}{\partial lnK_{it}} = \alpha_1 + \alpha_4 T$
- $e_L = \frac{\partial lnY_{it}}{\partial lnL_{it}} = \alpha_2 + \alpha_5 T$
- $e_{HC} = \frac{\partial lnY_{it}}{\partial lnHC_{it}} = \alpha_3 + \alpha_6 T$

3.3.2. Data

The data used in this essay is for South Africa's nine provinces for the period 2009 to 2018. Data on *Y* (output), *L* (labour), and *HC* (Human Capital) is from STATS SA. Output (*Y*) is GDP at constant 2010 prices, labour (*L*) is the labour force in millions, and human capital (*HC*) is proxied by the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education. This is in line with authors such as Rivera and Currais (1999),

Barro (2013) and Caselli (2005) that use educational attainment to reflect human capital, in contrast to studies that use average years of schooling or enrolment rates, as is the case with Mankiw, Romer and Weil (1992) and others. Data on capital (*K*) is obtained from Quantec (2022) and is proxied by Gross Fix Capital Formation (GFCF) at constant 2015 prices. The Quantec data set is their standardised ***Regional Capital Formation (RCAP) data set for fixed capital formation*** by six asset types, 50 Standard Industrial Classification categories and it is based on the 2011 local municipal/ward-based metro region level. Quantec's data set consists of the three organisational components of GFCF, which according to STATS SA comprises general government, public corporations and private business enterprises. This is significant as ***there is no formal disaggregated data set available for GFCF per province for private business***, as confirmed by STATS SA, which only has GFCF data sets for general government and public corporations.

Although capital (*K*) is normally reflected by the stock of private physical capital in empirical studies, e.g., Baier, Dwyer and Tamura (2006) and Garcia-Milà, McGuire and Porter (1996), Barro (1991) notes that the literature has usually used gross investment rates as a proxy for physical capital accumulation. This is to account for data constraints that have necessitated the literature [e.g., Benhabib and Spiegel (1994)] to proxy physical capital and the other growth accounting variables by those which are directly observable. In this regard, Barro (1989) used real investment expenditures (both private and public). This suggest that GFCF, which is a directly obsevable variable, can account for data constraints with regards to physical capital accumulation. Using GFCF, authors such as Asomani, Bhasin and Aglobitse (2019) have established the impact of public expenditure on economic growth in Ghana, while Akinola and Omolade (2013) investigated the relationship among savings, gross capital formation and economic growth in Nigeria. Thus, in line with Barro (1989) and Benhabib and Spiegel (1994), this essay used GFCF as a proxy for capital.

Table 3.1 provides descriptive statistics on the data used in this essay, i.e., provincial GDP (*Y*) and the various independent variables, capital (*K*), labour (*L*) and human capital (*HC*). Provincial (*Y*) reveal that the mean value for the nine provinces is R328 billion, with Gauteng producing the highest output at R1.1 trillion, while the Northern Cape produces the lowest output, at R59 billion. It is evident that Gauteng's output is substantially above the mean output of the nine provinces, with the data also reflecting a noticeable variation from the mean, at R274 billion. The same applies for capital (*K*) and labour (*L*). In the case of capital (*K*), the mean value for the nine provinces is R82 billion, with Gauteng having the highest capital formation,

at R256 billion (significantly higher than the mean) and the Northern Cape having the lowest, at R14 billion. The mean value for labour (L) in the nine provinces is 2.6 million, with the highest labour force of 7.2 million in Gauteng (also much higher than the mean) and the lowest of 381,000 in the Northern Cape. In terms of human capital (HC), the variation from the mean is not as wide for the nine provinces, which indicates less disparity between the provinces on their level of education. The mean value for the nine provinces is 26.5 percent, with Gauteng having the highest individuals aged 20 years and older who have completed grade 12 as highest level of education (35 percent), while the Limpopo has the lowest (15 percent).

Table 3.1: Data Description - South Africa's 9 Provinces

Variable	Minimum		Maximum		Mean	Median	Standard Deviation
Y	Northern Cape	59	Gauteng	1,099	328	220	274
K	Northern Cape	14	Gauteng	256	82	58	63
L	Northern Cape	0.38	Gauteng	7.21	2.25	1.68	1.74
HC	Limpopo	15.30	Gauteng	34.95	25.46	25.92	4.85

Notes: Y is in constant 2010 prices and as with K are in R billions. L is the labour force in millions. HC is Human Capital, which is the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education. Number of provinces N = 9.

In terms of the relationship between provincial (Y) and the various independent variables, Table 3.2 and Figure 3.2 in the Appendix indicate that the a priori expectation of a positive correlation for provincial (Y) with respect to capital (K), labour (L) and human capital (HC) is confirmed. The trend lines confirm that as capital (K), labour (L) and human capital (HC) increase, provincial (Y) increases.

Table 3.2: Correlation Matrix

	Y	***K***	***L***	***HC***
Y	1.000000			
K	0.984684	1.000000		
L	0.995537	0.977543	1.000000	
HC	0.697456	0.715595	0.687643	1.000000

3.4. Results

3.4.1. Hypothesis Testing

SFA requires a series of statistical tests. First, based on the existence of the inefficiency component, u_{it}, it was tested whether an OLS rather than stochastic frontier estimation better represent the data. This entailed testing the null hypothesis that the frontier coefficients are

jointly insignificant against the alternative hypothesis that at least one of the coefficients is significant, i.e., testing $H_0: \gamma = u = 0$. The results show that the H_0 is strongly rejected, which means that frontier is a better estimation technique than OLS. Second, it was checked whether a translog production function fits the data better than a Cobb-Douglas production function, i.e., testing whether we can reject $H_0: \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$. The results show that the H_0 is strongly rejected, which indicates that the translog specification is a better fit than the Cobb-Douglas specification. Third, the statistical distribution of the one-sided error term was tested to establish whether the one-sided error term follows a Half Normal (HN) versus a Truncated Normal (TN) distribution, i.e., testing whether to reject $H_0: \mu = 0$. The results show that H_0 is rejected, which indicates that the one-sided error term follows a HN distribution. Fourth, the time variance [Time Varying (TV) versus Time Invariance (TI)] of the one-sided error term was tested, i.e., testing whether to reject $H_0: \eta = 0$. The results show that the H_0 is rejected, which indicates that the one-sided error term is Time Invariant (TI). Table 3.3 indicates the results for the hypothesis tests.

Table 3.3: Hypothesis Testing - Output Growth in South Africa's 9 Provinces

Null Hypothesis Testing		LR	Critical Value	Degrees of Freedom	Decision at 5% Significance
SF versus OLS:	$H_0: \gamma = u = 0$	66.99	3.841	1	Reject
Cobb Douglas versus Translog:	$H_0: \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$	21.37	7.815	3	Reject
HN versus TN	$H_0: \mu = 0$	0.23	5.991	2	Fail to Reject
TV versus TI	$H_0: \eta = 0$	0.21	7.815	3	Fail to Reject

Notes: LR, Likelihood Ratio; SF, Stochastic Frontier; OLS, Ordinary Least Squares; HN, half normal distribution; TN, truncated normal distribution; TV, time varying; TI, time invarying.

3.4.2. Empirical Results

3.4.2.1. Technical Efficiency Estimation

Table 3.4 summarises the results on technical efficiency ranking for South Africa's nine provinces. Results show that the average technical efficiency for the nine provinces is of the order 0.92, indicating that, on average, provinces register more than 92 percent of the efficiency of the most efficient province. Technical efficiency scores are quite stable, as shown by the mean value and standard deviation (only 6 percent deviation from the mean, with scores varying between a minimum of 79 percent and a maximum of 99 percent). Gauteng and the Northern Cape have the highest rank whereas Mpumalanga and the Eastern Cape are the lowest ranked.

Table 3.4: Technical Efficiency Averages - Output Growth SA 9 Provinces

Province	Technical Efficiency
Gauteng	0.9903
Northern Cape	0.9809
North West	0.9656
KwaZulu-Natal	0.9504
Western Cape	0.9345
Limpopo	0.9286
Free State	0.8958
Mpumalanga	0.8841
Eastern Cape	0.7882
Average and Standard Deviation	0.9243 (0.0623)

In the case of the Eastern Cape, the provincial GDP was R236 billion in 2018, accounting for 7.5 percent of South Africa's total GDP, the fourth largest provincial economy. The Eastern Cape economy grew, between 2009 and 2018, at a Compound Annual Growth Rate (CAGR) of 1.5 percent, lower than the 1.8 percent average growth rate for South Africa during this period.[31] Despite the stable economic performance of the provincial economy, the Eastern Cape has however experienced an unemployment rate of 35.4 percent in 2018, higher than the national rate of 27.1 percent.[32] This might have impacted negatively on the growth in disposable income for the province that averages 2.2 percent (i.e., CAGR) between 2009 and 2018, the second lowest average growth rate amongst the nine provinces.[33] The high provincial poverty head count rate of 72.9 percent in 2016, higher than the national rate of 55.5 percent, might be the outcome of the high unemployment rate and low growth in disposable income in the Eastern Cape.[34] A key element that impacts on the Eastern Cape economy and its low efficiency score is its economic structure, which is dominated by services, specifically government services, i.e., government is the largest industry in the Eastern Cape, accounting for 21.4 percent of the provincial GDP.[35] In line with the crowding out theory, authors such as Barro (1990) have established that growth and saving rates fall with an increase in government spending, which is a possibility in the case of the Eastern Cape. A further element impacting on the low efficiency of the Eastern Cape is its low score of 28, in 2018, on the Municipal Financial Suntainability Index (MFSI).[36] This implies inadequate financial management practices and discipline, questioning the soundness of the governance exercised by municipalities in the Eastern Cape, with the resultant negative impact on service delivery. The low efficiency score of the Eastern Cape might also be explained by its high Gini Coefficient,[37] which in 2015 was 0.65, mirroring

[31] STATS SA, GDP (2019).
[32] STATS SA, Quarterly Labour Force Survey (QLFS) (2019).
[33] South African Reserve Bank (SARB) (2019).
[34] STATS SA (2015), poverty trends in South Africa, available at http://www.statssa.gov.za/publications/Report-03-10-06/Report-03-10-062015.pdf.
[35] STATS SA, GDP (2019).
[36] The MFSI is a scoring model developed by Ratings Africa that evaluates the operating performance, liabilities management, budget practices and liquidity position of a municipality and scores these components out of a 100.
[37] STATS SA used the Gini Coefficient as an inequality measures based on expenditure per capita by province.

the national figure of 0.65[38]. This indicates that the Eastern Cape government is spending less per individual on delivering the necessary services that could assist with productivity improvements in the province, i.e., education, health, infrastrucure, etc.

As with the Eastern Cape, the Mpumalanga economy grew at a CAGR, between 2009 and 2018, of 1.6 percent, lower than the 1.8 percent average growth rate for South Africa[39]. Although the province had a reasonable labour absorption rate of 42 percent in 2018, in line with the national absorption rate of 43 percent, the unemployment rate in Mpumalanga was 32.5 percent, higher than the national rate at 27.1 percent.[40] This might be explained by the population growth rate for the province that averaged 1.47 percent between 2009 and 2018, higher than the national average of 1.37 percent. Despite its stable economic performance, a key challenge facing the Mpumalanga province that impacts on its low efficiency score is the quality of the financial and operational management of its municipalities, i.e., the governance of its municipalities. With an average MFSI score of 30 in 2018, less than the national average of 38, Mpumalanga has to deal with inadequate financial management practices and discipline in its municipalities that impact negatively on their service delivery ability.[41] Mpumalanga's low efficiency score might also be explained by the quality of its road network, which in 2013 consisted of around 38 percent poor and very poor roads and ranked third worst amongst South Africa's provinces, based on the percentage of poor and very poor roads. Various studies have proved that a strong correlation exists between the condition of roads and the vibrations experienced by the vehicles travelling on the roads. These increased vibrations lead to structural damages to vehicles, increased vehicle maintenance and repair costs and consequently higher logistics costs.[42] A further element impacting on Mpumalanga's low efficiency score might be hidden in its economic structure, where utilities, in the form of electricity generation, have a disproportionate influence on the province's economy.[43] In 2018, utilities that includes electricity generation, accounted for 6.8 percent of Mpumalanga's economy, the sixth largest industry in the province. However, utilities accounted for 27.9 percent of employment in 2018, more than mining at 16.4 percent, which was the largest industry in the province, accounting for 20.8 percent of the provincial economy.[44] This is significant, as South Africa has experienced intermittent load-

[38] STATS SA (2019), Inequality Trends in South Africa - A multidimensional diagnostic of inequality, Report No. 03-10-19 available at http://www.statssa.gov.za/publications/Report-03-10-19/Report-03-10-192017.pdf.
[39] STATS SA, GDP (2019).
[40] STATS SA, Quarterly Labour Force Survey (QLFS) (2019).
[41] Ratings Africa (2019).
[42] CSIR (2014), The State of Logistics Survey for South Africa available at https://www.csir.co.za/sites/default/files/Documents/10th_SoL_Bold_Steps_Forward_web.pdf.
[43] In this regard, it should be noted that Mpumalanga is host to 11 of Eskom's 13 old build power stations, as well as one of the two new build power stations (Eskom available at https://www.eskom.co.za/Whatweredoing/ElectricityGeneration/PowerStations/Pages/Map_Of_Eskom_Power_Stations.aspx).
[44] STATS SA, GDP (2019).

shedding since 2007, with the total economic impact over the period (2007 to 2019) being a loss of between R167 billion and R338 billion.[45]

Despite having the smallest population (accounting for 2.2 percent of South Africa's population)[46] and the smallest GDP (accounting for 2.2 percent of South Africa's GDP) of all nine provinces, the Northern Cape had a CAGR over the 2009-2018 period of 1.8 percent, in line with the national average.[47] The Northern Cape has also tracked the national labour absorption (43 percent) and unemployment rates (27.1 percent) over the 2009 to 2018 period, with the province registering an absorption rate of 40.3 percent and an unemployment rate of 27.6 percent.[48] This has meant that the Northern Cape's disposable income was the third highest of all nine provinces at 2.7 percent between 2009 to 2018,[49] while its poverty head count rate of 59 percent in 2016 was marginally higher than the national rate of 55.5 percent.[50] The economic performance of the province and its high efficiency score can thus be attributed, amongst others, to the fact that the Northern Cape consistently ranks amongst the better performing provinces in a number of indicators, which include its relatively high MFSI score over the 2014 to 2017 period. The Northern Cape had a higher score than the national average during this period, i.e., in 2014 the province had a score of 45 versus 43 for the national average and in 2017 it had a score of 46 versus 42. This points to adequate financial management practices and discipline in its municipalities.[51] As a further enhancement of its government services (the second largest industry in the province at 16.1 percent in 2018), the Northern Cape had a Gini-Coefficient of 0.6 in 2015 that is lower than the national figure of 0.65, indicating higher provincial spending on services that improve productivity.[52]

In 2018, Gauteng had a GDP of R1,099 billion, accounting for 34.9 percent of South Africa's GDP, the largest provincial GDP. Between 2009 and 2018, Gauteng had an average GDP growth rate of 2.2 percent, higher than the national average rate of 1.8 percent and all other provinces.[53] A key element of its high growth rate and efficiency score, is its reliance on the finance industry, the largest industry in the province that accounted for 21.4 percent of the

[45] CSIR (2020), Setting up for the 2020s - Addressing South Africa's electricity crisis and getting ready for the next decade available at https://cisp.cachefly.net/assets/articles/attachments/81125_rs_setting_up_for_2020.pdf.
[46] STATS SA (2019), Mid-year population estimates.
[47] STATS SA, GDP (2019).
[48] STATS SA, Quarterly Labour Force Survey (QLFS) (2019).
[49] South African Reserve Bank (SARB) (2021).
[50] STATS SA (2015), poverty trends in South Africa, available at http://www.statssa.gov.za/publications/Report-03-10-06/Report-03-10-062015.pdf.
[51] Ratings Africa (2019).
[52] STATS SA (2019), Inequality Trends in South Africa - A multidimensional diagnostic of inequality, Report No. 03-10-19 available at http://www.statssa.gov.za/publications/Report-03-10-19/Report-03-10-192017.pdf.
[53] STATS SA, GDP (2019).

province's GDP and employed 43.7 percent of the labour force in 2018.[54] The economic performance of the province is thus in line with the view of authors such as King and Levine (1993) that find that higher levels of financial development are positively associated with efficiency improvements and faster rates of economic growth. Furthermore, the increased efficiency associated with finance is from Gauteng's reliance on a skilled worked force, which is reflected in the fact that Gauteng had the highest skilled labour, as a proportion to the total labour force in South Africa. At 30.3 percent skilled labour, Gauteng had more skilled labour than the national proportion of 22.9 percent.[55] Gauteng's high efficiency score, related to its labour force, is in line with the view of authors such as Romer (1990) that emphasized human capital as a catalyst to economic development and Garzarelli, Limam and Rossi (2014) that found that human capital strongly and positively affect technical efficiency. A further element that contributes to Gauteng's high efficiency score is its relatively developed road network, which in 2013 had around 52 percent good and very good roads and only had 14 percent poor and very poor roads. This is in relation to the road network condition in Limpopo (the other good performer) that had 53 percent good and very good roads and 19 percent poor and very poor roads.

Table 3.5 presents the results of the stochastic frontier estimations. The first nine rows show the coefficients of the estimated frontiers based on equation (3.7), while the last three rows report the two inefficiency statistics (the inefficiency variance, σ_u^2, and the inefficiency indicator, γ, which measures the percentage of the error term that is explained by inefficiency) and the log-likelihood.

As consistent with expectations, the coefficient for $\ln K$ and $\ln L$ is positive and highly significant, indicating that capital and labour positively impact on output growth. However, against expectations, the coefficients for $\ln HC$ is negative and highly significant, indicating that human capital negatively impacts on output growth. This may be explained by the fact that there is a lack of skilled workers in the various provinces. At a national level, this is reflected in the fact that South Africa was ranked 102 out of 141 countries, in 2019, for the skillset of its graduates.[56] This can also be seen at a provincial level, where the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education is around 30 percent for South Africa.[57] The occupation profile of the various provinces also reflects this

[54] STATS SA, Quarterly Labour Force Survey (QLFS) (2019).
[55] STATS SA, Labour Market Dynamics in South Africa.
[56] Global Competitiveness Report (2019).
[57] STATS SA, General Household Survey (2009-2018)

reality, as around 22.9 percent of South Africa's workforce is skilled, while 77.1 percent of the workforce is semi-skilled or low-skilled.[58]

The coefficients on T and T^2 are negative, while it is insignificant for T and significant for T^2, suggesting that technology change for the nine provinces have a negative impact on output.

Table 3.5: Stochastic Frontier and Technical Efficiency Estimation SA 9 Provinces

Parameter	Variable	Estimate	Standard Error	t-ratio
α_0	Frontier Intercept	11.1027*	0.5362	20.7050
α_1	ln*K*	0.1020*	0.0420	2.4318
α_2	ln*L*	0.9448*	0.0405	23.3440
α_3	ln*HC*	-0.2838*	0.0855	-3.3206
α_4	*T*ln*K*	-0.0040	0.0116	-0.3477
α_5	*T*ln*L*	-0.0022	0.0099	-0.2170
α_6	*T*lnHC	0.0489*	0.0121	4.0292
α_7	*T*	-0.0029	0.1295	-0.0224
α_8	T^2	-0.0030*	0.0008	-3.6143
σ_u^2	Inefficiency Variance	0.0122**	0.0063	1.9381
γ	Inefficiency indicator	0.9077*	0.0532	17.0474
	Log-Likelihood	169.7552		

Notes: * Significant at 1%; ** Significant at 5%; *** Significant at 10%. Number of provinces N = 9. Number of periods T = 10.

However, technological change interacts with human capital (*T*ln*HC*) to generate output growth, i.e., technological change is human capital augmenting. The explanation might be that despite the low proportion of its skilled workforce, South Africa's semi-skilled workforce (around 48 percent of the total workforce) is adequate to generate additional output in combination with the available technology. This might also be assisted by the fact that South Africa was ranked 40 out of 141 countries, in 2019, for the extent of staff training.[59] In contrast to human capital, technological change does not interact with capital and labour to generate output growth, i.e., technological change is not capital and labour augmenting. In the case of *T*ln*K*, one explanation could be that the level of public sector (government) Gross Fixed Capital Formation (GFCF) in the nine provinces is low and declining. In this regard, it was noted that public-sector investment in South Africa's infrastructure slowed for a second consecutive year, falling by 8.2 percent in 2018, following a 4.0 percent decline in 2017 to levels last seen in 2014. The biggest declines in public sector capital expenditure between 2016 and 2018 have been experienced in Gauteng (-10.4 percent in 2017 and 5.0 percent in 2018) and Kwazulu-Natal (-9.6 percent in 2017 and 7.1 percent in 2018), the two largest contributors to South

[58] STATS SA, GDP (2019).
[59] Global Competitiveness Report (2019).

Africa's GDP. This is significant as public capital, specifically infrastructure, is central to the activities of households and firms (Romp and de Haan, 2005). Thus, it was highlighted that capital investment (public capital) improves logistics, education, connectivity, facilitates trade, attracts investment, and allows communities to access a range of services such as water, electricity and sanitation, i.e., in essence, capital expenditure forms the backbone on which the economy functions.[60]

3.4.2.2. Output Growth Decomposition

Table 3A.3 in the Appendix decomposes output growth per province. It is established that labour growth is the main driver of growth in the nine provinces. This is followed by physical capital accumulation. Human capital accumulation follows, despite a higher share of TFP in growth for three of the nine provinces compared to human capital. TFP is the least important factor of growth amongst the nine provinces. This is in line with authors such as Baier, Dwyer and Tamura (2006) and Young (1995) that established that physical capital, humand capital and labour contribute more to GDP than TFP. This is also evident in South Africa, where in a growth accounting study, at a national level, by Fedderke (2002), it was found that over the period 1970 to 1997 growth in the 1970s and 1980s was led by growth in physical capital and labour, with very little contribution from TFP. Arora (2006), in a growth accounting study for South Africa for the period 1980 and 2003, identified that the avarage contributions to GDP growth of labour, capital and TFP were, 0.8 percentage points, 0.7 percentage points and 0.3 percentage points respectively. Kumo (2017) noted that while in the first decade of democracy there was a rapid increase in employment and TFP, the global financial crisis of 2008–09 and domestic structural weaknesses have resulted in a gradual deterioration in employment gains and TFP, with an increased influence of capital.

It should be noted that the performance of each province is linked to their achievements in terms of labour, physical and human capital accumulation and TFP growth. The North West province, the province that registered the lowest output growth (0.71 percent) over the 2009 to 2018 period, had the third lowest Gross Fix Capital Formation (GFCF) at R49 billion, the third lowest labour force of 1.3 million and had the fourth lowest individuals 20 years and older that completed grade 12 (i.e., Human Capital) of all nine provinces, as reflected in Figures 3.3 to 3.5 in the Appendix. North West is thus the province with the second lowest contribution of TFP to total growth and the lowest contribution of physical and human capital to total growth.

[60] STATS SA, Capital expenditure by the public sector 2018.

Labour is the second highest contributor to growth in the North West. The provinces with the highest growth rates over the 2009 to 2018 period, Gauteng (2.17 percent), Kwazulu-Natal (2.09 percent) and the Western Cape (2.04 percent) have amongst the highest contribution of physical and human capital to total growth, as well as TFP to total growth. These were also the provinces with the highest accumulation of capital, labour and human capital, as outlined in Figures 3.3 to 3.5 in the Appendix. Although labour is the main driver of growth in the three highest growth provinces, it accounts for the least towards growth (in these provinces) of all nine provinces.

This might also be an indication of the economic structure of the nine provinces, as outlined in Figure 3.1 in the Appendix, with Gauteng, Kwazulu-Natal and the Western Cape being dominated by the tertiary and secondary sectors that are more capital intensive and require higher skilled human capital that positively impact on TFP. In contrast, the North West province, Mpumalanga and Limpopo are dominated by the primary sector, requiring less capital and lower skilled human capital that result in lower TFP.

3.5. Conclusion

This essay addresses the hypothesis that physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces. Stochanstic Frontier Analysis (SFA) is applied to South Africa's nine provinces to decompose output growth. This is to account for the limitations of the standard growth accounting and cross-country analysis, that have been the main empirical techniques employed by neoclassical and new growth theories, to adequately clarify the sources of growth and their relative impact. The relative importance of physical capital and TFP in contributing to the economic growth of South Africa's nine provinces is considered, as each province has its own unique industrial makeup, with different sectors dominating in specific provinces, suggesting tailor policymaking for each province. However, data availability at a sub-national level proved to be a further limitation. The data used in this essay is for South Africa's nine provinces for the period 2009 to 2018. Although data on output (Y), reflected as GDP at constant 2010 prices and data on labour (L), as the labour force in millions, were readily available, data on capital (K) and human capital (HC), as used in most empirical studies, prove to be more elusive. While capital (K) is normally reflected by the stock of private physical capital in empirical studies, data constraints normally necessitate the use of Gross Fix Capital Formation (GFCF) as a proxy, given its direct observability (Barro, 1989). This essay accordingly used GFCF at constant 2015 prices as a proxy for capital (K). As

there is no official data set available for GFCF at a provinciale level from STATS SA (South Africa's official statistics provider), data from Quantec (a private data publihser) was used, as it has developed the necessary data set. Data availability has also necessitated the use of educational attainment, i.e., the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education to reflect human capital (HC). This is in line with authors such as Rivera and Currais (1999), in contrast to the normal use of average years of schooling or enrolment rates, as is the case with Mankiw, Romer and Weil (1992) and others.

This essay contributes to the literature, as it focuses on the sub-national level as opposed to the national level that is the focus of most studies in the growth literature. Furthermore, this essay employs Stochastic Frontier Analysis (SFA) as an alternative to the standard growth accounting and cross-country analysis that have been the main empirical techniques employed by neoclassical and new growth theories. This essay thus contributes to the understanding of which sources of growth is more important, i.e., physical capital or TFP, as dispute still exists concerning the most important determinants of economic growth.

This essay establishes that labour growth is the main driver of economic growth in the nine provinces, followed by physical capital and human capital accumulation, with TFP being the least important factor of growth. This essay thus confirms that in contrast to the established growth literature, e.g., Solow (1957) and Chenery (1986), physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces. In addition, this essay identifies that the source of growth for each individual province differs based on (i) the achievements of each province with regards to factor accumulation and (ii) its economic structure. Thus, based on achievements on factor accumulation, the North West province, with the third lowest GFCF and labour force and the fourth lowest human capital of all nine provinces in 2018, is the province with the second lowest contribution of TFP to total growth and the lowest contribution of physical and human capital to total growth. Furthermore, Gauteng, Kwazulu-Natal and Western Cape, the provinces with the highest accumulation of capital, labour and human capital growth rates over the 2009 to 2018 period, also have the highest contribution of physical and human capital to total growth, as well as TFP to total growth. In terms of economic structure, Gauteng, which is dominated by the tertiary and secondary sectors that are more capital intensive and require higher skilled human capital, physical and human capital accumulation are more important to growth, while growth in the North West, which is dominated by the primary sector, is driven by labour growth.

This suggests that for growth to be sustainable, each provincial government should increase the relevant capital investments [i.e., capital (*K*)] and invest in productivity enhancing factors [human capital (*HC*)] that would enrich its growth potential based on its unique requirements. In the case of capital (*K*), each province should ensure that its public sector GFCF is adequate to sustain its economic growth, as Romp and de Haan (2005) noted that public capital is central to the activities of households and firms and according to STATS SA, it forms the backbone on which the economy functions. It is thus evident that the Free State, Limpopo and Mpumalanga that had some of the lowest public sector GFCF in 2018, also had the lowest efficiency scores of all nine provinces, suggesting increased public capital expenditure to augment their technical efficiency to drive economic growth. With regards to human capital (*HC*) (i.e., education), provinces (such as Limpopo and the Eastern Cape with the lowest education achievements also had some of the lowest technical efficiency scores) should ensure a higher percentage of their populations aged 20 years and older complete grade 12 as highest level of education, as higher educational attainment (human capital) positively impact economic growth (Caselli, 2005). In addition, provinces should ensure that their municipalities improve their Municipal Financial Suntainability Index (MFSI) scores, i.e., improve the soundness of the governance exercised by their municipalities, as this will enhance provincial spending on services that improve productivity. This is to account for the fact that quality institutions (property rights, government effectiveness, etc.), are examples of factors that can improve TFP (Grier and Tullock, 1989; Kormendi and Meguire, 1985).

Given the limitations of this essay relating to data constraints at the sub-national level, future research should assist in refining the variables used as proxies for capital (*K*) and human capital (*HC*). Future research should also explore the importance of public capital versus private capital in the technical efficiency of South Africa's nine provinces, specifically in the context of STATS SA asserting that public capital forms the backbone on which the economy functions. The suggestion is that public capital is a catalyst for private capital, as identified by Eberts (1986) that establishes that public capital-stock makes a positive and significant contribution to manufacturing output. In addition, the importance of the institutional quality of municipalities, which is manifested in their Municipal Financial Suntainability Index (MFSI) scores, should also receive attention to further motivate intervention at this level to improve the economic performance of provinces.

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3.7. Appendix

Table 3A.1: GDP by province

a. Constant 2010 prices - Rand million

Province	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Western Cape	363,601	372,788	386,830	397,707	407,932	417,068	423,022	427,116	432,438	435,964
Eastern Cape	206,737	211,600	219,470	223,935	227,003	229,963	231,824	233,404	234,783	236,141
Northern Cape	58,795	60,089	61,274	63,253	64,784	66,697	67,432	66,619	68,509	68,853
Free State	143,574	147,190	150,166	154,670	157,573	160,710	160,246	159,805	162,088	161,755
KwaZulu-Natal	418,879	433,846	449,826	461,604	473,222	484,795	489,326	491,995	500,887	504,487
North West	174,552	180,221	184,328	180,888	186,194	179,371	187,329	180,548	184,177	185,264
Gauteng	905,976	937,178	971,893	998,095	1,025,717	1,050,091	1,062,174	1,074,906	1,086,228	1,098,566
Mpumalanga	197,775	202,902	207,405	211,751	216,009	222,299	221,868	222,091	226,288	227,648
Limpopo	197,051	202,196	207,066	209,175	214,742	217,096	221,016	219,983	224,585	225,862
GDP at market prices	**2,666,940**	**2,748,008**	**2,838,257**	**2,901,078**	**2,973,175**	**3,028,090**	**3,064,237**	**3,076,466**	**3,119,983**	**3,144,539**

b. Constant prices - percentage contributions

Province	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Western Cape	13.6%	13.6%	13.6%	13.7%	13.7%	13.8%	13.8%	13.9%	13.9%	13.9%
Eastern Cape	7.8%	7.7%	7.7%	7.7%	7.6%	7.6%	7.6%	7.6%	7.5%	7.5%
Northern Cape	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%
Free State	5.4%	5.4%	5.3%	5.3%	5.3%	5.3%	5.2%	5.2%	5.2%	5.1%
KwaZulu-Natal	15.7%	15.8%	15.8%	15.9%	15.9%	16.0%	16.0%	16.0%	16.1%	16.0%
North West	6.5%	6.6%	6.5%	6.2%	6.3%	5.9%	6.1%	5.9%	5.9%	5.9%
Gauteng	34.0%	34.1%	34.2%	34.4%	34.5%	34.7%	34.7%	34.9%	34.8%	34.9%
Mpumalanga	7.4%	7.4%	7.3%	7.3%	7.3%	7.3%	7.2%	7.2%	7.3%	7.2%
Limpopo	7.4%	7.4%	7.3%	7.2%	7.2%	7.2%	7.2%	7.2%	7.2%	7.2%
GDP at market prices	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

c. Constant 2010 prices - percentage changes

Province	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Western Cape	-1.4	2.5	3.8	2.8	2.6	2.2	1.4	1.0	1.2	0.8
Eastern Cape	-1.0	2.4	3.7	2.0	1.4	1.3	0.8	0.7	0.6	0.6
Northern Cape	-2.3	2.2	2.0	3.2	2.4	3.0	1.1	-1.2	2.8	0.5
Free State	-2.3	2.5	2.0	3.0	1.9	2.0	-0.3	-0.3	1.4	-0.2
KwaZulu-Natal	-1.4	3.6	3.7	2.6	2.5	2.4	0.9	0.5	1.8	0.7
North West	-2.9	3.2	2.3	-1.9	2.9	-3.7	4.4	-3.6	2.0	0.6
Gauteng	-1.4	3.4	3.7	2.7	2.8	2.4	1.2	1.2	1.1	1.1
Mpumalanga	-1.4	2.6	2.2	2.1	2.0	2.9	-0.2	0.1	1.9	0.6
Limpopo	-1.6	2.6	2.4	1.0	2.7	1.1	1.8	-0.5	2.1	0.6
GDPR at market prices	**-1.5**	**3.0**	**3.3**	**2.2**	**2.5**	**1.8**	**1.2**	**0.4**	**1.4**	**0.8**

Source: STATS SA, GDP (2019)

Table 3A.2: The Importance of Factor Inputs and TFP for Output Growth

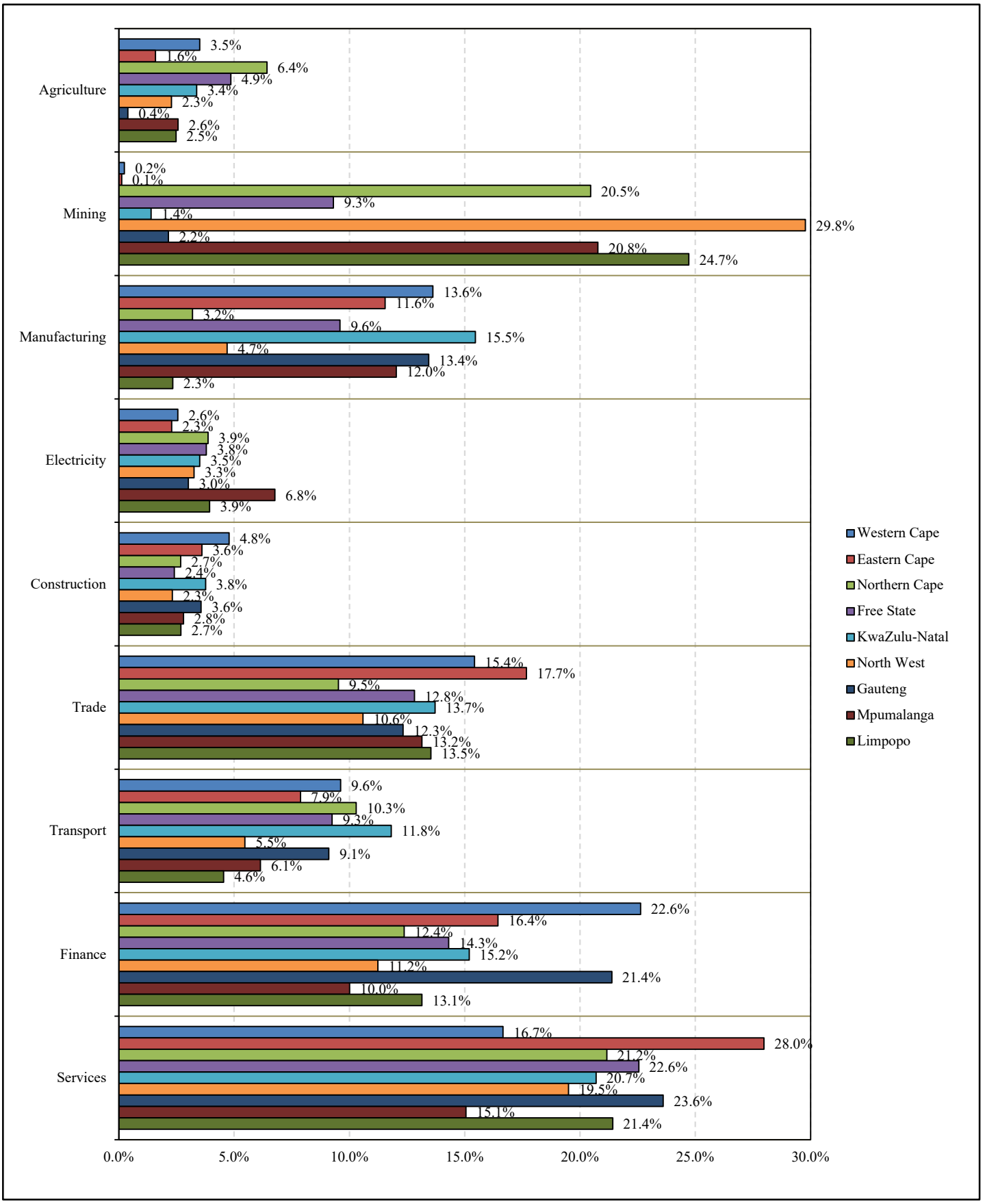
Study	Dependent Variable	Data, Country & Estimator	Growth Associated with Capital	Growth Associated with TFP
Solow (1957)	Gross National Product (GNP)	Time series data between 1909 to 1949 for the United States using growth accounting	12%	88%
Abramovitz (1956)	Net National Product (NNP)	Time series data between 1869 to 1878 and 1944 to 1953 for the United States using growth accounting	10%	90%
Denison (1985)	Potential National Income (NI)	Time series data between 1929 to 1982 for the United States using growth accounting	32%	68%
Young (1995)	Gross Domestic Product (GDP)	Time series data between 1966 to 1991 for Hong Kong and between 1966 to 1990 for Singapore, South Korea and Taiwan [Newly Industrialising Countries (NICs)] based on neoclassical growth theory and using growth accounting	Physical Capital is 50% and Labour is 36%	14%
Baier, Dwyer and Tamura (2006)	Income per worker	Time series data for 145 countries between 1860 to 2000 based on neoclassical growth theory and using growth accounting	Physical and human capital is 86%	14%
Miller and Upadhyay (2000)	Real GDP per worker	Panel data with five-year intervals: 1960-64, 1965-69, 1970-74, 1975-79, 1980-84, and 1985-89 for 83 countries in the following regions: Africa (19 countries), Caribbean, Central America, and North America (11), South America (11), Asia (16), Europe (20), and Oceania (4) based on endogenous growth theory using cross-country analysis	58%	42%
Mankiw, Romer and Weil (1992)	GDP per working-age person	Cross section data for 98 countries between 1960 to 1985 based on endogenous growth theory and using Ordinary Least Squares (OLS) for cross-country analysis	Physical Capital is 48% and Human Capital is 23%	29%
Benhabib and Spiegel (1994)	Per capita Income	Cross-country data for 121 countries for the period 1965 to 1985 based on endogenous growth theory and using Ordinary Least Squares (OLS) for cross-country analysis	Physical capital is around 50% and Labour is around 20%	30%

Notes: Growth Theory is the Theoretical Framework Underpinning the Various Studies
Source: Authors

Table 3A.3: SA 9 Provinces Output Growth Decomposition in Rates

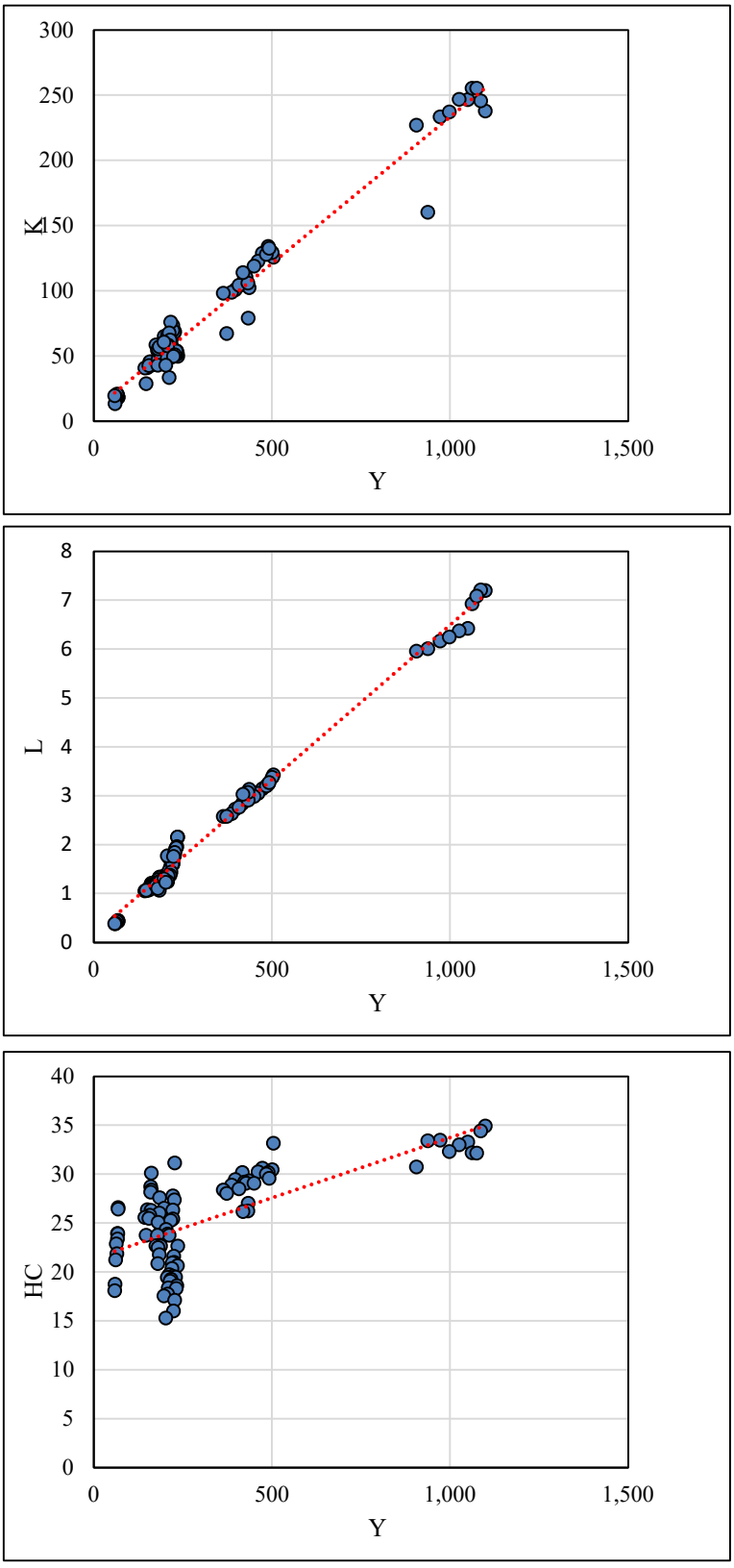
Province	***Y***		***K***		***L***		***HC***		***TFP***	
	Growth Rate	% Share in Toal Growth	Growth Rate	% Share in Toal Growth	Growth Rate	% Share in Toal Growth	Growth Rate	% Share in Toal Growth	Growth Rate	% Share in Toal Growth
Western Cape	2.04%	100%	0.17%	8.43%	2.05%	100.43%	-0.01%	-0.38%	-0.17%	-8.48%
Eastern Cape	1.49%	100%	0.15%	10.26%	2.10%	140.35%	-0.03%	-2.23%	-0.72%	-48.37%
Northern Cape	1.78%	100%	0.07%	3.70%	1.40%	78.95%	-0.07%	-3.74%	0.38%	21.10%
Free State	1.34%	100%	0.16%	11.81%	1.43%	106.98%	-0.03%	-2.16%	-0.22%	-16.63%
KwaZulu-Natal	2.09%	100%	0.23%	10.91%	1.30%	62.23%	-0.04%	-1.92%	0.60%	28.78%
North West	0.71%	100%	-0.06%	-9.18%	1.51%	214.53%	-0.03%	-4.91%	-0.71%	-100.44%
Gauteng	2.17%	100%	0.16%	7.51%	2.01%	92.47%	-0.02%	-1.02%	0.02%	1.04%
Mpumalanga	1.58%	100%	0.15%	9.71%	3.02%	191.04%	-0.03%	-1.88%	-1.56%	-98.87%
Limpopo	1.53%	100%	0.01%	0.52%	3.50%	228.11%	-0.03%	-2.18%	-1.94%	-126.45%
Averages	**1.64%**	**100%**	**0.12%**	**5.96%**	**2.04%**	**135.01%**	**-0.03%**	**-2.27%**	**-0.48%**	**-38.70%**

Figure 3.1: South Africa's Provincial Economic Structure - 2018



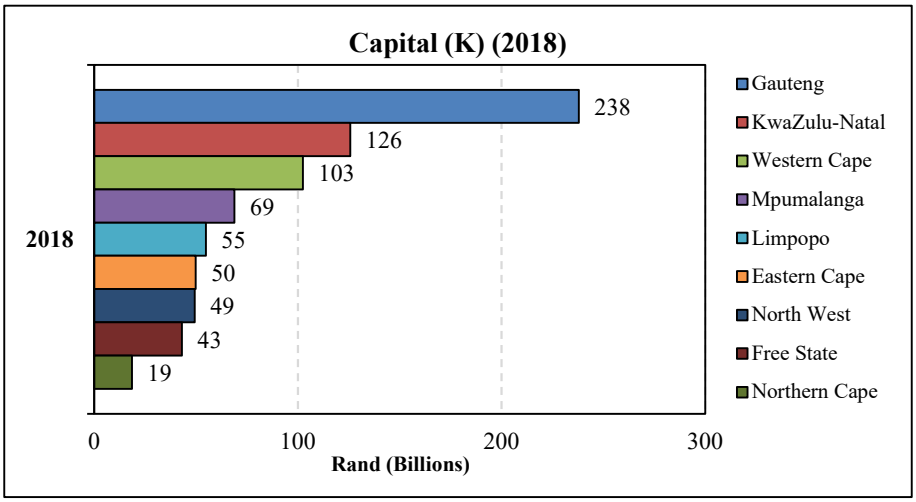
Source: STATS SA, GDP (2019)

Figure 3. 2: Scatter Plot of Y with respect to K, L and HC



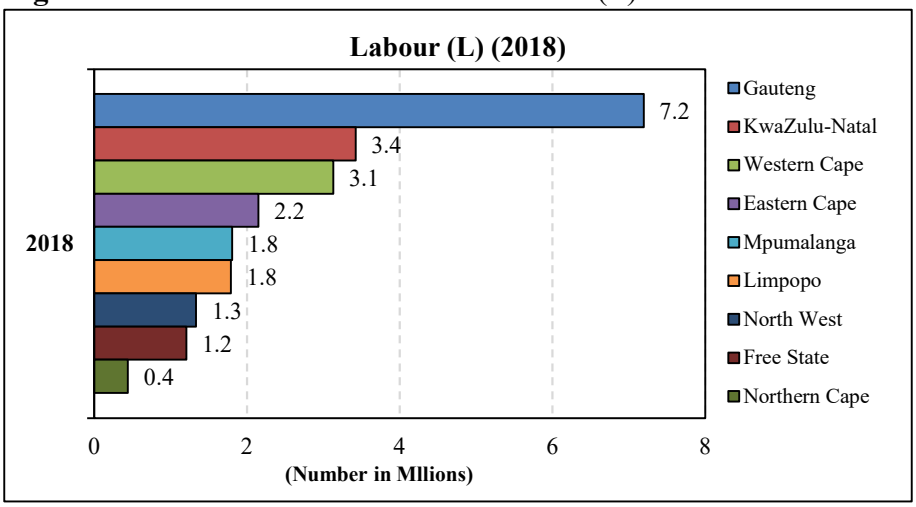
Notes: Y and K is in billions; L is in millions and HC is the percentage of individuals aged 20 years and older who have completed grade 12.as highest level of education.

Figure 3.3: South Africa's Provincial Capital (K) - 2018



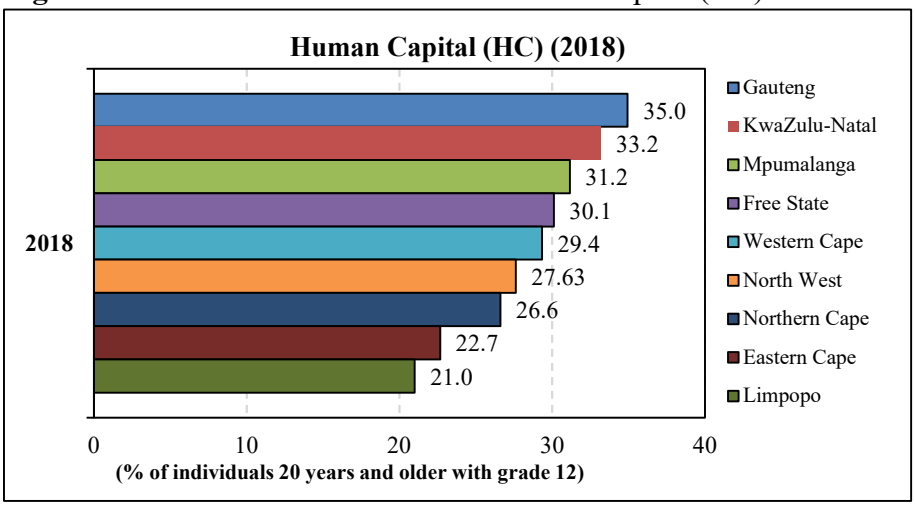
Source: Quantec (2022)

Figure 3.4: South Africa's Provincial Labour (L) - 2018



Source: STATS SA, Quarterly Labour Force Survey (QLFS) (2019)

Figure 3.5: South Africa's Provincial Human Capital (HC) - 2018



Source: STATS SA, General Household Survey (2009-2018)

Chapter 4 : Essay 3

Does Health Care Contribute to the Technical Efficiency (TE) of South Africa's Nine Provinces?

Abstract

This essay explores whether health care (public health expenditure) positively affects the technical efficiency of South Africa's nine provinces. The growth elements in South Africa's nine provinces are decomposed through the use of Stochastic Frontier Analysis (SFA) to establish the impact of health care on the technical efficiency of South Africa's nine provinces. The contribution this essay makes to the literature is that in using public health expenditure as a health indicator, this essay establishes the indirect impact of health through TFP on economic growth. This is to account for the fact that health spending affects growth directly or indirectly through the accumulation of education and health capital. Furthermore, in using SFA, this essay addresses the limitations of the standard growth accounting and cross-country analyses of neoclassical and new growth theories that do not adequately clarify the sources of growth and their relative impact. As consistent with the literature, it is established that health (public health expenditure) has a significant impact on the Technical Efficiency (TE) of South Africa's nine provinces. Provincial governments should therefore ensure a positive real rate of growth in their public health expenditures, with their health investments (e.g., vaccination programmes, antibiotic distribution programmes, micronutrient supplementation schemes, etc.) to increase to allow for a positive pass-through to increased health outcomes, i.e., increased life expectancy and reduced fertility rates have a positive impact on productivity and economic growth. As this essay focuses on public health expenditure (health care) as a proxy for health, future research should also explore the impact of life expectancy and fertility rate on the technical efficiency in South Africa's nine provinces, as further measures of health.

4.1. Introduction

As is the case in other emerging and developing countries, South Africa's economic growth (and development more generally) is dependent on the interplay between several factors that include trade openness, information technology, quality of education, financial development, institutional quality, human capital development, etc. According to authors such as Tompa (2002), human capital (which has traditionally been interpreted as education and skills) has been identified as a key determinant of productivity growth that assists with economic growth. She and other authors have however indicated that there is increasing attention directed to health as a form of human capital that is key in augmenting growth and wealth accumulation. In this regard, Alexa, Pop-Silagh and Cismas (2016) noted that "health has been recognised as an important factor in growth dating back to Grossman (1972) who modelled optimal investment in increasing longevity." The catalytic role health can play in augmenting the drivers of economic growth (trade openness, financial development, institutional quality, etc.) has been highlighted in the literature by authors such as Bloom, Canning and Sevilla (2001 & 2004); Bloom, Canning, Kotschy, Prettner, and Schünemann (2019) and Barro (2013). They indicated that health has a sizable impact and is a better predictor than education and skills for the subsequant pace of economic growth. Only a few studies have found no positive effect of health improvements on economic growth (Acemoglu and Johnson, 2006). However, the overwhelming evidence from the literature is that improved health increases the quality of the workforce, enhances productivity and improves knowledge absorption.

Although health is associated with faster rates of economic growth, most empirical studies – underpinned by the two main growth theories, i.e., neoclassical (exogenous) growth theory advanced by Solow (1956) and Swan (1956) and new (endogenous) growth theory introduced by Romer (1986) and Lucas (1988) – attribute output growth to two production inputs (capital and labour) and Total Factor Productivity (TFP). TFP represents the efficiency with which the factors of production (capital and labour) are used and is a fusion of all other factors, other than physical capital and labour, that impact productivity. Health is an example of a factor that can improve TFP. However, as Garzarelli, Limam, and Rossi (2014) have noticed, the established growth literature does not allow for the decomposition of TFP to adequately reflect the contribution of other factors to output growth, as it leaves a lumpy factor in output growth other than capital and labour. In addition, Venkataramani, Shanmugam and Ruger (2006) noted that empirical studies have generally specified health as an input in the production function process, rather than as part of TFP, which does not detail how exactly health accomplishes output

growth. In an effort to overcome the limitations of these empirical studies, authors such as Koop, Osiewalski and Steel (1995) proposed a stochastic frontier framework, i.e., using Stochastic Frontier Analysis (SFA) to more acurately decompose the elements of growth, specifically TFP that can be further decomposed into Technical Efficiency (TE) and Technology Change (TC).

Thus, given the limitations of the empirical studies of the established growth literature that decomposes output growth into capital, labour and grouping all other factors (including health) in the lumpy factor of TFP, as well as using health as an input in the production function process rather than as part of TFP, this essay uses SFA to explore to what extent health care (public health expenditure) impacts on the Technical Efficiency (TE) of South Africa's nine provinces.

The significance of exploring and quantifying the impact of health care on the technical efficiency in economic growth in South Africa's nine provinces is informed by the literature that identifies health (which has, amongst others, been proxied by public health expenditure, life expectancy and fertility rate) as a key enabler for growth. Various channels have been identified through which health can affect productivity: (i) workers have more physical and mental energy, are absent from work less often, and have a longer life expectancy; workers are keen and motivated to (ii) invest more in education; (iii) save more for retirement, encouraging capital accumulation; (iv) have more labour force participation, while better health reduces fertility that (v) spurs sustained income growth (Bloom and Canning, 2000; Bloom and Canning, 2005; Bloom, et al., 2019; Bloom, et al., 2001; Bloom, Canning and Sevilla, 2004; and Finlay, 2007).

The importance of establishing the impact of health care on the Technical Efficiency (TE) of South Africa's nine provinces is informed by the varied health outcomes amongst the different provinces. In this regard, Hlafa, Sibanda and Hompashe (2019) indicated that although the democratic government, since 1994, restructured the public health care sector to improve access to medical resources for everyone, the burden of diseases [both non-communicable (e.g., strokes, cancer, heart diseases, etc. and communicable diseases (e.g., HIV/AIDS and sexually transmitted infections)] have increased fourfold. This has led to increased mortality rates (decreasing life expectancy), a loss of healthy lives and ultimately reduced productivity.

In South Africa, the National Department of Health was tasked with addressing these issues within the context of Outcome 2 (a long and healthy life for all South Africans) of the

Government's Medium Term Strategic Framework (MTSF) for the period 2014-2019. The MTSF priorities for health are derived from South Africa's National Development Plan (NDP) and included raising life expectancy to at least 70 years; ensure that the generation of under-20s is largely free of HIV; significantly reduce the burden of disease; achieve an infant mortality rate of less than 20 deaths per 1,000 live births, and an under-five mortality rate of less than 30 per 1,000 live births.

Despite South Africa's stark realities, the United Nations Children's Fund (UNICEF) (2017) indicated that there are signs of a declining trend in infant and under-five mortality rates, while the HIV prevalence rates among young people (15–24 years old) show a slow, but consistent decline between 2013 and 2015. UNICEF (2017) also highlighted that health spending continues to be stable in South Africa, both as a percentage of total government spending (ranging between 13.4 and 14.1 percent) and as a share of the economy (varying between 3.7 and 3.9 percent of GDP) over the 2013/14 to 2019/20 period. Over the 2009 to 2018 period, South Africa's Compound Annual Growth Rate (CAGR) of public health expenditure was 10.3 percent, as indicated in Table 4A.1 in the Appendix. Furthermore, as Table 4A.2 in the Appendix identifies, the CAGR of public health expenditure as a percent of GDP increased by 8.3 percent over the 2009 to 2018 period. Mpumalanga's public health expenditure (the highest) had a CAGR of 9.9 percent of its provincial GDP, while the Eastern Cape (the lowest) had a CAGR of 7.3 percent of its provincial GDP over the 2009 to 2018 period[61].

However, UNICEF (2017) has expressed concern that provincial health programmes over the Medium-Term Expenditure Framework (MTEF) show no signs of positive growth, with provincial departments of health budgets only projected to grow at a real average annual rate of less than 0.1 percent over the MTEF. This is significant; Hlafa, Sibanda and Hompashe (2019) identified that the provision of public health care falls directly under the provincial spheres of government, with UNICEF (2017) noting that 97.2 percent of the consolidated government health expenditure in the 2017/18 financial year was spent by provinces. It is thus the provinces that determine the expenditure on health care and the resultant impact on health care outcomes that impact productivity.

In this regard, it should be noted that according to UNICEF (2017), Gauteng (the highest contributor to South Africa's GDP in 2016 at 34.6 percent and leading with a growth rate of 1.4

[61] STATS SA, Financial statistics of provincial government.

percent)[62] had the highest expenditure (22 percent of South Africa's total health care budget) in 2017/2018 on health care amongst the nine provinces. Similarly, the North West province (which was the seventh largest contributor to South Africa's GDP in 2016 at 6.4 percent) with a negative growth rate of -3.6 percent[63], had the third lowest expenditure (5.6 percent) on health care in 2017/2018, as identified in Table 4A.3 in the Appendix. This ties in with the main findings of the article by Hlafa, Sibanda and Hompashe (2019) that identified that the relationship between public health expenditure and health outcomes in South Africa varied across provinces depending on provincial management and infrastructure availability.

This essay thus asserts that health care (public health expenditure) positively affects the technical efficiency of South Africa's nine provinces. In addressing this hypothesis, this essay answers the question: What is the impact of health care on the technical efficiency of South Africa's nine provinces?

This essay differs from earlier studies, as it focuses on the sub-national level as opposed to the national level. It also differs from previous studies in establishing the indirect impact of health through TFP on economic growth. Furthermore, this essay uses Stochastic Frontier Analysis (SFA) as an alternative to the standard growth accounting and cross-country analyses that have been the main empirical techniques employed by neoclassical and new growth theories.

SFA is applied to South Africa's nine provinces over the period 2009 to 2018 to decompose output growth at the sub-national level to establish the impact of health care, which is proxied by public health expenditure. In line with previous literature, the analysis finds that health has a significant impact on the Technical Efficiency (TE) of South Africa's nine provinces.

The rest of this essay is structured as follows. Section 2 provides an overview of the theoretical and empirical literature regarding the growth theories underpinning the focus of this essay, as well as the impact of health on productivity and growth. In Section 3 (the methodology section), the general stochastic production frontier model is identified as the basis for the preferred empirical specification and research technique, while the data used is also outlined. In Section 4, the empirical results are presented. Section 5 concludes.

[62] STATS SA, GDP (2019).
[63] STATS SA, GDP (2019).

4.2. Literature Review

4.2.1. Theoretical Overview

Explaining the difference in growth rates among countries has been the focus of numerous economic studies, underpinned by the two main growth theories, i.e., neoclassical (exogenous) growth theory advanced by Solow (1956) and Swan (1956) and new (endogenous) growth theory introduced by Romer (1986) and Lucas (1988). Based on these two growth theories, the established growth literature attributes output growth to (i.e., decomposes growth into) physical capital (machinery and equipment), labour and knowledge [Total Factor Productivity (TFP)]. However, the essence of the exogenous and endogenous growth theories is that in the long-run, the rate of economic growth depends on the growth rate of TFP, which is determined by the rate of technological progress, i.e., economic growth is mainly attrubuted to TFP.

TFP represents the efficiency with which factors of production (capital and labour) are used and is a fusion of all other factors, other than physical capital and labour, that impacts on productivity, i.e., these other factors improve the level of output produced per unit of input. Human capital (education, health and skilled labour), which was identified by endogenous growth theory, is an example of a factor that can improve TFP (Romer, 1986 and Romer, 1990). Mankiw, Romer and Weil (1992) also emphasized the importance of human capital, as it serves as a catalyst to economic development.

Health, which is the focus of this essay, is an important form of human capital, because it increases workers' physical and mental capacities, which allow them to use technology more efficiently (Bloom and Canning, 2005 and Bloom et al., 2019). This has promted the identification of a number of parthways through which health improvements can influence income growth. In this regard, Bloom (2000) indicated that the impoved health of individuals directly increases their labour market participation and productivity. Better health is also associated with increasing life expectancy that creates incentives for individuals to invest more in education and retirement, resulting in greater accumulation of human and physical capital (Bloom et al., 2019; Bloom, Canning, and Moore, 2014; Prettner, 2013). ***Furthermore, better health reduces fertility that spurs sustained income growth*** (Bloom et al., 2019; Galor and Weil, 2000).

Thus, the mechanism through which the elements of TFP, which includes health, impacts on growth is through productivity that creates new profit opportunities; firms produce greater

output for the same level of input and earn higher revenues, which increases investment demand, inducing a level of saving and investment that makes capital per hour of labour grow and ultimately generate higher growth (Gross Domestic Product). However, as Garzarelli, Limam, and Rossi (2014) have noticed, the established growth literature does not allow for the decomposition of TFP to adequately reflect the contribution of other factors to output growth (including health), as it leaves a lumpy factor in output growth other than capital and labour.

4.2.2. Empirical Overview

Health, together with education and experience, is associated with human capital. Although empirical studies have traditionally used education and skills as human capital, Tompa (2002) and other authors have indicated that there is increasing attention been given to health as a form of human capital. In establishing the importance of health to output growth, the empirical studies on health are normally underpinned by the two growth theories and generally specify health as an input in the production function process, rather than including it as part of TFP (Venkataramani et al., 2006).

In providing a selection of papers that used health as a determinant of economic growth, Bloom et al. (2004) identified life expectancy as the most widely used indicator of health, establishing that life expectancy has a significant positive effect on the rate of economic growth. Bloom et al. (2001) and others have noted that life expectancy has appeared in many cross-country growth regressions, with the general finding that it has a significant positive effect on the rate of economic growth. In this regard, Sala-I-Martin (1997) identified that "out of more than 32,000 regressions involving permutations of over 60 variables, initial life expectancy is a positive and significant predictor of economic growth during 1960 to 1992 in more than 96 percent of the specifications". Life expextancy is thus one of the most robust predictors of subsequent economic growth. One of the channels through which health can affect productivity is through increasing life expectancy that creates incentives for individuals to invest in education, innovation and physical capital (Bloom et al., 2019). Murray and Chen (1992) and Murray and Lopez (1997) noted that even though it measures mortality rates rather than morbidity, higher life expectancy is generally associated with better health status and lower morbidity. Furthermore, Finlay (2007) indicated that life expectancy will expand the time horizon over which returns to education and savings for retirement can be earned, thus encouraging investment as the present value of lifetime earnings increases. Using an extended version of the neoclassical growth model and Three Stage Least Squares (3SLS), Barro (1996,

2013) investigated the relationship between life expectancy and economic growth employing panel data for 100 countries from 1960 to 1990. He found that a rise in life expectancy from 50 to 70 years (that is, by 40 percent) would raise the growth rate ***on impact*** by 1.4 percentage points per year. Bloom et al. (2001, 2004) established that a one-year improvement in a population's life expectancy contributes to a 4 percent increase in output, using an endogenous growth model and Two Stage Least Squares (2SLS) with a panel of countries observed every 10 years from 1960 to 1990. Similarly, Sachs and Warner (1997) used the general framework of the Solow growth model and Ordinary Least Squares (OLS) for a cross-section of Sub-Saharan Africa (SSA) countries for the period 1965 to 1990 to establish that, at the lowest level of life expectancy (in their sample of countries) at about 32 years, raising life expectancy by one year, to 33 years, is associated with a rise in average annual growth of 0.24 percentage points.

As a further measure of health, Barro (2013) established a negative relationship between fertility rate and economic growth, suggesting that a drop in the fertility rate would raise the growth rate of per capita output. In this regard, a higher fertility rate is associated with more resources being dedicated to childrearing, rather than to production (Becker and Barro, 1988). Using an extended version of the neoclassical growth model and Three Stage Least Squares (3SLS), while employing panel data for 100 countries from 1960 to 1990, Barro (1996, 2013), showed that the coefficient for fertility in his studies is negative, -0.016 (0.005) – a higher rate of fertility has a negative effect on growth. This is echoed by Bhargava, Jamison, Lau, and Murray (2001) that established that the total fertility rate in their study was negatively associated with GDP growth rates and was statistically significant, i.e., the coefficient for fertility in their study is significantly negative, -0.028 (0.008). In the conceptual framework for their analysis, they used the demographic literature relating life expectancy to income that was integrated with a commonly used growth model. They used a dynamic random effects model, with panel data for 92 countries between 1965 to 1990. In contrast to studies that focused on the direct impact of health on economic growth, Finlay (2007) used growth theory with a system of equations approach to jointly determine economic growth, education and fertility for a cross section of 63 countries from 1960 to 2000. They determined that the indirect effect of health on economic growth is positive and significant, i.e., a decrease in mortality will decrease fertility that will raise total years of schooling, which in turn increases GDP.

Tompa (2002) identified health expenditure as a further measure to capture health. Authors such as Aboubacar and Xu (2017) found that health expenditure has a significant impact on

economic growth, specifically in the Sub-Saharan Africa (SSA) region. The coefficient of health expenditure in their study is positive and significant, implying that a 1 percent increase in health expenditure, affects economic growth by 0.157 percent. They used growth theory with the General Method of Moments (GMM) technique, applying annual data on 36 SSA countries over the period 1995 to 2014. Similarly, Piabuo and Tieguhong (2017) found in their study that a unit change in health expenditure can potentially increase GDP per capita by 0.38 percent for five African countries that had 15 percent of their government expenditure on health. They used time series data for five Sub-Saharan African countries (Botswana, Rwanda, Zambia Madagascar, Togo) for the 1995 to 2015 period, employing endogenous growth models using Panel Ordinary Least Squares (OLS), Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS). The postive impact of health expenditure on growth is also affirmed by Baldacci, Clements, Gupta, Cui (2004) that estbalished that an increase in health spending of 1 percentage point of GDP is associated with a rise of 0.5 percentage point in annual per capita GDP growth. They used growth theory for a panel dataset of 120 developing countries from 1975 to 2000 and employing panel data regressions in a system of four equations for real per capita income growth, total investment, education attainment, and health status. In line with authors such as Baldacci, Clements, Gupta, Cui (2004) and others, this essay uses public health expenditure as a measure of health (i.e., health care).

Table 4A.4 in the Appendix reports a selection of the papers that include health as a determinant of economic growth, specifically focusing on those papers that use health expenditure, life expectancy and fertility rate as proxies for health.

Contrary to the overwhelming evidence outlined in these studies, Acemoglu and Johnson (2006) is one of a few studies that have found no positive effect of health improvements on economic growth. Their study is based on panel data for 59 countries for the period 1940 to 1980, using Ordinary Least Squares (OLS) and Two Stage Least Squares (2SLS) estimates. Exploiting the global epidemiological revolution (the wave of international health innovations and improvements that began in the 1940s) as an instrument for life expectancy, they argue that increasing life expectancy raises population growth that reduces the capital per worker, as in the neoclassical growth model, which in turn reduces income growth. This argument has, however, been refuted by authors such as Finlay (2007) who indicates that in addition to the direct effect of health on labour productivity, health can also influence economic growth through its incentive effect on education investment, i.e., ignoring the indirect effect of health on economic growth underestimate the positive impact health has on economic growth. Thus,

the overwhelming evidence from the literature is that improved health increases the quality of the workforce, enhances productivity and improves knowledge absorption.

It should however be noted that these empirical studies have generally specified health as an input in the production function, which does not detail how exactly health accomplishes this and it may not be desirable since health (as an input) in general is viewed as indirectly augmenting the production process (Venkataramani et al., 2006). Given this view, this study therefore differs from previous studies, as it focuses on health as part of TFP in impacting output growth, specifically exploring the impact of health care on the Technical Efficiency (TE) in production, with a focus on South Africa's nine provinces. According to Farrell (1957), TE reflects the ability of a firm to minimize input use so as to produce a given amount of output. Venkataramani et al. (2006) noted that this essentially means that health as a determinant of TE allows firms to use their capital and labour more efficiently.

To allow health care to be estimated as part of TFP in establishing its impact on TE in production, this study uses Stochastic Frontier Analysis (SFA). This empirical technique evolved as a further methodology to decompose output growth more satisfactorily, given the limitations of growth accounting and cross-country analysis to adequately clarify the sources of growth and their relative impact. In this regard, Makiela (2014) indicated that the established growth literature uses a one-stage decomposition of output growth. The more advanced methodology that emerged, i.e., Frontier Analysis (FA), subsequently used a two-stage decomposition of output growth. Thus, in addition to the traditional production factors (e.g., physical capital and labour), FA further decompose TFP into Technical Efficiency (TE) and Technical Change (TC) or progress. This two-stage decomposition of output growth assisted to further enhance the understanding of which components are relatively more important in determining output growth and it allows health to be estimated as part of TFP, instead of specifying it as an input in the production function process.

Makiela (2014) noted that this framework was first used in the context of a frontier analysis by Färe, Grosskopf, Norris, and Zhang (1994), who used Data Envelopment Analysis (DEA) to analyse economic growth of selected countries. Given the perceived limitation of DEA due to the linear function which significantly constraints the analysis, Koop, Osiewalski and Steel (1995, 1999) developed a stochastic frontier framework, i.e., using Stochastic Frontier Analysis (SFA) to derive the components of output growth. This essay follows the latter authors in using

SFA as the prefered method for decomposing output growth to estabish the impact of health on the technical efficiency of South Africa's nine provinces.

4.3. Methodology

4.3.1. Empirical Specification and Research Technique

According to Farrell (1957), Technically Efficient (TE) reflects the ability of a firm to minimize input use to produce a given amount of output. Using a production frontier, which represents the maximum output that a firm can generate from each level of input, firms (i.e., South Africa's nine provinces) in a particular industry operate either on the frontier, if they are TE, or beneath the frontier, if they are not. Farrell (1957) introduces the basic framework for studying and measuring inefficiency, which is defined as the deviations of actual from "optimum behaviour." Frontier Analysis establishes the optimum benchmark against which deviations are calculated. The literature distinguishes between two major concepts used for measuring this frontier function: non-parametric and parametric approaches. Fiorentino, Karmann and Koeter (2006), Kiyota (2011) and Kaparakis, Miller and Noulas (1994), and others, outline the two approaches as follows. The non-parametric approach, i.e., Data Envelopment Analysis (DEA), was introduced by Charnes, Coopers and Rhodes (1978) and consists of estimating the frontier by using linear programming to calculate piecewise linear segments of the efficient frontier. It neither imposes any assumptions about functional form of the frontier nor any distributional assumptions about inefficiency. Its main disadvantage lies in the fact that it is unable to decompose the deviations of a certain firm from the efficient production frontier into components: inefficiency and random error parts. The parametric approach, i.e., Stochastic Frontier Analysis (SFA), was developed (independently) by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) and estimates the frontier with statistical methods. It imposes an explicit functional form for both the frontier and deviations from it that is inefficiency. SFA is considered to be more sophisticated compared to DEA, as the estimation of efficiency is based on economic optimisation, given the underlying assumption of a stochastic optimal frontier. It allows for incorporating technical efficiencies and decomposes random error terms and the inefficiency of the production unit and takes into account the existence of exogenous shocks or statistical noise. As mentioned earlier, this is the preferred method of this essay, given its advantages over DEA.

The general stochastic production frontier model used by this essay has as its main focus the decomposition of TFP to obtain an estimator for one of its constituent parts, i.e., Technical

Efficiency (TE). The other component of TFP is Technical Change (TC), which is depicted by a time trend and interactions of the regressors with time. Although early studies on SFA used cross-section data, later studies employed panel data. In line with these later authors, this essay uses panel data to construct the frontier production function as:

$$Y_{it} = X_{it}\beta + v_{it} - u_{it}, \quad \textbf{(4.1)}$$

where Y_{it} presents the output of province i at time t; X_{it} is a vector containing the production inputs; β is a vector of unknown parameters; v_{it} is a symmetric random error to account for statistical noise; and u_{it} is a non-negative random variable associated with technical inefficiency.

Assuming a transformation of model (4.1) to a translog production function, with South Africa's nine provinces producing three production factors, namely physical capital, labour and human capital, the new model can be expressed in the following way:

$$InY_{it} = \alpha_0 + \alpha_1 InK_{it} + \alpha_2 InL_{it} + \alpha_3 InHC_{it} + \alpha_4 TInK_{it} + \alpha_5 TInL_{it} + \alpha_6 TInHC_{it} + \alpha_7 T + \alpha_8 T^2 + v_{it} - u_{it}\ , \quad \textbf{(4.2)}$$

where for province i at time t, *Y* is output, *K* is capital, *L* is labour, *HC* is human capital, *T* is a time trend to account for Technical Change TC, v is a random error that accounts for statistical noise, and u is a non-negative random variable associated with technical inefficiency.

This essay assumes, following Garzarelli, Limam, and Rossi (2014), that a province's distance to the best practice output level is a function of its level of health care. In the literature, the impact of health on economic growth is analysed using a variety of population health indicators such as life expectancy, adult survival rate, child mortality, fertility rate, adult height, etc. However, based on data availability and relevance identified by the literature, health care is reflected by Public Health Expenditure (*PHE*). The hypothesis is that health care (public health expenditure) positively affects the technical efficiency of South Africa's nine provinces. Public health expenditure is selected, as health investments could lead to large improvements in health outcomes (e.g. increased life expectancy and reduced fertility rates) that expand prodictivy and growth (Barro, 2013). Health spending affects growth directly or indirectly through the accumulation of education and health capital. In this regard, Baldacci, Clements, Gupta, Cui (2004) noted that an increase in health spending of 1 percentage point of GDP is associated

with an increase of 0.6 percentage points in the under-5 child survival rate, a rise by about 2 percentage points (i.e., from 90 to 92) in the net enrollment rate (education) and a growth rate that would rise by a total of 0.5 percentage point in annual per capita GDP.

Based on its relevance, the essay estimates a stochastic frontier where the technical inefficiency component u_{it} of equation (4.2) is modelled according to one specification relating to Public Health Expenditure (*PHE*):

$$u_{it} = \delta_0 + \delta_1 PHE + \omega_{it}. \qquad \textbf{(4.3)}$$

One version of equation (4.2) is estimated for South Africa's nine provinces, with technical inefficiency modelled as reflected in equation (4.3). As mentioned earlier, most empirical studies have studied the direct impact of health on growth, with studies that analyse the indirect impact of health (as in the current study) not that common. The empirical literature that focuses on exogenous and endogenous growth theory thus informs the variable selection for the model specification in equation (4.3). The use of public health expenditure as part of the inefficiency component is informed by authors such as Rivera and Currais (1999), Baldacci, Clements, Gupta, and Cui (2004) and Piabuo and Tieguhong (2017) that use this variable in their studies to establish the impact of health on economic growth. Rivera and Currais (1999), for example, established that between 21 and 47.5 percent of GDP per worker, over the 1960 to 1990 period, can be explained by improvements in health-care expenditures at the country level.

All the unknown parameters in model (4.2) were estimated in a single-stage Maximum-Likelihood (ML) procedure, promoted by Coelli, Prasada Rao, O'Donnell, and Battese (2005) and using FRONTIER, a computer programme for SFA, developed by Coelli (1996), specifically for the measurement of efficiency and/or productivity. Coelli (1996) indicated that FRONTIER considers two primary model specifications (i) an error components specification with time-varying efficiencies permitted, proposed by Battese and Coelli (1992) and (ii) a model specification in which the firm (provincial) effects are directly influenced by a number of variables (i.e., health), proposed by Battese and Coelli (1995). This essay considers the latter model specification of Battese and Coelli (1995) that is expressed as:

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it}) \qquad , i = 1, \ldots., N, t = 1, \ldots., T, \qquad \textbf{(4.4)}$$

where Y_{it} is the logarithm of the production of province i at time t; X_{it} is a $kx1$ vector of input quantities (capital, labour and human capital) of province i at time t; β is a vector of unknown

parameters; the V_{it} are random variables assumed to be $iid.N(0, \sigma_{V^2})$ and independent of the U_{it} which are non-negative random variables (e.g., health for the current essay) assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the $N(M_{it}, \sigma_{U^2})$ distribution; where:

$$M_{it} = Z_{it}\delta, \tag{4.5}$$

where Z_{it} is a $px1$ vector of variables (health in the current essay) which may influence the efficiency of a province; and δ is a $1xp$ vector of parameters to be estimated (Coelli, 1996).

4.3.2. Data

Data on *Y* (output), *K* (capital), *L* (labour), *HC* (Human Capital), and *PHE* (Public Health Expenditure) is from STATS SA and is for South Africa's nine provinces for the period 2009 to 2018. Output (*Y*) is GDP at constant 2010 prices, labour (*L*) is the labour force in millions, and human capital (*HC*) is proxied by the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education. Although average years of schooling or enrolment rates is used by Mankiw, Romer and Weil (1992) and others, as proxy for human capital, this essay uses educational attainment to reflect human capital, in line with authors such as Rivera and Currais (1999), Barro (2013) and Caselli (2005). Data on capital (*K*) is obtained from Quantec (2022) and is proxied by Gross Fix Capital Formation (GFCF) at constant 2015 prices.

Capital (*K*) is normally reflected by the stock of private physical capital in empirical studies, e.g., Baier, Dwyer and Tamura (2006) and Garcia-Milà, McGuire and Porter (1996). However, due to data constraints it necessitated the literature to proxy physical capital by those data which are directly observable (Benhabib and Spiegel, 1994). Barro (1991) notes that the literature has therefore used gross investment rates [e.g., Gross Fix Capital Formation (GFCF)] as a proxy for physical capital accumulation, with Barro (1989) using real investment expenditures (both private and public) as proxy for capital. Thus, in line with Barro (1989) and Benhabib and Spiegel (1994), this essay uses GFCF as a proxy for capital.

Table 4.1 provides an overview of the data used, which indicates that the Northern Cape has the lowest GDP, capital formation, labour force and expenditure on public health, while Limpopo has the lowest number of individuals aged 20 years and older who have completed

grade 12 as highest level of education, the proxy for human capital. Gauteng consistently ranks highest on all variables (GDP, capital, labour, human capital, and public health expenditure). In terms of public health expenditure (*PHE*), the mean value in 2018 for the nine provinces is R14 billion, with Gauteng having the highest expenditure on health at R41 billion, while the Northern Cape only spent R2 billion on health. Gauteng's expenditure on health is substantially above the mean, while the data does not reflect a noticeable variation from the mean, at R9 billion.

Table 4.1: Data Description - South Africa's 9 Provinces

Variable	Minimum		Maximum		Mean	Median	Standard Deviation
Y	Northern Cape	59	Gauteng	1,099	330	220	275
K	Northern Cape	14	Gauteng	256	83	58	63
L	Northern Cape	0.38	Gauteng	7.21	2.25	1.66	1.75
HC	Limpopo	15.30	Gauteng	34.95	25.51	26.03	4.86
PHE	Northern Cape	2	Gauteng	41	14	10	9

Notes: Y, K and PHE are in R billions. L is the labour force in millions. HC is Human Capital, which is the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education. Number of provinces N = 9.

4.4. Results

4.4.1. Hypothesis Testing

As stochastic frontier analysis requires a series of statistical tests, two hypothesis tests were performed to establish the appropriateness of some of the test procedures. First, based on the existence of the inefficiency component, u_{it}, we test whether an OLS rather than stochastic frontier estimation better represent the data. This entails testing the null hypothesis that the frontier coefficients are jointly insignificant against the alternative hypothesis that at least one of the coefficients is significant, i.e., testing $H_0: \gamma = u = 0$. The results show that the H_0 is strongly rejected, which specify that frontier analysis is a better estimation technique than OLS. Second, we check whether a translog production function fits the data better than a Cobb-Douglas production function, i.e., testing whether we can reject $H_0: \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$. The results in Table 4.2 denote that the null hypothesis is rejected, which indicates that the translog specification is a better fit than the Cobb-Douglas speficication.

Table 4.2: Hypothesis Testing - Health Care in SA 9 Provinces

Null Hypothesis Testing		LR	Critical Value	Degrees of Freedom	Decision at 5% Significance
SF versus OLS:	$H_0: \gamma = u = 0$	14.89	7.815	3	Reject
Cobb Douglas versus Translog:	$H_0: \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$	36.58	7.815	3	Reject

Notes: LR, Likelihood Ratio; SF, Stochastic Frontier; OLS, Ordinary Least Squares

4.4.2. Empirical Results

Table 4.3 summarises the results on technical efficiency ranking for South Africa's nine provinces. Results show that the average technical efficiency for the nine provinces is of the order 0.92, indicating that, on average, provinces register more than 92% of the efficiency of the most efficient province. Technical efficiency scores are quite stable, as shown by the mean value and standard deviation (only 4 percent deviation from the mean, with scores varying between a minimum of 85 percent and a maximum of 97 percent). Gauteng and Limpopo have the highest rank whereas the Free State and Mpumalanga are the lowest ranked. These results are reflective of both health and economic factors peculiar to each individual province.

Table 4.3: SA 9 Provinces and Technical Efficiency Averages - Health Care

Province	Technical Efficiency
Gauteng	0.9681
Limpopo	0.9608
Northern Cape	0.9490
North West	0.9412
Western Cape	0.9229
KwaZulu-Natal	0.9149
Eastern Cape	0.8845
Free State	0.8808
Mpumalanga	0.8475
Average	**0.9189 (0.0408)**

Mpumalanga's low efficiency score is related to its low public health expenditure, with the province ranked last in 2016 of all nine provinces in terms of provincial government spending on health care per person at R2,704, below the national figure of R3,332.[64] This is critical, as higher health care expenditure is associated with higher efficiency and higher economic growth (Aboubacar and Xu, 2017). The economic factors impacting on Mpumalanga's low efficiency score are: (i) its low Municipal Financial Suntainability Index (MFSI)[65] score of 30, in 2018, less than the national average of 38, pointing to inadequate financial management practices and discipline in its municipalities that impact negatively on their service delivery ability,[66] and (ii) the low quality of its road network, with the province ranked third worst amongst South Africa's provinces in 2013, leading to higher logistics costs.[67]

[64] STATS SA, Mid-year population estimates (2019).
[65] The MFSI is a scoring model developed by Ratings Africa that evaluates the operating performance, liabilities management, budget practices and liquidity position of a municipality and scores these components out of a 100.
[66] Ratings Africa (2019).
[67] CSIR (2014), The State of Logistics Survey for South Africa available at https://www.csir.co.za/sites/default/files/Documents/10th_SoL_Bold_Steps_Forward_web.pdf.

In the Free State, its health factors contribute to its low efficiency score. In 2016, the province had the second lowest public health expenditure (R9.53 billion)[68] and the lowest life expectancy (59) of the nine provinces (refer to Table 4.4). Thus, according to Bloom et al. (2019), the Free State's low life expectancy does not create incentives for individuals to invest in education, innovation and physical capital, affecting productivity and economic growth. The economic factors that impact on its low efficiency score are: (i) Its economic structure, where government services are the largest industry, accounting for 15.5 percent of the provincial GDP and likely leading to increased inefficiencies[69]. This is reflected in the quality of the financial and operational management of the Free State's municipalities, i.e., the governance of its municipalities. With an average MFSI score of 17 in 2018, less than the national average of 38, the Free State has to deal with inadequate financial management practices and discipline in its municipalities that impact negatively on their service delivery ability[70]. (ii) The quality of its road network, which in 2013 consisted of around 65 percent poor and very poor roads and ranked the worst amongst South Africa's provinces, based on the percentage of poor and very poor roads. Various studies have proved that a strong correlation exists between the condition of roads and higher logistics costs that impact on economic growth[71].

Table 4.4: South Africa's 9 Provinces Health Indicators - 2018

Province	PHE	TFR	LE
Gauteng	41	1.90	66.34
KwaZulu-Natal	39	2.78	61.41
Eastern Cape	22	2.85	62.96
Western Cape	21	2.01	68.33
Limpopo	18	2.90	64.63
Mpumalanga	12	2.44	64.32
North West	10	2.68	61.82
Free State	10	2.34	58.99
Northern Cape	5	2.61	61.71

Notes: Public Health Expenditure (PHE) are in R billions. Total Fertility Rate (TFR) is the average number of children that would be bo alive to a woman (or a group of women) during her lifetime if she were to pass through all her childbearing years conforming to the ag specific fertility rates of a given year. Life Expectancy (LE) at birth reflects the overall mortality level of a population. The data reflects t average provincial life expectancies at birth for the 5-year periods 2001–2006; 2006–2011; 2011–2016 and 2016–2021.
Source: STATS SA, Financial statistics of provincial government & Mid-Year Population Estimate

In the case of Gauteng, its health factors are of particular importance to its high efficiency score, as in 2016, the province had the highest public health expenditure (R41.1 billion) of the nine provinces,[72] the lowest total fertility rate (1.90)[73] of the nine provinces, while it was ranked second in terms of life expectancy (66) of all nine provinces (refer to Table 4.4). The economic

[68] STATS SA, Financial statistics of provincial government.
[69] STATS SA, GDP (2019).
[70] Ratings Africa (2019).
[71] CSIR (2014), The State of Logistics Survey for South Africa available at https://www.csir.co.za/sites/default/files/Documents/10th_SoL_Bold_Steps_Forward_web.pdf.
[72] STATS SA, Financial statistics of provincial government.
[73] STATS SA, Mid-year population estimates.

factors impacting on its high efficiency score are: (i) finance (that contributes to efficiency improvements and growth) being the largest industry in the province, accounting for 21.4 percent of the province's GDP and employing 43.7 percent of the labour force in 2018,[74] (ii) the province having more high skilled labour (30.3 percent) than the national proportion of 22.9 percent,[75] which strongly and positively affect technical efficiency (Garzarelli, Limam and Rossi, 2014) and (iii) its relatively developed road network, which in 2013 consisted of around 52 percent good and very good roads and only 14 percent poor and very poor roads, the best of all nine provinces, leading to lower logistics costs.

The high efficiency score for Limpopo is somewhat surprising, as one would have expected the Western Cape and Kwazulu-Natal to be more efficient, given their higher relative ranking in relation to Limpopo on a number of key indicators, e.g., economic size (GDP), capital expenditure (GFCF), labour, and human capital. It should, however, be noted that the difference in efficiency scores (standard deviation) between Limpopo and the Western Cape and Kwazulu-Natal is only 1.8 percent, implying that there might be other indicators that positively contribute to Limpopo's higher efficiency score. Its health factors might provide some of the reason, as in 2016, the province had the fifth highest public health expenditure (R18 billion) of the nine provinces[76], while it was ranked third in terms of life expectancy (65) of all nine provinces (refer to Table 4.4). Limpopo's economic factors might also explain its high efficiency score. In the case of Limpopo, the province had a GDP of R226 billion at constant 2010 prices in 2018, accounting for 7.2 percent of South Africa's GDP, the sixth largest provincial economy. Its average growth rate of 1.5 percent between 2009 and 2018 was lower than the national average of 1.8 percent[77]. Despite its low economic performance, Limpopo had a labour absorption rate of 39 percent between 2009 and 2018, close to the national absorption rate of 43 percent (between 2009 and 2018). Of interest is Limpopo's low unemployment rate of 18.7 percent between 2009 and 2018, lower than the national average rate at 27.1 percent and the lowest amongst the nine provinces[78]. Limpopo's high efficiency score may be attributed to, amongst other, its relatively developed road network, which in 2013 had around 53 percent good and very good roads, a higher percentage than the other provinces. It also had only 19 percent poor and very poor roads, the second lowest amount of all provinces. The implication is lower logistics costs that impact positively on efficiencies and economic growth[79]. A further

[74] STATS SA, Quarterly Labour Force Survey (QLFS) (2019).
[75] STATS SA, Labour Market Dynamics in South Africa.
[76] STATS SA, Financial statistics of provincial government.
[77] STATS SA, GDP (2019).
[78] STATS SA, Quarterly Labour Force Survey (QLFS) (2019).
[79] CSIR (2014), The State of Logistics Survey for South Africa available at https://www.csir.co.za/sites/default/files/Documents/10th_SoL_Bold_Steps_Forward_web.pdf.

positive element of Limpopo's high efficiency score is that although Limpopo's MFSI score has been decreasing since 2014, it was consistently above the national average in four out of the last five years. In 2014 Limpopo had a MFSI score of 55, higher than the national average score of 43 and the second highest provincial score. In 2017, it had a MFSI score of 44, higher than the national average score of 42 and the third highest provincial score. This points to relatively adequate financial management practices and discipline in its municipalities[80]. As an enhancement of its government services (the second largest industry in the province at 17.7 percent in 2018), Limpopo had a Gini-Coefficient of 0.61 in 2015 that is lower than the national figure of 0.65. This indicates higher provincial spending on services that improve productivity and ultimately economic growth[81].

Table 4.5 presents the results of the stochastic frontier estimations. The first nine rows show the coefficients of the estimated frontiers based on equation (4.2), while the next four lines displays the coefficients of the equation explaining technical inefficiency based on specification (4.3). The last three rows report the two inefficiency statistics (the inefficiency variance, σ_u^2, and the inefficiency indicator, γ, which measures the percentage of the error term that is explained by inefficiency) and the log-likelihood.

Table 4.5: Stochastic Frontier and Technical Efficiency Estimation - Health Care

Parameter	Variable	Estimate	Standard Error	t-ratio
α_0	Frontier Intercept	11.0837*	0.7924	13.9872
α_1	ln*K*	0.0955***	0.0622	1.5352
α_2	ln*L*	0.9394*	0.0545	17.2470
α_3	ln*HC*	-0.1681*	0.0571	-2.9420
α_4	*T*ln*K*	0.0437*	0.0155	2.8188
α_5	*T*ln*L*	-0.0472*	0.0136	-3.4645
α_6	*T*ln*HC*	0.0470*	0.0125	3.7470
α_7	*T*	-0.5831*	0.1783	-3.2704
α_8	T^2	0.0008	0.0009	0.8915
δ_0	Inefficiency Intercept	0.9115**	0.4983	1.8290
δ_1	ln*PHE*	-0.0377**	0.0220	-1.7122
σ_u^2	Inefficiency Variance	0.0073*	0.0009	8.4922
γ	Inefficiency indicator	1.0000*	0.0000	458,687.8400
	Log-Likelihood	136.7886		

Notes: * Significant at 1%; ** Significant at 5%; *** Significant at 10%. Number of provinces N = 9. Number of periods T = 10.

Consistent with expectations, capital (ln*K*) and labour (ln*L*) positively impact on output growth, while against expectations, human capital (ln*HC)* negatively impact on output growth. Human

[80] Ratings Africa (2019).
[81] STATS SA (2019), Inequality Trends in South Africa - A multidimensional diagnostic of inequality, Report No. 03-10-19 available at http://www.statssa.gov.za/publications/Report-03-10-19/Report-03-10-192017.pdf.

capital may be explained by the lack of skilled workers in the various provinces, as around 22.9 percent of South Africa's workforce is skilled, while 77.1 percent of the workforce is semi-skilled or low-skilled.[82]

Although technology change (T and T^2) for the nine provinces has a negative impact on output growth, it interacts positively with both physical and human capital to generate output growth, i.e., technology change is physical and human capital augmenting. However, technology change does not interact with labour to generate output growth, i.e., technology change is not labour augmenting.

In relation to the coefficient of the technical efficiency component, the coefficient on the Public Health Expenditure (*PHE*) variable is negative and significant, implying a positive impact on technical efficiency and growth. [83] This implies that public health expenditure seems to increase efficiency, in line with the literature that indicates that there is a strong positive relationship between health care expenditure and the quality of the workforce, i.e., increased productivity and economic growth (Alexa, Pop-Silagh and Cismas, 2016, Aboubacar and Xu (2017), Piabuo and Tieguhong (2017), and others).

Given the positive impact of public health expenditure on the efficiency of South Africa's nine provinces, it is important that policy should be directed at public health measures that according to Bloom et al. (2019) are an important lever for fostering economic growth. The Commission on Macroeconomics and Health (2001) identified vaccination programmes, antibiotic distribution programmes, and micronutrient supplementation schemes, as the types of health investments that could lead to large improvements in health outcomes (e.g., increased life expectancy) for relatively low expenditures. With improved health outcomes, fertility rates typically decline and thereby expand productivy and growth (Barro, 2013). The implication is that although public health expenditure has been shown to increase efficiencies, the negative real rate of growth in public health expenditure has meant that the full benefits of increased prodcutivity and economic growth have not accrued to South Africa's nine provinces. In this regard, the negative real average annual growth rate for public health expenditure was -10.7 percent between 2009 and 2018 in South Africa's nine provinces. The Northern Cape (the lowest) had a negative real average annual growth rate of -28.9 percent, while Mpumalanga (the highest) had a rate of -3.9 percent, as refelcted in Table 4A.5 in the Appendix. It is thus

[82] STATS SA, GDP (2019).
[83] In SFA, a negative coefficient for an efficiency component indicates a positive effect and vice versa.

imperative that the provincial health departments ensure that their health programmes over the Medium-Term Expenditure Framework (MTEF) take the inflation rate into account in order for a positive real rate of growth in public health expenditure, as alluded to by UNICEF (2017).

Given the important link between public health expenditure, life expectancy and economic growth, a study on their interplay in the Nigerian economy is instructive. Using time series data between 1977 to 2008 and a Vector Autoregressive (VAR) model, Ogungbenle, Olawumi and Obasuyi (2013) found a positive relationship exists among gross domestic product, public health expenditure and life expectancy in Nigeria. Furthermore, they found (i) no causal linkage between life expectancy and public health expenditure, implying that for life expectancy to improve in Nigeria, public health spending should increase; (ii) no causal linkage between life expectancy and economic growth suggesting that sustainable economic growth is dependent on measures to boost life expectancy and (iii) a causal linkage between public health expenditure and economic growth indicating that if the Nigerian government can increase public health expenditure, it will boost economic growth.

4.5. Conclusion

The hypothesis of this essay is that health care positively affects the technical efficiency of South Africa's nine provinces. Stochanstic Frontier Analysis is applied to South Africa's nine provinces to decompose output growth to establish the impact of health care on the technical efficiency of South Africa's nine provinces. This is to account for the limitations of the standard empirical techniques used by growth accounting and cross-country analysis (i.e., neoclassical and new growth theories) that do not adequately clarify the sources of growth and their relative impact. A limitation of specific interest to this essay is the fact that most empirical studies have studied the direct impact of health on growth, with studies that analyse the indirect impact of health (as in the current study) not that common. Therefore, based on a review of the literature by this essay, health (public health expenditure) as part of the inefficiency component in a frontier analysis has not been identified in other studies. The empirical literature that focuses on exogenous and endogenous growth theory thus informs the variable selection for the model specification in equation (4.3). A further limitation relates to data availability at a sub-national level, i.e., data for South Africa's nine provinces for the period 2009 to 2018 for capital (K) and human capital (HC). While capital (K) is normally reflected by the stock of private physical capital in empirical studies, data constraints have necessitated the use of Gross Fix Capital Formation (GFCF) as a proxy, given its direct observability (Barro, 1989). In the case of human

captal (*HC*), data availability has also necessitated the use of educational attainment, i.e., the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education to reflect human capital (HC) (Rivera and Currais, 1999). This is in contrast to the normal use of average years of schooling or enrolment rates, as is the case with Mankiw, Romer and Weil (1992) and others.

The contribution this essay makes to the literature is that it enhances the understanding of economic growth at a sub-national level as opposed to the national level, which is the focus of most empirical studies. In addition, using public health expenditure as a health indicator, this essay establishes the indirect impact of health through TFP on economic growth. This is to account for the fact that health spending affects growth directly or indirectly through the accumulation of education and health capital (Finlay, 2007). Furthermore, this essay uses Stochastic Frontier Analysis (SFA) as an alternative to the standard growth accounting and cross-country analyses that have been the main empirical techniques employed by neoclassical and new growth theories.

As consistent with the literature, Aboubacar and Xuv(2017) and Piabuo and Tieguhong (2017), it is established that health (public health expenditure) has a significant impact on the Technical Efficiency (TE) of South Africa's nine provinces, implying that the firms in the various provinces are able to use their physical inputs (such as labour or capital) in a more efficient manner (Venkataramani et al., 2006).

To allow life expectancy to improve in South Africa's nine provinces, as sustainable economic growth is dependent on measures to boost life expectancy, public health spending should increase, in line with the findings of Ogungbenle, Olawumi and Obasuyi (2013) in Nigeria. This suggests that the provincial governments should ensure a positive real rate of growth in their public health expenditures and that their health investments (e.g., vaccination programmes, antibiotic distribution programmes, micronutrient supplementation schemes, etc.) should increase to allow for a positive pass-through to increased health outcomes, i.e., increased life expectancy and reduced fertility rates that have a positive impact on productivity and economic growth.

The limitations of this essay relating to data constraints at the sub-national level, suggest that future research should assist in refining the variables used as proxies for capital (*K*) and human capital (*HC*). In the case of human capital (*HC*), data availability on average years of schooling

or enrolment rates should be considered. As this essay focused on public health expenditure (health care) as a proxy for health, future research should also explore the impact of life expectancy and fertility rate as further measures of health. In this regard, it is important to note that Bloom et al. (2004) identified life expectancy as the most widely used indicator of health, establishing that life expectancy has a significant positive effect on the rate of economic growth. Furthermore, Barro (2013) established a negative relationship between fertility rate and economic growth, suggesting that a drop in the fertility rate would raise the growth rate of per capita output.

4.6. References

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4.7. Appendix

Table 4A.1: South Africa's Nine Provinces Public Health Expenditures (PHE)

Province	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	CAGR (2009-2018)
Western Cape	8,567,075	10,245,114	12,201,802	13,236,841	14,398,482	15,700,000	17,072,000	18,502,000	19,832,000	21,256,000	10.6%
Eastern Cape	10,025,123	11,612,323	12,724,924	14,327,813	15,067,124	16,440,000	16,972,000	18,363,000	19,914,000	21,679,000	8.9%
Northern Cape	1,715,039	2,176,171	2,495,607	2,949,349	3,084,088	3,349,000	3,653,000	4,101,000	4,299,000	4,511,000	11.3%
Free State	4,397,651	5,174,873	5,937,392	6,722,080	7,467,690	7,573,000	8,133,000	8,524,000	8,894,000	9,531,000	9.0%
KwaZulu-Natal	16,629,114	19,701,132	19,994,302	23,986,774	26,567,434	28,709,000	30,458,000	33,302,000	36,115,000	38,946,000	9.9%
North West	4,332,180	5,006,716	5,505,573	6,156,692	6,782,868	8,082,000	8,092,000	8,728,000	9,312,000	9,928,000	9.7%
Gauteng	15,182,434	17,856,422	20,077,541	23,204,403	26,071,198	26,632,000	30,274,000	34,098,000	36,595,000	41,151,000	11.7%
Mpumalanga	4,364,758	5,612,347	6,330,307	6,995,333	7,260,518	7,787,000	8,570,000	9,743,000	10,267,000	11,783,000	11.7%
Limpopo	7,750,868	8,775,592	10,217,864	11,064,316	12,533,602	12,821,000	14,186,000	15,083,000	16,844,000	18,009,000	9.8%
Total	**72,964,242**	**86,160,690**	**95,485,312**	**108,643,601**	**119,233,004**	**127,093,000**	**137,410,000**	**150,443,000**	**162,072,000**	**176,794,000**	10.3%

Source: STATS SA, Financial statistics of provincial government

Table 4A.2: South Africa's Nine Provinces PHE as % of Provincial GDP

Province	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	CAGR (2009-2018)
Western Cape	2.4%	2.7%	3.2%	3.3%	3.5%	3.8%	4.0%	4.3%	4.6%	4.9%	8.4%
Eastern Cape	4.8%	5.5%	5.8%	6.4%	6.6%	7.1%	7.3%	7.9%	8.5%	9.2%	7.3%
Northern Cape	2.9%	3.6%	4.1%	4.7%	4.8%	5.0%	5.4%	6.2%	6.3%	6.6%	9.4%
Free State	3.1%	3.5%	4.0%	4.3%	4.7%	4.7%	5.1%	5.3%	5.5%	5.9%	7.5%
KwaZulu-Natal	4.0%	4.5%	4.4%	5.2%	5.6%	5.9%	6.2%	6.8%	7.2%	7.7%	7.7%
North West	2.5%	2.8%	3.0%	3.4%	3.6%	4.5%	4.3%	4.8%	5.1%	5.4%	8.9%
Gauteng	1.7%	1.9%	2.1%	2.3%	2.5%	2.5%	2.9%	3.2%	3.4%	3.7%	9.3%
Mpumalanga	2.2%	2.8%	3.1%	3.3%	3.4%	3.5%	3.9%	4.4%	4.5%	5.2%	9.9%
Limpopo	3.9%	4.3%	4.9%	5.3%	5.8%	5.9%	6.4%	6.9%	7.5%	8.0%	8.2%
South Africa	**2.7%**	**3.1%**	**3.4%**	**3.7%**	**4.0%**	**4.2%**	**4.5%**	**4.9%**	**5.2%**	**5.6%**	8.3%

Source: STATS SA, Financial statistics of provincial government

Table 4A.3: South Africa's Nine Provinces % Contribution to Total PHE

Province	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Western Cape	11.7%	11.9%	12.8%	12.2%	12.1%	12.4%	12.4%	12.3%	12.2%	12.0%
Eastern Cape	13.7%	13.5%	13.3%	13.2%	12.6%	12.9%	12.4%	12.2%	12.3%	12.3%
Northern Cape	2.4%	2.5%	2.6%	2.7%	2.6%	2.6%	2.7%	2.7%	2.7%	2.6%
Free State	6.0%	6.0%	6.2%	6.2%	6.3%	6.0%	5.9%	5.7%	5.5%	5.4%
KwaZulu-Natal	22.8%	22.9%	20.9%	22.1%	22.3%	22.6%	22.2%	22.1%	22.3%	22.0%
North West	5.9%	5.8%	5.8%	5.7%	5.7%	6.4%	5.9%	5.8%	5.7%	5.6%
Gauteng	20.8%	20.7%	21.0%	21.4%	21.9%	21.0%	22.0%	22.7%	22.6%	23.3%
Mpumalanga	6.0%	6.5%	6.6%	6.4%	6.1%	6.1%	6.2%	6.5%	6.3%	6.7%
Limpopo	10.6%	10.2%	10.7%	10.2%	10.5%	10.1%	10.3%	10.0%	10.4%	10.2%
GDP at market prices	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: STATS SA, Financial statistics of provincial government

Table 4A.4: Estimates of the effect of health on economic growth

Study	Dependent Variable	Health Measure	Other Covariates	Growth Effect	Data & Country	Estimator
Aboubacar and Xu (2017)	Average GDP per capita	Health expenditure per capita	Average Foreign Direct Investment (FDI), Official Development Assistance (ODA), Population age, Gross Domestic Saving (GDS)	The coefficient of health expenditure is positive and significant, implying that a 1% increase in health expenditure, affects economic growth by 0.157%	Annual data on 36 Sub-Saharan Africa countries over the period 1995 to 2014	Growth theory using General Method of Moments (GMM)
Baldacci, Clements, Gupta, Cui (2004)	Average real GDP per capita	Health spending (in percent of GDP), Under-5 child mortality (per 1000 live births), Fertility rate (per 1000 people per year)	Investment ratio, Composite enrolment rate, Primary school enrolment rate, Secondary school enrolment rate, Education spending, population growth, Trade openness, Changes in terms of trade, Fiscal balance, Inflation rate, Governance index	An increase in health spending of 1 percentage point of GDP is associated with a rise of 0.5 percentage point in annual per capita GDP growth	A panel dataset for 120 developing countries from 1975 to 2000	Growth theory using panel data regressions in a system of four equations for (1) real per capita income growth, (2) total investment, (3) education attainment, and (4) health status
Barro (1996 & 2013)	GDP	Life Expectancy, Fertility Rate	Male secondary and higher schooling, log(GDP) x male schooling, Government consumption ratio, Rule of law index, Terms of trade change, Democracy index, Democracy index squared , Inflation rate	A rise in life expectancy from 50 to 70 years (that is, by 40 percent) would raise the growth rate on impact by 1.4 percentage points per year The coefficient for life expectancy is a significantly positive 0.042 (0.014) - life expectancy proxies not only for health status but more broadly for the quality of human capital The coefficient for fertility is significantly negative -0.016 (0.005) - a higher rate of fertility has a negative effect on growth	Panel data for 100 countries from 1960 to 1990	Extended version of the neoclassical growth model using Three Stage Least Square (3SLS)

Study	Dependent Variable	Health Measure	Other Covariates	Growth Effect	Data & Country	Estimator
Bhargava, Jamison, Lau, and Murray(2001)	Real GDP per capita	Adult survival rate, Fertility rate	Tropics, openness, Logarithm of investment/GDP ratio	Total fertility rate was negatively associated with GDP growth rates and was statistically significant, i.e., the coefficient for fertility is significantly negative -0.028 (0.008)	Panel data for 92 countries between 1965–1990	Demographic literature relating life expectancy to income and integrated with growth models, using dynamic random effects model
Bloom, Canning and Sevilla (2001) & (2004)	GDP	Life Expectancy	Schooling, Experience, Experience squared, Technology catch-up	A one-year improvement in a population's life expectancy contributes to a 4 percent increase in output	A panel of countries observed every 10 years from 1960 to 1990	Endogenous growth model using Two Stage Least Square (2SLS)
Esen and Keçili (2021)	GDP per capita	Health expenditure per capita, Life expectancy at birth	Household consumption per capita (logged), Trade, Foreign direct investment (logged)	There is a unidirectional relationship between health expenditure per capita, life expectancy and GDP per capita. Thus, as health expenditure and life expectancy increase, this has a significant impact on GDP per capita	Time series data for the period 1975 to 2018 for Turkey	Growth theory using Granger causality test
Finlay (2007)	Real GDP per capita	Fertility rate, Adult male mortality, Life expectancy	Total years of schooling, East Asian & African countries dummy, Population coastal density, Fraction of tropical area, Malaria prevalence in 1960s, Fraction Confucian	The indirect effect of health on economic growth is positive and significant, i.e. a decrease in mortality will decrease fertility, raising total years of schooling, increasing GDP	Cross section of 63 countries from 1960 to 2000	Growth theory using a system of equations approach to jointly determine economic growth, education and fertility

Study	Dependent Variable	Health Measure	Other Covariates	Growth Effect	Data & Country	Estimator
Piabuo and Tieguhong (2017)	GDP per capita	Health expenditure per capita, Life expectancy	Household final consumption expenditure per capita, Labour force, Trade (% of GDP)	A unit change in health expenditure can potentially increase GDP per capita by 0.38% and 0.3 % for the five other African countries that achieve the Abuja target of a 15% increase in health expenditure and for Economic Community for Central African (CEMAC) countries respectively	Time series data for six Economic Community for Central African (CEMAC) member states (Cameroon, Equatorial Guinea, Gabon, Chad, Central African Republic, Democratic republic of Congo) and five other Sub-Saharan African countries (Botswana, Rwanda, Zambia Madagascar, Togo) for 1995 to 2015	Endogenous growth models using Panel Ordinary Least Square (OLS), Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS)
Sachs and Warner (1997)	Real GDP per capita	Life expectancy, life expectancy squared	Openness, openness X log(GDP), land-locked, government saving, tropical climate, institutional quality, natural resource exports, growth in economically activepopulation minus population growth	At the lowest level of life expectancy at about 32 years, raising life expectancy by one year, to 33 years, is associated with a rise in average annual growth of 0.24 percentage points	A cross-section of Sub-Saharan Africa (SSA) countries for the period 1965-90	The general framework of the Solow growth model using Ordinary Least Square (OLS)

Notes: Growth Theory is the Theoretical Framework Underpinning the Various Studies
Source: Authors

Table 4A.5: SA 9 Provinces Real Rate of Growth of PHE

Province	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	CAGR
Western Cape	7.1%	14.7%	13.5%	2.7%	2.9%	2.8%	4.0%	1.9%	1.8%	2.4%	-11.6%
Eastern Cape	22.0%	11.1%	4.4%	6.6%	-0.6%	2.8%	-1.3%	1.7%	3.0%	4.0%	-17.4%
Northern Cape	4.4%	21.7%	9.2%	11.9%	-1.1%	2.4%	4.3%	5.6%	-0.4%	0.2%	-28.9%
Free State	7.2%	12.8%	9.3%	7.2%	5.0%	-4.4%	2.7%	-1.4%	-0.9%	2.3%	-11.8%
KwaZulu-Natal	6.9%	13.6%	-3.3%	13.6%	4.7%	1.9%	1.5%	2.8%	3.0%	3.0%	-8.9%
North West	8.6%	10.8%	4.7%	5.9%	4.2%	12.3%	-4.3%	1.4%	1.3%	1.8%	-15.9%
Gauteng	11.0%	12.8%	7.1%	9.4%	6.2%	-3.7%	8.7%	5.9%	1.9%	7.4%	-4.4%
Mpumalanga	13.7%	23.3%	7.4%	4.6%	-1.9%	1.1%	5.2%	6.9%	0.1%	9.6%	-3.9%
Limpopo	21.7%	8.6%	10.9%	2.5%	7.1%	-3.6%	5.8%	0.0%	6.1%	2.1%	-22.9%
Total	**11.6%**	**13.2%**	**5.6%**	**7.7%**	**3.8%**	**0.5%**	**3.4%**	**3.0%**	**2.3%**	**4.2%**	**-10.7%**

Note: (CAGR) Compound Annual Growth Rate
Source: STATS SA - Financial statistics of provincial government, GDP and CPI data

Chapter 5

Conclusion

5.1. Summary

This PhD thesis validates the hypotheses that: (i) financial development [epitomised by Financial Centres (FCs)] positively affects the technical efficiency in Sub-Saharan Africa (SSA) through the channel of institutions (Essay 1), (ii) physical capital accumulation is more important than Total Factor Productivity (TFP) in driving the growth in South Africa's nine provinces (Essay 2) and (iii) health care positively affects the technical efficiency of South Africa's nine provinces (Essay 3).

The growth elements in SSA and South Africa's nine provinces are decomposed through the use of Stochastic Frontier Analysis (SFA) to establish (i) the impact of financial development and institutions on the technical efficiency in SSA, (ii) the relative importance of the various sources of growth in South Africa's nine provinces and (iii) the impact of health care on the technical efficiency of South Africa's nine provinces. Stochastic Frontier Analysis (SFA) is used to account for the limitations of the standard growth accounting and cross-country analyses of neoclassical and new growth theories that do not adequately clarify the sources of growth and their relative impact.

In Essay 1, financial centres are identified as host to a stock exchange, with banking as a further measure of financial development, with financial centres recognised as the highest form of financial innovation in the financial sector (City of London, 2011). In Essay 2, the relative importance of physical capital and TFP in contributing to the economic growth of South Africa's nine provinces are considered, as each province has its own unique industrial makeup, with different sectors dominating in specific provinces, suggesting tailor policymaking for each province. In Essay 3, health is considered, given the varied health outcomes amongst South Africa's nine provinces (Hlafa, Sibanda and Hompashe, 2019)

The results in Essay 1 confirm that Financial Development (FD) impacts on Technical Efficiency (TE) through Institutions (I). Furthermore, banking development (*FII*) does not seem to increase technical efficiency by itself, while stock market development (*FMI*) seems to increase efficiency by itself. However, when interacted with institutional quality (IQ), banking

development (*FII*) seems to increase technical efficiency, while for stock market development (*FMI*) it does not seem to increase technical efficiency. The implication is that, against expectations, banking development is more important than stock market development in contributing to financial development and consequently increases in productive efficiency, in SSA. Essay 2 establishes that labour growth is the main driver of economic growth in South Africa's nine provinces, followed by physical capital and human capital accumulation, with TFP being the least important factor of growth. Essay 2 thus confirms that in contrast to the established growth literature, e.g., Solow (1957) and Chenery (1986), physical capital accumulation is more important than TFP in driving the growth in South Africa's nine provinces. In addition, Essay 2 identifies that the source of growth for each individual province differs based on its economic structure. In this regard, Gauteng, which is dominated by the tertiary and secondary sectors that are more capital intensive and require higher skilled human capital, physical and human capital accumulation are more important to growth, while growth in the North West, which is dominated by the primary sector, is driven by labour growth. As consistent with the literature, Aboubacar, and Xuv(2017) and Piabuo and Tieguhong (2017), Essay 3 establishes that health (public health expenditure) has a significant impact on the Technical Efficiency (TE) of South Africa's nine provinces, implying that the firms in the various provinces are able to use their physical inputs (such as labour or capital) in a more efficient manner (Venkataramani et al., 2006).

5.2. Contribution To Literature

The contribution this PhD thesis makes to the literature is that it decomposes the growth elements in SSA and South Africa's nine provinces through the use of Stochastic Frontier Analysis (SFA) as an alternative to the standard growth accounting and cross-country analyses that have been the main empirical techniques employed by neoclassical and new growth theories. The three essays of this PhD thesis thus assist in identifying the relative importance of the various sources of growth, i.e., capital, labour and TFP, as well as decomposing TFP to reflect the contribution of other factors to output growth, i.e., quality institutions, financial development and health. This is to account for the fact that dispute still exists concerning the most important determinants of economic growth (Limam and Miller, 2004 and Limam, Miller and Garzarelli, 2019). Stochactic Forntier Analysis, as the preferred empirical technique, thus provides the link between the three essays of this PhD thesis.

This PhD thesis (Essays 2 and 3) also contributes to the literature by focusing on the sub-national level (South Africa's nine provinces) as opposed to the national level that is the focus of most studies in the growth literature. Focusing on the sub-national level accounts for the fact that growth rates at a national level mask the true extent of economic growth at a regional level within countries, i.e., at a sub-national level. In this regard, the nine provinces of South Africa grow at different rates and exhibit different levels of GDP.[84] In addition, using public health expenditure as a health indicator, Essay 3 contributes to the understanding of the indirect impact of health through TFP on economic growth. It should be noted that health spending affects growth directly or indirectly through the accumulation of education and health capital (Finlay, 2007). Essay 1 also further enhances the understanding of the impact of financial development on economic growth, specifically within the context of the level of banking development and stock market development in SSA.

5.3. Policy Implications

The findings have policy implications for SSA countries and South Africa's nine provinces. Policy makers in SSA should ensure an appropriate institutional environment (e.g., addressing issues of property rights and government effectiveness) in their countries to allow the financial sector (banks and stock exchanges) to play its catalytic role in facilitating productive efficiency and economic growth (Levine, 2004: 5). In South Africa's nine provinces, each provincial government should increase the relevant capital investments and invest in productivity enhancing factors (e.g., human capital) that would enrich their growth potential based on their unique requirements. Provinces should therefore ensure that: (i) their public sector Gross Fix Capital Formation (GFCF) is adequate to sustain their economic growth, as Romp and de Haan (2005) noted that public capital is central to the activities of households and firms and (ii) a higher percentage of their populations aged 20 years and older complete grade 12 as highest level of education, as higher educational attainment (human capital) positively impact economic growth (Caselli, 2005). In addition, provinces should ensure that their municipalities improve their Municipal Financial Suntainability Index (MFSI) scores, i.e., improve the soundness of the governance exercised by their municipalities (institutional quality), as this will enhance provincial spending on services that improve productivity (Grier and Tullock, 1989; Kormendi and Meguire, 1985). Provincial governments should also ensure a positive real rate of growth in their public health expenditures, with their health investments (e.g., vaccination

[84] STATS SA, GDP (2019).

programmes, antibiotic distribution programmes, micronutrient supplementation schemes, etc.) to increase to allow for a positive pass-through to increased health outcomes, i.e., increased life expectancy and reduced fertility rates have a positive impact on productivity and economic growth (Ogungbenle, Olawumi and Obasuyi, 2013).

5.4. Limitations

A limitation in all three essays of this PhD thesis has been data constraints. In Essay 1, data on banking development and stock market development (financial development) were obtained by using the Financial Institutions Index (FII) and Financial Markets Index (FMI) of the International Monetary Fund (IMF), which are relative rankings of countries on the depth, access and efficiency of their financial institutions and financial markets. Banking development is normally proxied by credit to the private sector in percent of GDP [Private Capital (PC)], while stock market capitalisation to GDP [Market Capitalisation Ratio (MCR)], stocks traded to GDP [Shares Traded Ratio (STR)] and stock market turnover ratio (stocks traded to capitalisation) [Turnover Ratio (TR)] are proxies for stock market development (Levine and Zervos 1998). Data constraints further affect Essay 1 with regards to the initial identified period for the research. Although 1999-2013 was initially identified, data availability required a revision of the period to 2002 to 2017. Data availability has also resulted in Cabo Verde, Sudan and Zimbabwe being removed from the list of 20 SSA countries that are host to FCs. Data availability in Essays 2 and 3 meant that while capital (K) is normally reflected by the stock of private physical capital in empirical studies, data constraints have necessitated the use of Gross Fix Capital Formation (GFCF) as a proxy, given its direct observability (Barro, 1989). Data availability in Essays 2 and 3 has also necessitated the use of educational attainment, i.e., the percentage of individuals aged 20 years and older who have completed grade 12 as highest level of education to reflect human capital (HC), in line with authors such as Rivera and Currais (1999), in contrast to the normal use of average years of schooling or enrolment rates, as is the case with Mankiw, Romer and Weil (1992) and others.

A limitation of specific interest to Essay 3 is the fact that most empirical studies have studied the direct impact of health on growth, with studies that analyse the indirect impact of health (as in Essay 3) not that common. Therefore, based on a review of the literature by this PhD thesis, health (public health expenditure) as part of the inefficiency component in a frontier analysis has not been identified in other studies. The empirical literature that focuses on exogenous and

endogenous growth theory thus informs the variable selection for the model specification of the inefficiency component in Essay 3.

5.5. Suggested Future Research

At a country level, given the importance of institutional quality to the economic growth prospects for SSA countries, as identified in Essay 1, it is important to establish what might impact on the appropriate institutions available in these countries. Legal origin, i.e., whether a country's commercial/company law derives from British, French, German, or Scandinavian law tradition shapes national approaches to laws concerning creditors and the efficiency with which those laws are enforced, i.e., legal origin influences the appropriate institutions available in a country (Levine, Loayza and Beck, 2000). As most African countries obtained their legal systems through occupation and colonisation, with British (common law) and French (civil law) law traditions being the most previlent, future research should thus consider legal origin in establishing the impact of financial development and institutions on the technical efficiency in SSA.

The limitations of Essays 2 and 3 relating to data constraints at the sub-national level, informs the relevance of future research that should refine the variables used as proxies for capital (*K*) and human capital (*HC*), e.g., in the case of human capital (*HC*), average years of schooling or enrolment rates should be considered. Future research, at a sub-national level, should also explore the importance of public capital [public Gross Fix Capital Formation (GFCF)] versus private capital (private GFCF) in the technical efficiency of South Africa's nine provinces. This is relevant in the context of STATS SA asserting that public capital forms the backbone on which the economy functions and Eberts (1986) suggests that public capital is a catalyst for private capital. Given the importance of institutional quality at a country level, e.g., in SSA, it should also be of importance at a sub-national level. Thus, the importance of the institutional quality of municipalities, which is manifested in their Municipal Financial Suntainability Index (MFSI) scores, should also receive attention to further motivate intervention at this level to improve the economic performance of provinces. In addition to public health expenditure, life expectancy and fertility rate are futher measures of health (human capital) (Finlay, 2007). As Essay 3 only focused on public health expenditure (health care) as a proxy for health, future research should also explore the impact of life expectancy and fertility rate as further measures of health. This is significant as Bloom et al. (2004) identified life expectancy as the most widely used indicator of health, establishing that life expectancy has a significant positive effect on the

rate of economic growth, while Barro (2013) established a negative relationship between fertility rate and economic growth, suggesting that a drop in the fertility rate would raise the growth rate of per capita output.

5.6. References

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