UNIVERSITY OF GHANA

HUMAN CAPITAL, PRIVATE PHYSICAL CAPITAL, PUBLIC INFRASTRUCTURE AND ECONOMIC GROWTH IN GHANA: AN ARDL BOUND TESTING APPROACH

BY

JOSHUA OBENG BOADI

(10637821)

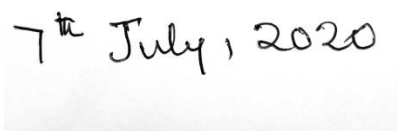
THIS THESIS IS SUBMITTED TO THE DEPARTMENT OF FINANCE, UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL (FINANCE) DEGREE

DEPARTMENT OF FINANCE

JULY, 2019

DECLARATION

I, hereby, declare that this thesis is my own original research and has not been presented by anyone for any academic degree in this or any other university.



…… ……..

JOSHUA OBENG BOADI DATE

(10637821)

CERTIFICATION

I, hereby, certify that this research work was supervised in accordance with research procedures laid down by the University of Ghana.

…… 07/07/2020

DR. AGYAPOMAA GYEKE-DAKO DATE

(SUPERVISOR)

7th July, 2020

……... ……

DR. PATRICK OPOKU ASUMING DATE

(CO-SUPERVISOR)

DEDICATION

I dedicate this work to:

My father and Mother: Ernest and Paulina

My siblings: Kwabena, Kyerematenng and Kwaku

My daughters: Michelle and Jessica

\

ACKNOWLEDGEMENTS

My greatest thanks go to the Almighty God who gave me the strength and grace to go through this MPhil course. I would like to express my sincere appreciation to Agyapomaa Gyeke-Dako (PhD) and Patrick Opoku Asuming (PhD) for the guidance, encouragement and constructive advice they provided throughout this research. I was fortunate to have supervisors who were understanding and never irritated by the many mistakes I committed during the course of the research. I say a big thank you. I appreciate the assistance of Mr. Isaac Mensah for his support and constructive criticism of my work. Finally, I wish to acknowledge the support from members of the Church of Pentecost, Grace Assembly, East Legon for your prayers throughout this research work.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

AIC	Akaike Information Criterion
ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributive Lag
BLUE	Best Linear Unbiased Estimator
CBA	Cost-Based Approach
EBA	Education-Based Approach
ELEC	Electricity Production and Transmission
ERP	Economic Recovery Program
GDP	Gross Domestic Product
GES	Ghana Education Service
HC	Human Capital
HQ	Hannan Quinn
IBA	Income-Based Approach
INFRA	Public Infrastructure
K	Private Physical Capital
LEXP	Life Expectancy
MDG	Millennium Development Goal
OECD	Organisation for Economic Cooperation and Development
PP	Phillip-Perron
PCA	Principal Component Analysis
R&D	Research and Development
SAP	Structural Adjustment Program
SECENR	Secondary School Enrolment Rate

SDG	Sustainable Development Goal
SIC	Schwarz Bayesian Information Criterion
TEL	Fixed Telephone Subscription
TFP	Total Factor Productivity
UDHR	Universal Declaration of Human Rights
WDI	World Development Indicators

ABSTRACT

Ghana's achievements in advancing education and health have been remarkable. Conversely, World Bank Human Capital Report has ranked Ghana as the last but one country on harmonized test scores of children from basic to secondary school in the World. Premature births, infections and complications during and after pregnancy and maternal deaths also remain high and infrastructure challenges persist in the power sector as well as the quality of services received by Ghanaians. The study examines the effect of human capital, private physical capital and public infrastructure on economic growth and the causality between the variables in Ghana considering two alternative measures of human capital (health and education) and public infrastructure (electricity and telephone subscription). Autoregressive Distributive Lag (ARDL) and pairwise granger causality test was used on annual data for Ghana from 1975 to 2017. The empirical results show that, in the short run, the individual measures of human capital (education and health) and public infrastructure (electricity) have positive and significant effects on economic growth, although the contribution of health is relatively larger than that of education. In the long run, the variables of the study do not have significant effect on economic growth. When composite human capital, physical capital and composite public infrastructure were examined, composite human capital has positive and significant effects on economic growth in the short run. However, in the long run, composite human capital, composite public infrastructure and physical capital do not have significant effect on economic growth. Unidirectional causality was found between human capital (education and health) and economic growth, bidirectional causality between private physical capital and economic growth and unidirectional causality between public infrastructure (electricity) and economic growth. No causality was found between public infrastructure (telephone subscription) and economic growth in Ghana.

This finding emphasizes the importance of both alternative measures of human capital and aligns with the argument in the literature that neither education nor health is a perfect substitute for the other as a measure of human capital. It is recommended government improves human capital development and find lasting solution to Ghana's infrastructure challenges.

Key Words

Autoregressive Distributive Lag (ARDL), Human Capital, Private Physical Capital, Public Infrastructure, Economic Growth, Causality, Ghana,

CAVEAT

All mistakes in this research are entirely mine.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Classical growth theory posits physical capital is the main source of growth, however, the conclusion from the modern growth literature is economic growth is influenced by many factors apart from physical capital. Growth is also determined by human capital and public infrastructure. Human capital is essential in strengthening investment in technology, raising technical progress (Freire-Seren, 2001), stimulating long run growth (Canning & Pedroni, 2008) and increasing productivity (Wang & Liu, 2016). Thus, Shultz (1961a) and Becker (1994) defined human capital "as the set of knowledge, skills, competencies and abilities that are embodied in individuals and which individuals acquire overtime through training, education, work experience, medical care and migration''.

Human capital therefore encompasses all investment made to improve human skills including education, health and training/experience. Adequate education and improved health can result in high labour productivity and a decrease in inequality facilitates the adoption of technologies in production and speeds up demographic transition (Ogundari & Awokuse, 2018). Human capital cannot be the sole source of growth except there is high investment in physical capital. Physical capital has also been identified to play essential role in economic growth (Galbraith, 2014). Endogenous growth theory holds high investments in human capital and physical capital is necessary to achieve tremendous economic growth. However, for long term economic growth to

occur there must be increase in the rate of savings and high investment in technology. Thus, private physical capital and human capital are considered primary source of economic growth.

Another economic growth determinant is investment in public infrastructure. Direct investment in public infrastructure creates production facilities, stimulates economic activities, creates employment opportunities and influence national competitiveness. Lack of public infrastructure development creates bottlenecks for sustained growth. Availability of quality roads, telecommunication technologies, railway infrastructure, water infrastructure, air transport infrastructure and supply of electricity promotes the success of factors of production. Factors of production depend on a considerable extent on the efficiency of usage of public infrastructure facilities. It has been observed that lack of human capital, physical capital and quality infrastructure to a large extent explain the differences in the economic development of countries.

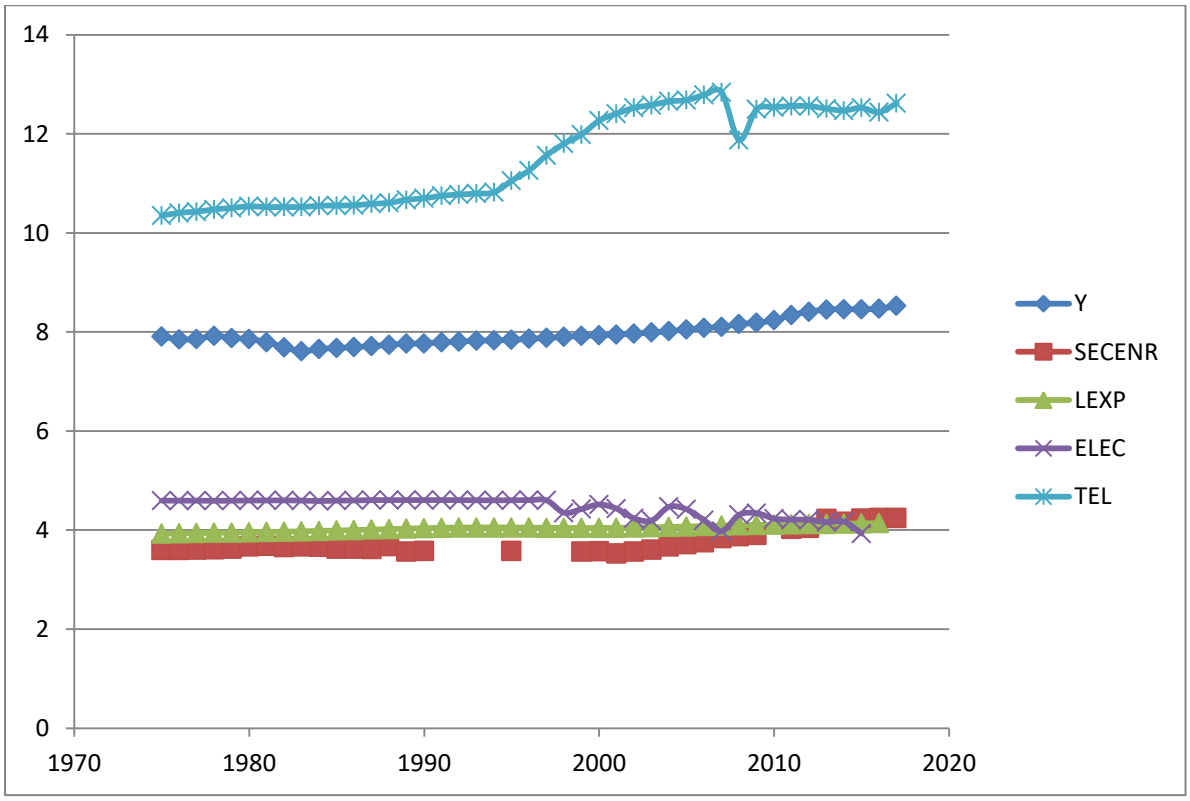
1.2 Problem Statement

The Education strategic Plan sets the policy drivers for Ghana's education. These drivers include access, quality and management. Policy interventions such as provision of infrastructure, promoting gender equity, provision of textbooks etc. are meant for improvement in education. Subsequently, education expenditure of the government of Ghana has over the years increased substantially to meet the strategic plans. As a result, gross enrolment rates in primary and secondary school has increased from 57 percent to 73 percent. Ghana's achievements in advancing education have been lauded by international agencies. However, World Bank Human Capital Report (2019) has ranked Ghana as the last but one country on harmonized test scores of children from basic to secondary school in the World. The report identified that poor quality of learning in schools in Ghana is responsible for the low ranking. Further, the report indicated that though

Ghana has done well in improving basic and secondary school enrolment, there is no corresponding improvement in the quality of education offered. In addition to the claim of the World Bank report, the Ghana Education Service has reiterated that there is still high incidence of functional illiteracy in basic and secondary school due to poor content of educational materials.

Ghana's National Health Policy entitled "Creating Wealth through Health" is meant to support the achievement of the national vision of transforming the nation into high income country. The policy states among other things that ill health is both a cause and consequence of poverty. As a result, Ghana has committed to increasing health expenditure to reduce poverty. Ghana's healthcare expenditure has increased over the past two decades. General government health expenditure increased from $60 per capita in 2014 to $67 in 2017. Life expectancy has also improved in Ghana. Life expectancy at birth rose from 56 years in 1990 to 61 years in 2012 and subsequently to 63 years in 2017. But Ghana still has heath challenges. One child in every five experience stunted growth caused by inadequate nourishment and unhealthy environment. Children's physical, social and cognitive development and ability to learn, school performance and socio economic development becomes affected. Premature births, infections and complications during and after pregnancy and maternal deaths remain high.

Figure 1: log of GDP, Secondary School Enrolment, Life Expectancy, Electricity and Telephone Subscription in Ghana



Source: Computed with data from WDI, 2017

Regarding public infrastructure, Ghana compared with low income countries have good infrastructure. Ghana has succeeded in raising household access to power/electricity and telephones, however, challenges still lie in the power sector and the quality of services received by Ghanaians. Ghana spends 20 per cent of GDP on infrastructure development equivalent to $1.2 billion per year and $1.1 billion a year is lost to inefficiencies relating to energy. Despite the tremendous infrastructure investment, Ghana's power sector has reduced growth by 0.5 percentage points due to power outages and inconsistent energy supply. Mitigating Ghana's infrastructure problems demands increased and consistent spending of $2.3 billion every year.

This research examines the short run and long run effect of human capital, private physical capital and public infrastructure on economic growth in Ghana as well as the causality between the variables. Also, a composite index is formed of human capital measures and public infrastructure measures using Principal Component Analysis (PCA) and their effect together with physical capital on economic growth is examined. No study to the best of my knowledge has examined the effect of human capital, public infrastructure and physical capital on economic growth in Ghana by using a composite index of human capital and public infrastructure within an ARDL model.

This research is important because (1) educated people without good health cannot affect productivity positively. On the other hand, healthy people without proper education cannot contribute immensely to growth (2) per capita expenditure on education and health has increased over the years to necessitate high economic growth (3) health and education combined is believed to affect economic growth positively (4) Ghana's infrastructure spending has improved over the decade to produce high growth. Thus, determining the effect of human capital and public infrastructure on economic growth is essential. Short run decisions affect the long-term effects. In establishing the short run and long run effects of the variables, it is important to understand that separating the interaction between human capital, physical capital, infrastructure and economic growth at low frequencies from those at high frequencies will facilitate the understanding of whether the variables move together in the long run. The long run is considered the period where the variables of the study are stable and in equilibrium. The short run is where variables are affected by shocks.

1.3 Research Objectives

The main objective is to examine the short run, long run and causal relationship between human capital, private physical capital, public infrastructure and economic growth in Ghana. This is supported by the following objectives:

1. Determine the short-run and long-run effect of human capital, private physical capital and public infrastructure on economic growth in Ghana.
2. Examine the effect of composite human capital, private physical capital and composite public infrastrucuture on economic growth in Ghana.
3. Determine the causality between human capital and economic growth in Ghana.
4. Determine the causality between private physical capital and economic growth in Ghana.
5. Determine the causality between public infrastructure and economic growth in Ghana

1.4 Research Questions

1. What is the short-run and long-run effect of human capital, private physical capital and public infrastructure on economic growth in Ghana?
2. What is the effect of composite human capital, private physical capital and composite public infrastrucuture on economic growth in Ghana?
3. What is the causality between human capital and economic growth in Ghana?
4. What is the causality between private physical capital and economic growth in Ghana?
5. What is the causality between public infrastructure and economic growth in Ghana?

1.5 Significance of Study

The study will enrich our understanding of the literature on human capital, private physical capital and public infrastructure effect on economic growth in Ghana. Also, it allows readers to better appreciate the importance of human capital formation, private physical capital accumulation and

public infrastructure for economic growth and their spill over effect on technology development and adoption, innovation and increase in productivity. The research employs PCA to investigate the effect of composite human capital and composite public infrastructure on economic growth. Also, the effect of the measures of human capital and public infrastructure on economic growth is examined to gain thorough understanding. To the best of my knowledge, the research is the first to investigate the variables impact on economic growth in Ghana using the widely accepted ARDL model. This research provides premise for policy formulation by the government through the identification of the importance of improving the quality of education, health and government infrastructure spending on energy generation and telecommunication infrastructure development.

1.6 Research Limitations

Some challenges and limitations are anticipated in the research. The first is access to data. Data on human capital and private physical capital as well as public infrastructure were limited for Ghana. Data on road transportation, water infrastructure were non-existing for Ghana. Also, the government expenditure on health and education which the research sought to use as proxy for human capital had data gaps. Furthermore, several proxies exist for the variables considered in the research. Coming up with a good variable to measure human capital and public infrastructure is a challenge. The author is faced with this challenge in choosing a proxy for human capital and public infrastructure.

1.7 Organisation of Study

The study is organized into five chapters. Chapter one provides a background to the study, identifies the gap, why this study is of importance and finally how the rest of the thesis is to be organized. Chapter two proceeds to fish out existing theoretical and empirical literature on the subject and submit empirical findings on studies done on human capital, private physical capital,

public infrastructure and economic growth. Chapter three offers the methodology of the study and other relevant information on how the study was carried out. Chapter four presents analysis and discussions and Chapter five summarizes and concludes the thesis bringing out the findings, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

There is on-going discourse in the economic literature about the factors that determine economic growth of countries. Some of the factors explored by past authors include human capital, private physical capital and infrastructure. In this chapter, the study begins with a presentation of the definition of concepts and measurement of variables of the study. This is followed by overview of economic growth, human capital and infrastructure development in Ghana. Empirical works related to the research topic and the neoclassical and endogenous growth theories are also examined. This is necessary to establish what is already known as a result of previous studies. The chapter concludes with a summary.

2.2 Definition and Measurement of Economic Growth, Human Capital, Private Physical Capital and Public Infrastructure

2.2.1 Economic Growth

Economists are unsettled on why there exist differences in the economic progress of countries. Their concentration is fixed on factors that show how countries grow differently and accumulate wealth. In order to appreciate the differences among countries, the concept of economic growth must be understood. Economic growth is increase in the production and supply of economic goods to the population resulting from technology and other factors such as institutional and ideological adjustments (Kuznet, 1971). It is the increase in production of goods and services measured in nominal terms or real terms compared from one period to another. GDP measures the market value of goods manufactured and services rendered within a country at a time period. Besides economic growth is sustainable growth. Sustainable growth is welfare related and difficult to measure.

Understanding the determinants of economic growth is important in understanding how standards of living can be improved thereby reducing poverty (Sala-i-Martin, 2004).

Several authors have used many variables as proxies to measure economic growth but not all the proxies are able to capture the different dimensions of economic growth. The most widely and acceptable measure of economic growth is the changes in the Gross Domestic Product (GDP). Other indicator such as Industrial Production Index is used because some authors believe there is high correlation between Industrial Production Index and GDP. In this research, GDP per capita (Constant local currency) is used to measure economic growth. Other measures considered by some studies as proxy for economic growth is the inflation rate, foreign direct investment, control of corruption index, the genuine progress indicator, green GDPs, index of sustainable economic welfare and genuine wealth. It is believed these measures account for the well-being of inhabitants in an economy at any point in time.

2.2.2 Human Capital

Human capital is the knowledge, skills, attitudes, aptitudes and other acquired traits contributing to production (Goode, 1959). Becker (1994) referred to human capital as the "resources found in people". These resources may include knowledge, skills, competencies, and other attributes embodied in humans that are relevant for economic activity. Shultz (1961a) identifies skills and knowledge that people acquire as human capital. Human capital is broadly defined by the Organisation for Economic Cooperation and Development (OECD) as "the knowledge. skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic wellbeing. Laroche, Mérette, and Ruggeri (1999) further extended the notion of human capital to include innate capabilities.

Human capital includes investments that improve human skills such as education, experiential learning and job training. It is broader than just educational attainment. It also includes health. Human capital is very difficult to measure. Most studies use formal education to assess the impact of human capital on economic growth. This stems from the common understanding that education is essential for sustainable economic growth (Lucas, 1988; Barro, 1991). Human capital is conceptualized as the resources found in people acquired through education and quality health (Becker, 1994).

Human capital has been measured using several approaches. These include Cost-Based Approach (CBA), Income-Based Approach (IBA) and Education-Based Approach (EBA). Engel (1883) estimated human capital as child rearing costs to parents. The cost of rearing a person was equal to the summation of costs required to raise a child from conception to the age of 25. Dagum and Slottje (2000) posit CBA ignores the time value of money and the social cost of rearing people. This approach has been augmented. Jorgenson and Fraumeni (1989) have criticized CBA for failing to account for the crucial time dimension of educational investment and disregard the value of non-market activities. Income-Based Approach (IBA), on the other hand, value the human capital embodied in individuals as the total income that could be generated in the labour market overtime. It measures the stock of human capital by the summation of the discounted values of all the future income streams that all individuals expect to earn throughout their lifetime. The model rests crucially on the assumption that differences in wages truly reflect differences in productivity. The income-based approach was criticized for not deducting maintenance costs from gross earnings (De Foville, 1905; Eisner, 1989). Another shortcoming of the IBA is that data on earnings are not easily available. Finally, Education-Based Approach (EBA) measures human capital using education output indicators such as literacy rates, enrolment rates, dropout rates, repetition rates,

and average years of schooling in the population and test scores. The rational for this method is that these indicators are closely related to investment in education and that investment in education is a key element in human capital formation. Educational measures are therefore proxies for and not direct measures of human capital.

2.2.3 Private Physical Capital

Economists see capital as capital goods and money found in capital goods. In the pre-classical and classical era, capital was viewed as the "fund" required for the purchase of the means of production and also meet recurring expenditure. Turgot (1770) defined capital as "accumulated values". Ricardo (1817) regards capital as consisting of both fixed and circulating capital. His argument was that all capital rotates and is only a matter of level. Marx (1867) departed from both the pre-classical and the classical definition of capital and defined capital as the stock of commodities and the sum of value. Marx denotes physical capital as "non-reproductive capital" or "constant capital". Capital was seen as the means of production that does not change in the production process. They are simply used up in the production process. Schumpeter (1934) said capital is the means by which the entrepreneur procures the means with which to produce. The idea of capital is conceived as the means of obtaining production. Ultimately, Pérez (2002) reiterated that capital embodies both 'production capital' and 'financial capital

Physical capital stock measurement construction has long involved complications because for capital stock to be aggregated the availability of data is necessary. The construction of capital stock is seen as superior method. Since the construction of capital stock is time consuming, most of the related literature rely on proxy approach. For example, Barro (1991) and many of the related literature employed gross investment rates, gross fixed capital formation and gross capital formation as proxies for physical capital accumulation. Only few attempts have been made to

generate large dataset for physical capital. The few attempts rely on the perpetual Inventory method, the method most often used in constructing capital stock. The perpetual inventory method defines an economy's capital stock as an inventory. Ascertaining the capital stock in a period involves finding the weighted sum of the history of capital stock investments. The weights result from the geometric depreciation function.

2.2.4 Public Infrastructure

The term 'infrastructure' meant war logistics (Jerome, 1999). Infrastructure is grouped into two. The first is social infrastructure. It is infrastructure that ensures the education, health and culture of a people and has enormous effect on quality of life (DBSA, 1998). Such infrastructures ensure the supply of personnel to operate other resources. It promotes the political, social and economic empowerment of people. Thus, social infrastructure includes libraries, schools, hospitals, theatres, courts, parks etc. Social infrastructure is for public use. The second is economic infrastructure. Mody (1997) defines economic infrastructure as infrastructure that assists in production activities. These include power, transportation, telecommunication, sanitation, water and disposal systems etc. Throughout this research, the term 'infrastructure' refers to economic infrastructure.

Public infrastructure quantification, in literature, has received two main measurements namely the measurement in monetary (financial) terms and measurement in physical terms. In monetary terms, infrastructure is considered as flow or a stock variable. For example, if government spends on the provision of public services it instantaneously affects production. This is known as flow. In the second case, instead, what government spends "today" is added to the stock of public capital and involves adding up past gross investments, adjusted for depreciation. In physical terms two variations can be identified. Infrastructure can be considered simply in physical terms (e.g. kilometres of roads, electrical generating capacity, number of hospitals, etc.) or can be measured in

physical terms and transformed in monetary terms attributing monetary value to each infrastructure.

2.3 Overview of Economic Growth, Human Capital and Public Infrastructure in Ghana

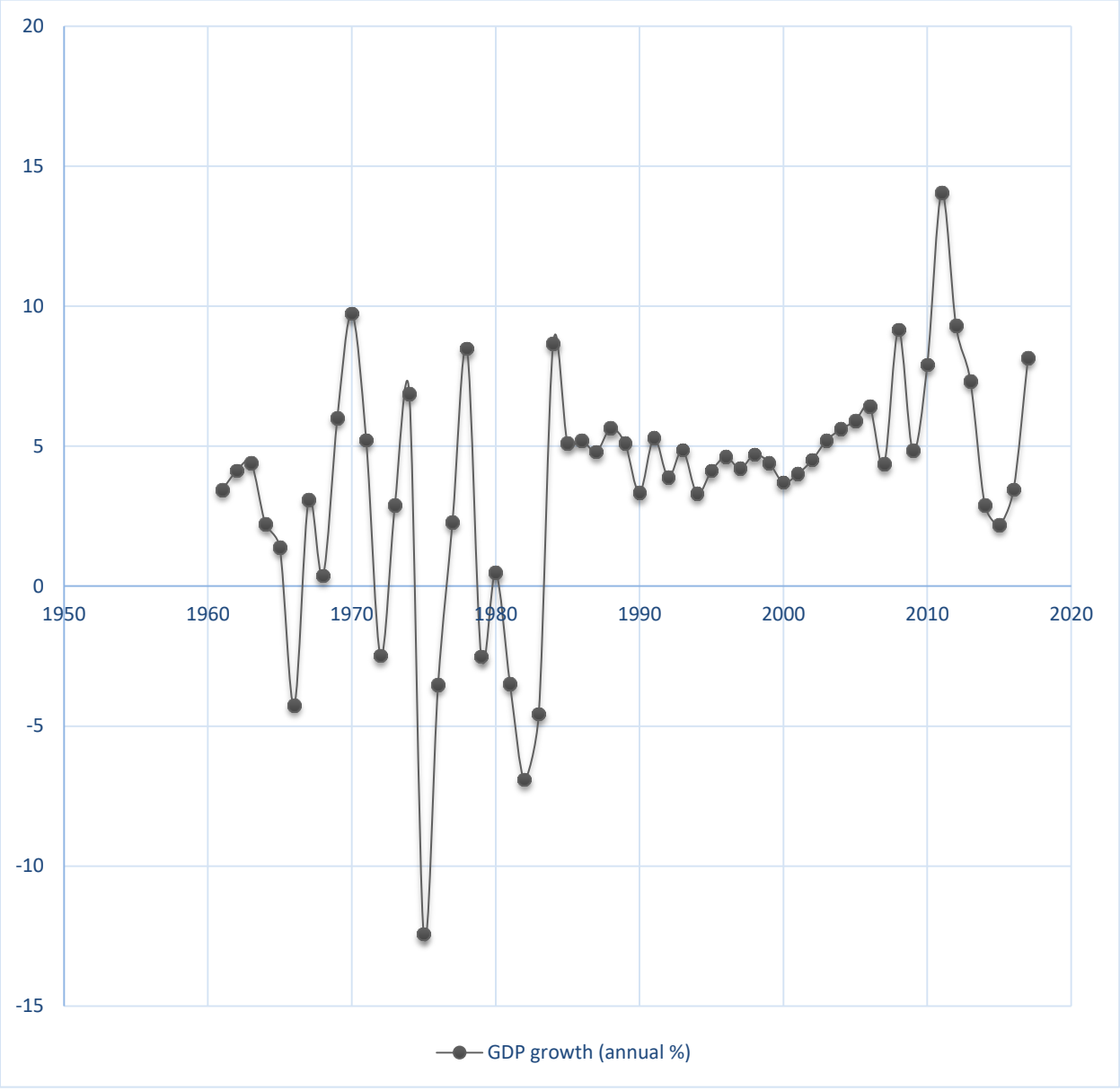
2.3.1 Economic Growth in Ghana

The first African nation to achieve independence from colonial rule was Ghana. There was much hope that Ghana will champion the path toward accelerated growth and development for Africa. Ghana experienced rapid growth but growth was not sustained for a long time. Growth turned negative by the year 1965. Ghana's growth record has been uneven. With high GDP growth recorded in the 1950s and early 1960s, the Ghanaian economy started to experience slowdown in economic growth in 1964. During much of the period after the mid-1960s, growth was turbulent and only began to stabilise by 1984. The first negative growth was recorded in 1966. Another lowest growth of negative 12% was experienced in 1975. Most of the years of negative growth coincided with periods of intense political instability and external shocks.

Liberal economic policies and programmes were instituted to halt the negative growth. The first, Economic Recovery Program (ERP), was implemented over 1983 to 1986. The ERP was intended to halt the downward economic spiral. In 1986, ERP was supplemented with the Structural Adjustment Programme (SAP) which brought exchange rate liberalization, fiscal discipline, tightening of monetary policy, foreign trade reforms, financial sector reforms, privatization of state-owned enterprises, investment expansion, price deregulation and labour market reforms. The economy responded strongly with growth rate of 8.6% in 1984. Aryeetey and Tarp (2000) stated that responds emanated from capital expansion from foreign direct investment and foreign aid. Ghana's economic growth has been resilient though the rate has been declining since 2011. The economy recorded real GDP growth rate of 4.2% in 2014. Since 2011, Ghana's growth has been

propelled by oil exports. Oil has become an increasingly important share of exports, about 40%. Ghanaian economy is continuously becoming oil-dependent. Real GDP grew by an average rate of 6.8% between 2006 and 2016.

Figure 2: GDP Growth in Ghana



2.3.2 Human Capital Development in Ghana

Ghana has in the past given top priority in improving education since achieving independence. The many Coup d'états affected education development of the nation. Plans by previous governments were abandoned. From 1983, significant improvements in politics have enhanced education. Before independence, education was controlled by ordinances (1925 Southern & Ashanti Ordinances; 1927 Upper & Northern Ordinances). After independence, The Education Act of 1961 was initiated (McWilliam & Kwamena-Po, 1975). In 1970, the Dzobo Committee was created to review the structure and quality of education in Ghana. Evans Anform Committee reviewed the report of the Dzobo committee. In 1987, the 6-3-3-4 format (six years of primary education, three years of junior secondary school education, three years of senior secondary school education and four years of university education was implemented. The 1980s also witnessed many education reforms meant to improve access to tertiary level education. The major objective of the Tertiary Education Reforms in 1980s was to expand access, improve quality teaching and learning and provide the much needed infrastructural base for accelerated technical manpower delivery for sustainable economic development.

2.3.3 Public Infrastructure in Ghana

Infrastructure contribution to Ghana's growth performance during the 2000s is remarkable, though power challenges have impeded growth. Ghana has increased access to infrastructure. Ghana has allocated substantial resources to the road sector in recent years. It spends on average 1.5 per cent of GDP on roads, one of the highest shares in West Africa. Ghana has made significant progress in modernizing its ports sector. Ghana's two major ports (Tema and Takoradi) are large relative to other West African ports. Ghana is one of only five African countries that have achieved the Millennium Development Goal (MDG) target for water supply. The percentage of households with

access to improved drinking water increased from 69 per cent in 2003 to 84 per cent in 2008, exceeding the MDG target of 76 per cent. Ghana has good power generation capacity and has made impressive progress on electrification. Ghana's electrification rate in 2003 was approximately 44 per cent, which was about three times as high as the benchmark for low-income countries in Africa. In particular, rural coverage was almost twice as high in Ghana. This strong performance is attributable to an accelerated expansion of electricity access in Ghana. During 1993-2003, 1.8 per cent of the population gained access to power annually, compared with the low-income benchmark of 1.4 per cent.

2.4 Theoretical Review

2.4.1 Neoclassical Growth Theory

Solow (1956) and Swan (1956) theory of economic growth continues to influence economic thinking about factors that determine economic growth. Solow (1956) and Swan (1956) believe that growth of output is determined by quantity of labour, capital (through savings and investment), technology and effectiveness of labour. This school of thought holds that labour, capital and technology are the inputs combined to produce output. According to Solow, growth in output of a country is due to exogenous (external) factors such as technological progress, population growth and constant savings rate. The theory explains that in the absence of technological progress, economic growth will cease.

The foundation of the theory is if capital and labour are multiplied by the same proportion, output of the same proportion will be gained. Also, holding the level of technology and labour constant, each additional unit of capital delivers positive additions to output, but these additions decreases as the number of machines rises. On the other hand, holding the level of technology and capital constant, each additional unit of labour delivers positive additions to output, but these additions

decreases as the number of labour rises. The neoclassical model posits that in the short run, countries can achieve higher economic growth by increasing their savings rate and at the same time containing population growth rate. In the long run, countries can only increase the standard of living through technological progress. Solow model reiterates that one-time change in the level of technology, the savings rate, the rate of population growth and the depreciation rate does not affect the steady state growth rates of per capita output, capital and consumption.

For this reason, the Solow model does not provide explanation of the determinants of long run per capita growth. The long run growth rates in the Solow model are determined entirely by exogenous elements. In the steady state, the per capita quantities of capital, output and consumption do not grow and the aggregate variables Capital, Output and Consumption grow at the exogenous rate of population growth. The conclusion therefore is the steady state growth rates are independent of the savings rate or the level of technology. Romer (1986) built on the traditional Solow model to explain long run determinants of economic growth,

2.4.2 Endogenous Growth Theory

In the mid-1980s, it became increasingly clear that the standard neoclassical growth model by Solow and Swan was theoretically unsatisfactory as a tool to explore the determinants of long-run growth. The endogenous growth theory broadened the concept of capital to include human components, and then assume that diminishing returns did not apply to this broader class of capital. The assumption of Romer (1986) was growth in output of an economy is determined by endogenous factors rather than exogenous factors. These endogenous factors include stock of human capital, physical capital and level of investment. Romer (1986) believes that households will invest capital goods (human capital and physical capital) that deliver the higher return. He

formulated an augmented production function by adding human capital and physical capital accumulation to the original Solow model.

Estache (2005) also augmented the Solow model to include infrastructure. Estache (2005) believes growth in GDP per capita can be determined in the long run by human capital, physical capital and infrastructure. The view was that technological progress in the form of generation of new ideas was the only way that an economy could escape from diminishing returns in the long run. The treatment of technological progress as exogenous must instead be explained within the growth model. The premise of the theory is the rate of technological advancement and stock of human capital determines economic growth. Romer (1986) proposed four basic inputs in his model. They are capital, labour, human capital and an index of technology. Endogenous growth theory holds that investment in human capital, innovation and knowledge are significant contribution to economic growth.

Romer (1986) emphasized that human capital leads to creation of new products (innovation). Individuals who utilize their education can create new products that can enhance technological progress. More technological progress implies more growth and more growth also create more education that can improve technical change. Therefore, Romer (1986) suggests that technical change is endogenous – it can increase when education increases. In effect, there exists increasing function of inputs on outputs because of technical change unlike in the neoclassical models. The endogenous theory challenges the neoclassical view and proposes channels through which the technological progress and the long-run economic growth are influenced.

The theory starts from the observation that technological progress takes place through innovations in the form of products, processes and markets. Innovation results from research and development

(R&D) expenditures of profit seeking firms. These firms will continue to invest in research and development. These R&D requires educated people. The educated will continue to produce new knowledge needed for the production of goods and services. Also, the endogenous growth theory argues investments in public infrastructure are crucial for economic growth. Thus, improvement in public infrastructure investments drives growth. Endogenous growth theory does not make the difference between physical capital and human capital clear. It assumes that human capital accumulates and when it is embodied in physical capital, then it becomes a driving force. However, it fails to clarify which is the driving force

2.5 Empirical Review

2.5.1 Human Capital Effect on Economic Growth

Endogenous growth emphasizes the importance of knowledge, skills, competencies etc. embodied in human as crucial for changes in the economic growth of a nation. There have been numerous empirical investigations focusing on the effects of human capital on economic growth. These studies reveal mixed relationship between human capital and economic growth.

Most empirical studies focus on how to promote and measure human capital (Aghion & Howitt, 1992). Other studies concentrate on the effect of human capital on economic growth and poverty reduction (Neeliah & Seetanah, 2016). Few studies have attempted to find out how the different measures of human capital can together affect economic growth. Asghar, Awan and Rehman (2012) investigated the role of human capital on economic growth of Pakistan using data from 1974 to 2009. Measuring human capital with education and health, Asghar et al. (2012) concluded that there is strong positive impact of human capital on economic growth despite less expenditure on education and health. Neeliah and Seetanah (2016) and Ogundari and Awokuse (2018) in a similar study of the effect of human capital on economic growth in Mauritius and Sub Saharan

Africa respectively, found that human capital is a significant growth determinant albeit the contribution of health is larger than education. This suggests that access to education and health enhances economic growth of an economy.

With the renewed effort to increase education enrolment at all levels in many developing countries, it is suggested that education could improve economic growth both in the short run and long run and decrease inequality. If this is true, then it implies that primary, secondary and tertiary education could enhance economic growth. Asteriou and Agiomirgianakis (2001) examined how enrolments rates in primary, secondary and institutions of higher education affect economic growth in Greece. Asteriou and Agiomirgianakis (2001) concluded that there exists positive relationship between education and GDP per capita growth. Afzal, Farooq, Ahmad, Begum and Quddus (2010). Gyimah-Brempong and Wilson (2004) and Nowak and Dahal (2016) in a similar study in Ethiopia, Ghana and Nepal respectively concluded that secondary and higher education contributes significantly to real per capita GDP growth. However, Shaihani, Harisb, Ismaila and Saida (2011) and Malangeni and Phiri (2018) disagreed with the findings that primary, secondary and higher education contributes to GDP growth. Shaihani et al. (2011) and Malangeni and Phiri (2018) conclude that primary and tertiary education have a significant negative relationship with economic growth both in the short run and long run and it is only secondary education that improves economic growth. This means that just improving primary, secondary and tertiary school enrolment does not necessarily improve economic growth.

The fact that education and health are components of human capital suggests health, to some extent, play an important role in human capital development. The issue of health has gained considerable attention amongst researchers and policymakers, particularly after it was noted that high degree of health positively affects economic growth. Acemoglu and Johnson (2007) and

Ecevit (2013) examined the impact of life expectancy on economic growth for USA and 21 OECD countries respectively. Acemoglu and Johnson (2007) and Ecevit (2013) concluded that life expectancy has positive and statistically significant impact on economic growth. Boachie (2015) and Ogunkunle, Opeloyeru, Fatoba, Ziyath and Adeniyi (2017) reinforced the findings of Acemoglu and Johnson (2007) and Ecevit (2013) by stating that growth is significantly determined by health. However, Ngangue and Manfred (2015) discovered that if classification is made according to income levels, health has insignificant effect on economic growth though they agree that improvement in life expectancy positively affects economic growth in developing countries.

The empirical literature on human capital and economic growth based on cross country studies are inconclusive whereas in single country analysis mostly studies support positive association between human capital and economic growth. However, it is observed that different studies have used different proxies for human capital and difference in measurement of human capital may be a source of bias in their empirical results. Furthermore, it can be concluded that earlier studies have used education as a proxy for human capital and more recent studies lay emphasis on both health and education as a proxy for human capital. This research studies the impact of education and health on economic growth in Ghana particularly looking at the effect on economic growth of education and health combined. Thus, the research hypothesises that:

H_0: There is positive effect of human capital on economic growth

H_1: There is negative effect of human capital on economic growth

2.5.2 Causality between Human Capital and Economic Growth

Neeliah and Seetanah (2016) examined the causality between human capital and economic growth. The authors found a bi-causal relationship between human capital and economic growth in

Mauritius. However, Tsen (2006) examined the causality between human capital accumulation and economic growth in China for the period 1952 to 1999 and discovered a contrary result. Tsen (2006) found that there is unidirectional causality between human capital and economic growth with causality running from education dimension of human capital to economic growth.

Tsen (2006) findings was confirmed by Choudhary and Sultana (2018) and Asteriou and Agiomirgianakis (2001) who also found a unidirectional causality between human capital and economic growth in Pakistan and Greece. Edrees (2016) also investigated the causal relationship between human capital and economic growth in Arab World countries for the period 1974 to 2013. The result indicates that the causal relationships between variables of interest are highly heterogeneous in the Arab world. The author found bidirectional causality running from economic growth to human capital.

Sharma and Sahni (2015) and Zivengwa, Hazvina, Ndedzu, and Mavesere (2013) explored the causal relationship between human capital investment and economic growth in India and Zimbabwe. They found a unidirectional causality between human capital investment and economic growth. This means the components of human capital are the key variables which are affecting economic growth of the Indian and Zimbabwean economy. This affirms the findings of Tsen (2006) and Neeliah and Seetanah (2016). From the above empirical findings, this research hypothesises that:

H_0: There is unidirectional causality between human capital and economic growth

H_1: There is bidirectional causality between human capital and economic growth

2.5.3 Private Physical Capital effect on Economic Growth

Early theories of growth and modern growth theories emphasise the importance of physical capital in economic growth. These theories reiterate that investment in fixed assets assist in increasing production of goods and services and eventually economic growth. King and Levine (1994) investigated the role of investment and physical capital accumulation in economic growth and development. King and Levine (1994) concluded that investments and physical capital may be a part of the process of economic development and long run growth but not an igniting source. Tang (2011), Arshad and Munir (2015), Yang and Zhao (2018) and Younis (2014) investigated the long-term relationship between economic growth and physical capital formation. They concluded that long-term relationship exists among physical capital accumulation and economic growth and investment in physical capital is a driving force for economic growth. Nejat and Sanlı (1999) and Choudhary and Sultana (2018) in a similar study also concluded that physical capital is a good proxy in explaining GDP growth. However, Joshua (2016) discovered that physical capital does not contributing to economic growth in developing regions. Physical capital only significantly contributes to growth in developed countries. From this it can be understood that physical capital effect varies with whether a country is developed or developing country. Therefore, the research hypothesises that:

H_0: There is positive effect of private physical capital on economic growth

H_1: There is negative effect of private physical capital on economic growth

2.5.4 Public Infrastructure Effect on Economic Growth

Infrastructure development has been identified as an important determinant of economic growth in both developing and developed countries across the world. Infrastructure determines the competitiveness of nations and the extent to which it can attract foreign direct investment. Empirical investigation into the effect of infrastructure on economic growth has largely been about transport infrastructure, road infrastructure, telecommunication infrastructure, water infrastructure etc. The results are mixed in terms of the effect of each infrastructure on economic growth in different countries. Panel data investigations also suggest mixed findings. To begin, Shaihani Harisb, Ismaila and Saida (2011) investigated the relationship between infrastructure capital and economic growth for the period 1990–2013. Using electricity generating capacity, roadway, railway, and telecommunications within vector error correction model, they found mixed support across time period and region for the contribution of infrastructure investment to economic development, this implies the real impact of telecommunication infrastructure on economic growth varies with time and region and thus not static. Owusu-Manu, Jehuri, Edwards, Boateng and Asumadu (2019) assessed the impact of infrastructure development on economic growth using an autoregressive distributed lag (ARDL) framework. Owusu-Manu et al. (2019) concluded that there is statistically significant relationship between infrastructure development and economic growth and pointed out that electricity-generating capacity has the greatest positive impact. Electricity production capacity however does not have significant impact on per capita output growth. On panel studies on the effect of infrastructure on economic growth, Égert, Koźluk and Sutherland (2009) examined whether investment in network infrastructure boosts long-term economic growth in OECD countries and whether infrastructure investment has a positive effect on growth that goes beyond the effect of the capital stock. Égert et al. (2009) concluded that there is positive impact of infrastructure investment on growth and that effect varies across countries, sectors and over time.

Nketiah-Amponsah and Sarpong (2019) also investigated the effect of infrastructure and foreign direct investment (FDI) on economic growth in Sub-Saharan Africa (SSA) using panel data on 46 countries covering the period 2003 to 2017. Nketiah-Amponsah and Sarpong (2019) also concluded that public provision of economic infrastructure reduces the cost of production for multinational enterprises, thus providing an incentive to increase investment in the domestic economy to sustain economic growth. Similar to the work of Nketiah-Amponsah and Sarpong (2019), Kodongo and Ojah (2016) used System GMM to estimate a model of economic growth augmented by an infrastructure variable, for a panel of 45 Sub-Saharan African countries, over the period 2000-2011. Kodongo and Ojah (2016) concluded that there is significant association between infrastructure spending and economic growth especially for lesser developed economies of the region than for the relatively more developed economies. Zergawu, Walle and Giménez-Gómez (2020) also examined the joint impact of infrastructure capital and institutional quality on economic growth using a large panel dataset covering 99 countries and spanning the years 1980–2015. Zergawu et al. (2020) found that the interaction terms between infrastructure capital and institutional quality show a positive and significant impact on economic growth suggesting that maximizing returns from infrastructure capital requires improving the quality of institutions. However, Tsaurai and Ndou (2019) found that the interaction between infrastructural and human capital development had a deleterious effect on economic growth using the random effect, whilst according to the fixed effects approach the interaction between infrastructure and human capital development had an insignificant positive influence on economic growth in transitional economies. Based on these empirical investigations, the research hypothesises that:

H_0: There is positive and significant effect of public infrastructure on economic growth

H_1: There is negative and insignificant effect of public infrastructure on economic growth

2.5.5 Causality between Public Infrastructure and Economic Growth

Onakoya, Salisu and Oseni (2012), Pradhan, Norman, Badir, and Samadhan (2013).and Kruger (2015) found a bi-directional causal relationship between infrastructure and economic growth. Pradhan and Bagchi (2013) also found a bidirectional relationship from economic growth to infrastructure in India. Edres (2016) found a feedback relationship between economic growth and infrastructure in African countries. The author used advanced panel granger causality analysis to test the causal nexus between infrastructure and economic growth in Africa, However, Sahoo, Dash and Nataraj (2010) and Sookha (2018) discovered a unidirectional causality from infrastructure development to output growth. Thus, the research hypothesises that:

H_0: There is unidirectional relationship between public infrastructure and economic growth

H_1: There is bidirectional relationship between public infrastructure and economic growth

2.6 Chapter Summary

This chapter started with definition and measurement of human capital, private physical capital, infrastructure and economic growth. It continued with the overview of economic growth, human capital, private physical capital and public infrastructure in Ghana. Endogenous growth theory and the neoclassical theory of economic growth were reviewed. Empirical research work on effect of human capital, private physical capital and public infrastructure on economic growth was reviewed. Finally, the causality between human capital, private physical capital, public infrastructure and economic growth was also examined.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, the study proposes the empirical methodology applied in finding answers to the research questions. The chapter includes theoretical framework, the econometric technique used, unit root test, ARDL model selection criteria, serial correlation, heteroskedasticity, model stability and the data sources.

3.2 Theoretical Framework and Empirical model

The Classical school of thought of economic growth attributes growth to physical capital accumulation. The Solow (1956) neoclassical growth theory, an extension of the classical theory, proposes growth is determined by human capital, physical capital, technology and labour. The Solow model has undergone series of modifications. The research follows an augmented version of the Solow growth model. The aggregate output of an economy can be written as follows:

$$GDP_t = f(K_t, L_t, A_t,) \quad (1)$$

Where GDP_t is GDP per capita growth, f is the level of technology that can transform physical capital ($K_{t,}$), labour ($L_{t,}$), total factor productivity (A_t) into aggregate output.and subscripts t denotes time. Following Solow (1956) and Mankiw, Romer and Weil (1992), the paper takes the functional form of equation (1) to be a Cobb-Douglas function and write it as follows:

$$GDP_t = A_t K_t^{\alpha} L_t^{\partial} \quad (2)$$

where $\alpha \, and \, \partial$ are the shares of physical capital and labour in output. A_t is total factor productivity. Many variables affect A_t. Therefore following empirical studies such as those by

Shahbaz and Lean (2012) and Takumah and Njindan Iyke (2015), A_t is written as a function of human capital (secondary school enrolment and life expectancy) and public infrastructure (electricity production and distribution and fixed telephone subscription) as:

$$A_t = \theta {SECENR_t}^{\beta 1} {LEXP_t}^{\beta 2} {ELEC_t}^{\beta 3} {TEL_t}^{\beta 4} \quad (3)$$

where θ is a constant. By replacing A_t in equation (2) with equation (3), we arrive at the augmented form of the growth equation which is as follows:

$$GDP_t = \theta {SECENR_t}^{\beta 1} {LEXP_t}^{\beta 2} {ELEC_t}^{\beta 3} {TEL_t}^{\beta 4} K_t^{\alpha} L_t^{\partial} \quad (4)$$

Taking the natural logarithm of both sides of equation (4) gives:

$$InGDP_t = In\theta + \beta_1 InSECENR_t + \beta_2 InLEXP_t + \beta_3 InELEC_t + \beta_4 InTEL_t + \alpha InK_t + \partial InL_t + \varepsilon_t \quad (5)$$

If $In\theta = \beta_0$, and labour (L) is considered abundant in Ghana (Frimpong & Adam, 2010) equation (5) becomes:

$$InGDP_t = \beta_0 + \beta_1 InSECENR_t + \beta_2 InLEXP_t + \beta_3 InELEC_t + \beta_4 InTEL_t + \alpha InK_t + \varepsilon_t \quad (6)$$

However, economic growth is affected by many factors apart from human capital and public infrastructure. The study therefore considers inflation, foreign direct investment and trade as control variables. Equation (6) is stated again with the control variables as:

$$InGDP_t = \beta_0 + \beta_1 InSECENR_t + \beta_2 InLEXP_t + \beta_3 InELEC_t + \beta_4 InTEL_t + \beta_5 InFDI_t + \beta_6 InTRA_t + \beta_7 InINF_t + \alpha InK_t + \varepsilon_t \quad (7)$$

Where In is the natural logarithm operator, GDP is gross domestic product (Constant local currency), SECENR is secondary school enrolment rate, LEXP is life expectancy, K is private

physical capital, ELEC is electricity production and transmission, TEL is fixed telephone subscription, FDI is foreign direct investment, TRA is trade and INF is inflation.

The variables are defined as:

Variable	Definition
GDP Per Capita	GDP divided by midyear population
SECENR	The ratio of total enrolment regardless of age, to the population of children (15 to 19 years) that are officially enrolled in secondary schools,
LEXP	The number of years a newly born infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life
K	The additions to the fixed assets of the economy plus net changes in the level of inventories
ELEC	Production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants divided by midyear population
TEL	The sum of active number of analogue fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones.
FDI	The net inflows of investment to acquire a lasting

	management interest in an enterprise operating in an economy other than that of the investor
INF	Changes in the cost to the average consumer of acquiring a basket of goods and services,
TRA	Sum of exports and imports of goods and services measured as a share of gross domestic product,
$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ and α	elasticities to be determined
$\boldsymbol{\varepsilon_t}$	error term.

3.3 Unit Root Test

In order for the result of a regression analysis to be reliable, variables must be stationary. Variables of an equation could be non-stationary at levels; in this case, a test is performed at first difference. If the variables still persist to be non-stationary, a test at second difference is performed. The order of integration of a variable is determined by the level a variable is differenced. Stationarity of a variable is checked by employing a unit root test. A regression based method proposed by Dickey and Fuller (1979) is used to investigate whether a variable has unit root. A null hypothesis that the series has unit root ($\emptyset = 1$) is tested against an alternate hypothesis that the series is stationary ($\emptyset = 0$). The Dickey-fuller (DF) test equation takes the form:

$$y_t = \emptyset \boldsymbol{y_{t-1}} + \boldsymbol{e_t} \quad (1)$$

But in practice equation (2) is employed in the regression

$$\Delta y_t = \varphi y_{t-1} + e_t \quad (2)$$

where (∅=1) is equivalent to the test of $\varphi = 0$ that is $\varphi - 1 = 0$. Here, the Dickey- Fuller test is appropriate if e_t is white noise. However, the presence of autocorrelation in the dependent variable Δy_t would make the test invalid. An augmented form of the test called Augmented Dickey Fuller test is used

3.3.1 Augmented Dickey Fuller (ADF) Test

Augmented Dickey Fuller test is used to correct the problem of autocorrelation. Augmented Dickey-Fuller test equation takes the form:

$$\Delta y_t = \alpha_0 + \varphi y_{t-1} + \sum_{i=0}^{k} \beta_1 \Delta y_{t-1} + e_t \qquad (3)$$

Where y_t is any variable in the model. k is lags of the dependent variable and Δy_t is incorporated into the model, that is (Δy_{t-1}) forms an augmentation in the model. The introduction of the ith number of lags of Δy_t ensures that the e_t is white noise and autocorrelation is absorbed in the Δy_t (Dickey & Fuller, 1981). A regression test is run on each variable against its lagged terms and lagged differenced term of the kind. The appropriate test with respect to the data characteristics is applied as follows. If the probability value is less than 5% significance level, then is said to be stationary.

3.3.2 Philip-Perron (PP) Test

Philips and Perron (1988) developed an alternative method for testing for the presence of unit root. The difference between the Augmented Dickey-Fuller test and the Phillip-Perron test is how serial correlation is controlled for in each test. The Philip-Perron Test employs a nonparametric autoregression for the Dickey Fuller test equation and modifies the t-ratio of the coefficient so that asymptotic distribution of the test statistic is not affected by serial correlation. The null hypothesis of unit root is tested against the alternative hypothesis of no unit root in the data.

3.4 Econometric Technique

The principal method of analysis is the Autoregressive Distributive Lag (ARDL) model developed by Koop, Pesaran and Potter (1996), Pesaran and Shin (1996) and Pesaran, Shin and Smith (2001). The ARDL approach is suitable in this study because the approach allows for the establishment of both the short-run and long-run relationships between human capital, private physical capital, public infrastructure and economic growth. Secondly, ARDL approach does not impose the restrictive assumption that all the variables under study must be integrated of the same order. It is applicable to variables that are integrated of order zero I(0) and order one I(1) or a mixture of both. Third, this approach is robust in small samples (Koop et al., 1996; Pesaran and Shin, 1996; Pesaran et al., 2001). Hence, the ARDL approach is the appropriate approach for the empirical analysis than Johansen cointegration test. Johansen cointegration is restrictive since it requires the variables of interest to be integrated of order one I (1). To achieve the objective of finding the short run and long run relationship between the variables of the study, equation (7) is expressed in ARDL form:

$$\Delta GDP_t = \beta_0 + \beta_1 GDP_{t-i} + \beta_2 SECENR_{t-i} + \beta_3 LEXP_{t-i} + \beta_4 ELEC_{t-i} + \beta_5 TEL_{t-i} + \beta_6 FDI_{t-i} + \beta_7 TRA_{t-i} + \beta_8 INF_{t-i} + \alpha K_{t-i} + \sum_{i=0}^{p} \beta_1 \Delta GDP_{t-i} + \sum_{i=0}^{q} \beta_2 \Delta SECENR_{t-i} + \sum_{i=0}^{r} \beta_3 \Delta LEXP_{t-i} + \sum_{i=0}^{s} \beta_4 \Delta ELEC_{t-i} + \sum_{i=0}^{t} \beta_5 \Delta TEL_{t-i} + \sum_{i=0}^{u} \beta_6 \Delta FDI_{t-i} + \sum_{i=0}^{v} \beta_7 \Delta TRA_{t-i} + \sum_{i=0}^{w} \beta_8 \Delta INF_{t-i} + \sum_{i=0}^{x} \alpha \Delta K_{t-i} + \varepsilon_t \quad (8)$$

where β_0 represents the intercept, *t* denotes year, *p,q,r,s,t,u,v,w,x r*epresents the lag order, ε_t represents the error term, and Δ represents the first difference operator. The long run relationship

between the variables of the study are examined using the F-statistics based on the null hypothesis ($H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \alpha = 0$) of no long run relationship among the variables against an alternative hypothesis ($H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq \beta_8 \neq \alpha \neq 0$) of long run relationship among variables. The null hypothesis is rejected if the *F*-statistic lies above the upper bound and accepted if the *F*-statistic lies below the lower bound (Pesaran, Shin, & Smith, 2001). The short run elasticities are also obtained with the error correction term (ECT) using the ARDL model below. ECT is the first lag of the error correction term.

$$\Delta GDP_t = \beta_0 + \beta_1 GDP_{t-i} + \beta_2 SECENR_{t-i} + \beta_3 LEXP_{t-i} + \beta_4 ELEC_{t-i} + \beta_5 TEL_{t-i} + \beta_6 FDI_{t-i} + \beta_7 TRA_{t-i} + \beta_8 INF_{t-i} + \alpha K_{t-i} + \sum_{i=0}^{p} \beta_1 \Delta GDP_{t-i} + \sum_{i=0}^{q} \beta_2 \Delta SECENR_{t-i} + \sum_{i=0}^{r} \beta_3 \Delta LEXP + \sum_{i=0}^{s} \beta_4 \Delta ELEC_{t-i} + \sum_{i=0}^{t} \beta_5 \Delta TEL_{t-i} + \sum_{i=0}^{u} \beta_6 \Delta FDI_{t-i} + \sum_{i=0}^{v} \beta_7 \Delta TRA_{t-i} + \sum_{i=0}^{w} \beta_8 \Delta INF_{t-i} + \sum_{i=0}^{x} \alpha \Delta K_{t-i} + \lambda ECT_{t-1} + \varepsilon_t \quad (9)$$

3.5 Model Selection Criteria

Several selection criteria have been proposed to help select the most appropriate model in relation to the lag order of the models. Some of these selection criteria are the Akaike Information criteria (AIC), Schwarz Bayesian criterion (SBC) and Hannan-Quinn (HQ). The competing models in the study based on the appropriate lags are ranked according to the values of the AIC, SBC or HQ with the best model being the one with the lowest information criterion. If two or more competing models have the same or similar AIC, SBC or HQ values, then the principle of parsimony is

applied to select the most appropriate model. The principle of parsimony states that a model with fewer parameters is usually better than a complex model.

3.5.1 Akaike Information Criterion (AIC)

The Akaike Information Criterion (AIC) was introduced by Hirotogu Akaike in 1973. The AIC was an extension to the maximum principle and consequently the maximum likelihood principle which is applied to estimate the parameters of the model once the structure of the model has been specified. The AIC is defined as: $AIC = 2(N) - 2(\log likelihood)$ where N is the number of parameters in the model. Given a family of competing models of various structures, the maximum likelihood estimation is used to fit the model and the AIC is computed based on each model fitted. The selection of the most appropriate model is then made by considering the model with the minimum AIC.

3.5.2 Schwarz Bayesian Information Criterion

The Schwarz Bayesian criterion (SBC) is related to the Bayes factor and is useful for selecting the most appropriate model out of a candidate of families of models. The BIC is obtained by replacing the $2(N)$in the AIC equation by $kIn(N)$. Hence, the BIC is defined as

$$BIC = kIn(N) - 2(\log likelihood)$$

where N denotes the number of parameters in the model. Again, the maximum likelihood estimation is used to fit the model and the BIC is computed for each of the models in a family of competing models and the fitted model with the minimum BIC is considered to be the most appropriate model.

3.6 Test for Autocorrelation

It is assumed that the error term is uncorrelated with one another. When error terms are correlated, the coefficient estimates of the ARDL model would be inefficient with the standard errors relatively smaller than the real standard errors. The study would employ Breusch–Godfrey LM test to check for the presence of serial correlation. To check for serial autocorrelation in the ARDL model, the probability value computed must be greater than the 5% significance level or the model will suffer from serial autocorrelation.

3.7 Heteroscedasticity Test

An assumption which is critical in the ARDL estimation is the assumption of homoscedasticity; that is the variance of the error term must be constant over time. When this assumption does not hold and the variances of the error term are non-constant, it is said to be heteroscedastic. Even in the presence of heteroscedasticity, the ARDL estimators will still give unbiased coefficient estimates but these estimates would not be the Best Linear Unbiased Estimator (BLUE). Hence any conclusion drawn on these estimates will be spurious and misleading because the ARDL model standard errors will be large. Spurious estimates are of no use in statistical inferences because conclusions based on them are meaningless. The study would employ a Breusch-Pagan-Godfrey Test to check whether the variances of error terms are consistent over time. To check for heteroscedasticity in the ARDL model, the probability value computed must be greater than the 5% significance level or the model will be homoscedastic.

3.8 Stability tests for the ARDL model

Stability test was conducted to assess the ARDL model stability. Cumulative sum of recursive residuals (CUSUM) and Cusum Sum of Square (CUSUMSQ) was employed to determine if the

model was stable. For the model to be stable, the line of stability must line with the 5% significance line.

3.9 Pairwise Granger Causality Test

The granger causality test as proposed by Granger and Ramanathan (1984) is used to test whether one variable is useful in forecasting another variable and vice-versa. Granger approach is used because it is superior to Sims (1972) approach and it performs well with varied lag length. The causality is confirmed by the probability value. The causality between human capital (secondary school enrolment, life expectancy and economic growth are found using the equations:

$$InSECENR_t = \alpha_1 + \sum_{i=1}^{p} \beta_1 InSECENR_{t-i} + \sum_{i=1}^{q} \beta_1 InGDP_{t-i} + \sum_{i=1}^{r} \beta_1 InLEXP_{t-i} + \mu_{1t} \quad (10)$$

$$InLEXP_t = \alpha_2 + \sum_{i=1}^{p} \beta_2 InLEXP_{t-i} + \sum_{i=1}^{q} \beta_2 InGDP_{t-i} + \sum_{i=1}^{r} \beta_2 InSECENR_{t-i} + \mu_{2t} \quad (11)$$

Secondly, the causality between private physical capital and economic growth is found using the equation:

$$InK_t = \alpha_3 + \sum_{i=1}^{p} \beta_3 InLEXP_{t-i} + \sum_{i=1}^{q} \beta_3 InGDP_{t-i} + \mu_{3t} \quad (12)$$

Finally, the causality between public infrastructure and economic growth is found using the equation:

$$InELEC_t = \alpha_4 + \sum_{i=1}^{p} \beta_4 InELEC_{t-i} + \sum_{i=1}^{q} \beta_4 InGDP_{t-i} + \sum_{i=1}^{r} \beta_4 InTEL_{t-i} + \mu_{4t} \quad (13)$$

$$InTEL_t = \alpha_5 + \sum_{i=1}^{p} \beta_1 InTEL_{t-i} + \sum_{i=1}^{q} \beta_5 InGDP_{t-i} + \sum_{i=1}^{r} \beta_5 InELEC_{t-i} + \mu_{5t} \quad (14)$$

3.10 Data Source

Annual time series data covering the period 1975 to 2017 is used in this study. The period covered is based on the consideration of data availability. The data were obtained from the World Development Indicators (WDI) database (year 2018) compiled by the World Bank. This is the most reliable and easily accessible data source. GDP per capita (constant local currency) is used to measure economic growth; gross capital formation (% of GDP) is used to measure private physical capital, human capital consists of enrolment rate, secondary (% gross) and life expectancy at birth (total years). Also, public infrastructure consists of fixed telephone subscription, and electricity production and transmission per capita (kWh). The researcher controlled for variables that also determine GDP per capita growth. Inflation rate, trade and foreign direct investment were considered. Trade was measured with trade (% of GDP). Inflation was measured with consumer price (annual %) and foreign direct investment was measured as FDI inflows (% of GDP). Trade was included because of the significant effect trade expansion can have on economic growth. Export and import can influence GDP growth by encouraging resource allocation efficiently, economies of scale exploitation and promotion of technological advancement (Helpman & Krugman, 1985). Inflation rate was also included because price stability is considered an essential tool in promoting economic growth and sustainable development and foreign direct investment brings in technology, knowledge and capital investment necessary to propel economic growth.

Variables	Proxies	Notation	Source
Human Capital	Enrolment rate, secondary (% gross)	SECENR	World Development Indicators (WDI)
	Life expectancy at birth (total years)	LEXP	World Development Indicators (WDI)
Private Physical Capital	Gross capital formation (% of GDP)	K	World Development Indicators (WDI)
Public Infrastructure	Fixed telephone Subscription	TEL	World Development Indicators (WDI)
	Electric power production and transmission (kWh) per capita	ELEC	World Development Indicators (WDI)
GDP Per Capita	GDP per capita (constant local currency)	GDP	World Development Indicators (WDI)
Trade Openness	Trade (% of GDP)	TRA	World Development Indicators (WDI)
Foreign Direct Investment	FDI net inflows (% of GDP)	FDI	World Development Indicators (WDI)
Inflation	Consumer prices (annual %)	INF	World Development Indicators (WDI)

Source: World Development Indicators (WDI), 2018, World Bank.

CHAPTER FOUR

ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents the analysis performed on the variables of the study. The results of the analysis is presented and interpreted for conclusions and recommendations. Diagnostic analysis of the stationarity of the variables of the study, bounds test for cointegration, the long run and short run estimates and the error correction term are examined. Finally, the serial correlation, heteroskedasticity, model stability and causality of the variables are assessed. The analysis begins with the descriptive statistics which facilitate the identification of the appropriateness of the data for regression analysis.

4.2 Descriptive Statistics

Table 1: Descriptive Statistics

	GDP	K	SECENR	LEXP	ELEC	TEL	TRA	INF	FDI
Mean	3012.064	17.90445	43.67013	56.13281	318.8182	0.006479	56.23146	29.84593	2.639134
Median	2755.190	16.49196	39.07192	57.03200	334.8928	0.003470	57.04611	18.69271	1.647297
Maximum	5044.047	29.81433	69.95347	62.74200	425.9385	0.016586	116.0484	122.8745	9.517043
Minimum	2015.589	3.749769	33.95046	49.33900	93.49242	0.000000	6.320343	3.030303	-0.660372
Std. Dev.	796.1503	7.024686	11.06593	3.859678	72.00234	0.004797	28.53759	27.80619	2.925535
Skewness	1.182934	0.025076	1.480130	-0.124093	-1.017164	0.597662	0.160434	2.119818	0.964268
Kurtosis	3.422085	1.961783	3.746686	1.986451	3.977052	2.063247	2.111126	7.111711	2.637059
Jarque-Bera	11.55098	1.845701	14.75775	2.132385	9.337383	4.612610	1.786107	69.76137	6.899661
Probability	0.003103	0.397385	0.000624	0.344317	0.009385	0.099629	0.409404	0.000000	0.031751
Sum	144579.1	734.0824	1659.465	2638.242	14028.00	0.311008	2699.110	1432.604	113.4828
Sum Sq dev	29791201	1973.848	4530.828	685.2671	222926.5	0.001081	38276.51	36339.67	359.4678
Observation	48	41	38	47	44	48	48	48	43

Source: Calculated with data from WDI. GDP per capita (GDP) is proxy for economic growth; enrolment rate, secondary (SECENR) and life expectancy at birth (LEXP) are proxies for human capital; gross capital formation (K) is proxy for private physical capital; and electricity production and transmission per capita (ELEC) and fixed telephone subscription (TEL) are proxies for public infrastructure. Trade (TRA), foreign direct investment (FDI) and Inflation (INF) are control variables.

In Table 1, average GDP per capita is GHC 3012.06. On average 43.67% of students of secondary school age (15years to 19 years) are enrolled in secondary school while 17.90 % of GDP is added to the Ghanaian economy as fixed assets and inventories. On average, infants will live 56 years if mortality at birth stays the same throughout the infant's life. On average, 318.82 kWh of electricity is produced and transmitted per capita. Finally, the average fixed telephone subscription per capita is 0.006. The median of students of secondary school age (15years to 19 years) is 39.07% with a minimum of 33.95%. The minimum life expectancy over the period is 49 years. Meanwhile a minimum of 3.75% of GDP is added to the Ghanaian economy in the form of fixed assets and inventories.

Maximum GDP per capita is GHS 5044.04 with variability of GHC 796.15. The maximum over the coverage period for secondary school enrolment rate and life expectancy are 69.15% and 63 years respectively with variability of 11.06% and 3.85 years. Over the study period, a maximum of 425.94 kWh of electricity is produced and transmitted per capita and 0.016 fixed telephone subscriptions per capita was recorded. A deviation of 72.00 kWh per capita was recorded for electricity production and transmission. Median GDP per capita is GHS 2700.85 with minimum of GHS 2755.19. On the control variables, 56% of goods and services are exported and imported. It cost the average Ghanaian consumer 29% higher to consume the same basket of goods and services every year. 2.67% of investments are investments made by foreigners in the country. The maximum and minimum import and export (% of GDP) are 116% and 6% respectively and it cost the average consumer as high as 122% and low as 3% to consume the same baskets of goods and services. While GDP per capita , secondary school enrolment, fixed telephone subscription, trade, foreign direct investment, inflation and gross capital formation have a long right tail (positive skewness), electricity production and transmission per capita and life expectancy have a long left

tail (negative skewness). GDP per capita, secondary school enrolment and trade are mesokurtic. The rest of the variables are platykurtic.

4.3 Pairwise Correlation Matrix

Table 2: Pairwise Correlation Matrix

	GDP	K	LEXP	SECENR	TEL	ELEC	FDI	INF	TRA
GDP	1.000								
K	0.418	1.000							
LEXP	0.770	0.752	1.000						
SECENR	0.825	0.206	0.655	1.000					
TEL	0.771	0.677	0.841	0.457	1.000				
ELEC	-0.869	-0.527	-0.810	-0.687	-0.878	1.000			
FDI	-0.667	0.127	-0.236	-0.826	-0.142	0.435	1.000		
INF	0.881	0.400	0.848	0.821	0.803	-0.850	-0.507	1.000	
TRA	0.769	0.680	0.843	0.454	0.999	-0.876	-0.136	0.803	1.000

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

The pairwise correlation matrix is shown in Table 2 which offers information on the strength as well as the direction of relationship between the variable of the study. It also tells whether there are problems of multicollinearity. In Table 2, LEXP, SECENR, TEL and ELEC are highly correlated. The control variables (FDI, INF and TRA) are also highly correlated. In order to correct for the multicollinearity, Principal Component Analysis (PCA) was undertaken on human capital and public infrastructure variables. However, the estimation technique used (ARDL) is able to correct for potential multicollinearity (Pesaran et al., 2001)

4.4 Unit Root Test at level using ADF Test

Table 3: Unit Root Test at level using ADF Test

Augmented Dickey-Fuller (ADF) Test LEVEL			Level of Integration
Variable	**Constant (P-value)**	**Constant & Trend (P-value)**	**I(d)**
GDP	0.9858	0.7144	Non stationary at level
SECENR	0.9933	0.9044	Non stationary at level
LEXP	0.8181	0.0492**	Stationary at level I(0)
K	0.1487	0.0099***	Stationary at level I(0)
ELEC	0.0000***	0.0000***	Stationary at level I(0)
TEL	0.8298	0.6962	Non stationary at level
TRA	0.4775	0.3595	Non stationary at level
FDI	0.6008	0.4292	Non stationary at level
INF	0.0035***	0.0013***	Stationary at level I(0)

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

Before testing for cointegration, conducting unit root test is necessary. To find stationarity of the variables of study, unit root test must be conducted using Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) test. Peseran et al. (2001) suggested ARDL technique can be applied when all the series are I (0) or I (1) and none is I (2). Accordingly, unit root tests were conducted to find the order of integration of the variables. The null hypothesis of unit root is tested against the alternative hypothesis of no unit root. First, the ADF test at level was conducted on the variables. The unit root test exhibited in table 3 shows GDP per capita, secondary school enrolment, fixed telephone subscription, trade and foreign direct investment are not stationary at level.

At constant and constant and trend, the probability values are not significant at 5%. Life expectancy, gross capital formation, electricity production and transmission per capita and inflation are stationary at level because their probability values are significant at 5%. The null hypothesis of unit root cannot be rejected for the alternative hypothesis of no unit root for GDP per capita, secondary school enrolment rate, fixed telephone subscription, trade and foreign direct investment. However, the null hypothesis is rejected for the alternative hypothesis of no unit root for life expectancy, gross capital formation, electricity production and transmission per capita and inflation. To ensure the stationarity of GDP per capita, secondary school enrolment, fixed telephone subscription, trade and foreign direct investment, ADF unit root test was also conducted at first difference. The result is exhibited in table 4

4.5 Unit Root Test at First Difference using ADF Test

Table 4: Unit Root Test at First Difference using ADF Test

Augmented Dickey-Fuller (ADF) Test FIRST DIFFERENCE			**Level of Integration**
Variable	**Constant (p-value)**	**Constant & Trend (p-value)**	**I(d)**
GDP	0.0012***	0.0001***	Stationary at first difference I(I)
SECENR	0.0000***	0.0000***	Stationary at first difference I(I)
LEXP	0.0024***	0.0206***	Stationary at level I(0)
K	0.0000***	0.0000***	Stationary at level I(0)
ELEC	0.0003***	0.0006***	Stationary at level I(0)
TEL	0.0000***	0.0000***	Stationary at first difference I(I)
TRA	0.0001***	0.0007***	Stationary at first difference I(I)
FDI	0.0000***	0.0000***	Stationary at first difference I(I)

INF	0.0000***	0.0000***	Stationary at level I(0)

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

The ADF test at first difference was conducted on the variables at constant and constant and trend. The unit root test exhibited in table 4 shows GDP per capita, secondary school enrolment, fixed telephone subscription, trade and foreign direct investment are stationary at first difference. Their probabilities are significant at 5%. At constant and constant and trend, the null hypothesis of unit root is rejected for the alternative hypothesis of no unit root for GDP per capita, secondary school enrolment, fixed telephone subscription, trade and foreign direct investment. Gross capital formation, electricity production and transmission per capita, life expectancy and inflation are stationary at level because their probability values are significant at 5%. The Phillip-Perron (PP) test, an alternative technique for conducting unit root test, was also used to check the stationarity of the variables. The results are exhibited in Table 4 and Table 5

4.6 Unit Root Test at Level using PP Test

Table 5: Unit Root Test at Level using PP Test

Phillip-Perron (PP) Test LEVEL			**Level of Integration**
Variable	**Constant (P-value)**	**Constant & Trend (P-value)**	**I(d)**
GDP	0.9932	0.9116	Non stationary at level
SECENR	0.9949	0.9074	Non stationary at level
LEXP	0.0000***	0.0000***	Stationary at level I(0)
K	0.0000***	0.0001***	Stationary at level I(0)
ELEC	0.0000***	0.0000***	Stationary at level I(0)

TEL	0.0000***	0.0000***	Stationary at level I(0)
TRA	0.6319	0.5015	Non stationary at level
FDI	0.6169	0.4378	Non stationary at level
INF	0.0034***	0.0011***	Stationary at level I(0)

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively***.**

The PP test at level was conducted on the variables. The null hypothesis of unit root is tested against the alternative hypothesis of no unit root. The unit root test in table 5 shows GDP per capita, secondary school enrolment, trade and foreign direct investment are not stationary at level. At constant and constant and trend, their probability values are insignificant at 5%. Life expectancy, gross capital formation, electricity production and transmission per capita, inflation and fixed telephone subscription are stationary at level because their probabilities are significant at 5%. The null hypothesis of unit root cannot be rejected for the alternative hypothesis of no unit root for GDP per capita, secondary school enrolment, trade and foreign direct investment. However, the null hypothesis of unit root is rejected for the alternative hypothesis of no unit root for life expectancy, gross capital formation, electricity production and transmission per capita, fixed telephone subscription and inflation. To ensure the stationarity of GDP per capita, secondary school enrolment, trade and foreign direct investment, unit root test was also conducted at first difference. The result is exhibited in table 6

4.7 Unit Root Test at First Difference using PP Test

Table 6: Unit Root Test at First Difference using PP Test

Phillip-Perron (PP) Test FIRST DIFFERENCE			**Level of Integration**
Variable	**Constant (P-value)**	**Constant & Trend (P-value)**	**I(d)**
GDP	0.0011***	0.0001***	Stationary at first difference I(1)
SECENR	0.0000***	0.0000***	Stationary at first difference I(1)
LEXP	0.0000***	0.0000***	stationary at level I(0)
K	0.0000***	0.0001***	stationary at level I(0)
ELEC	0.0000***	0.0000***	stationary at level I(0)
TEL	0.0000***	0.0000***	stationary at level I(0)
TRA	0.0003***	0.0024***	Stationary at first difference I(1)
FDI	0.0000***	0.0000***	Stationary at first difference I(1)
INF	0.0000***	0.0000***	stationary at level I(0)

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

The unit root test was conducted on GDP per capita, secondary school enrolment, trade and foreign direct investment at first difference. The unit root test exhibited in table 6 shows GDP per capita, secondary school enrolment, trade and foreign direct investment are stationary at first difference. Their probabilities are significant at 5%. At constant and constant and trend, the null hypothesis of unit root is rejected for the alternative hypothesis of no unit root for GDP per capita, secondary school enrolment rate, trade and foreign direct investment. Life expectancy, gross capital

formation, electricity production and transmission per capita, inflation and fixed telephone subscription are stationary at level because their probability values are significant at 5 %.

4.8 Summary of ADF and PP Unit Root test

Table 7: Summary of ADF and PP Unit Root test

	Augmented Dickey Fuller (ADF) Test		Phillip Perron (PP) Test	
Variable	**P-value**	**I(d)**	**P-value**	**I(d)**
GDP	0.0001***	I(I)	0.0001***	I(1)
SECENR	0.0000***	I(I)	0.0000***	I(1)
LEXP	0.0492**	I(0)	0.0000***	I(0)
K	0.0099***	I(0)	0.0001***	I(0)
ELEC	0.0000***	I(0)	0.0000***	I(0)
TEL	0.0000***	I(I)	0.0000***	I(0)
TRA	0.0001***	I(I)	0.0024***	I(I)
FDI	0.0000***	I(I)	0.0000***	I(I)
INF	0.0013***	I(0)	0.0011***	I(0)

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

From table 7 above, GDP per capita, secondary school enrolment and fixed telephone subscription are integrated at I(1) for both ADF and PP test. However, life expectancy, gross capital formation and electricity production and transmission per capita are integrated at I(0) for both ADF and PP test. Pesaran et al. (2001) suggested ARDL technique can be applied when all the series are I(0) or I(1) or mixture of both and none is I(2). The bound test for cointegration between the variables of the study is performed after identifying that the variables are integrated at I(0) and I(1). The result is exhibited in table 8.

4.9 Bounds Test for Cointegration

Table 8: Bounds Test for Cointegration

F-Bounds Test			**Null Hypothesis: No levels relationship**	
Test Statistic	**Value**	**Significance**	**I(0)**	**I(1)**
			Asymptotic: n=1000	
F-statistic	**3.890*** **	10%	1.66	2.79
K	8	5%	1.91	3.11
		2.5%	2.15	3.4
		1%	2.45	3.79

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively*

The ARDL bounds test for cointegration proposed by Pesaran et al. (2001) is calculated in table 8 above. The null hypothesis of no cointegration is tested against the alternative hypothesis of long run cointegration. To reject the null hypothesis of no cointegration for the alternative hypothesis, the F-statistics should be greater than the upper bound critical values at 5% significance level. The F-statistics calculated above 3.890 is greater than the upper bound critical values of 3.79 at 1% significance level. The null hypothesis of no cointegration is rejected for the alternative hypothesis of long run cointegration. This shows the variables of the study are cointegrated in the long run. Having established that cointegration exist between the variables of the study, the optimal lag length is established based on the Akaike Information Criterion (AIC) for the best model (see appendix 1). Akaike information criterion selects the best model with the specification: ARDL (1, 2, 2, 2, 2, 2, 2, 2, 2) shown in table 9. .

4.10 Long Run Estimates

Table 9: Long Run Estimates

ARDL Long Run Form
Dependent Variable: D(GDP)
Selected Model: ARDL(1, 2, 2, 2, 2, 2, 2,2, 2)

Levels Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
K	0.552940	3.425444	0.161421	0.8737
LEXP	0.953276	9.038725	0.105466	0.9172
SECENR	0.755775	3.588584	0.210605	0.8357
ELEC	2.219316	13.26662	0.167286	0.8691
TEL	0.291229	1.935796	0.150444	0.8822
TRA	-2.654520	13.94185	-0.190399	0.8513
INF	-0.416550	2.036767	-0.204515	0.8404
FDI	-0.009065	0.658035	-0.013776	0.9892

EC = GDP - (0.5529*K + 0.9533*LEXP + 0.7558*SECENR + 2.2193
*ELEC + 0.2912*TEL -2.6545*TRA -0.4165*INF -0.0091*FDI)

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively***.**

In the long run, a 1% increase in secondary school enrolment will lead to 0.75 increases in GDP per capita, all things being equal. On the average, a year increase in life expectancy will increase GDP per capita by 0.95, all things being equal. This finding corroborate the findings of Neeliah and Seetanah (2016) and Ogundari and Awokuse (2018). The authors discovered that, in the long run, human capital measured by secondary school enrolment and life expectancy has positive impact on economic growth.

On the average, 1% increase in gross capital formation (K) will lead to 0.55 increase in GDP per capita, all things being equal. This results corroborates the findings of Arshad and Munir (2015). On the average, a unit (kWh) increase in electricity production and transmission per capita increase GDP per capita by 2.22, all things being equal, while an increase in fixed telephone subscription per capita increases GDP per capita by 0.29, all things being equal. The results above substantiates the findings of Choudhary and Sultana (2018).

On the control variables, a percentage increase in trade reduces GDP by 2.65 while a percentage increase in inflation reduces GDP by 0.42**.** GDP is reduced by 0.01 if foreign direct investment increases by one (1) per cent, all things being equal. In the long run, gross capital formation, secondary school enrolment, life expectancy, electricity production and transmission per capita and fixed telephone subscription have positive but insignificant effect on GDP growth in Ghana after controlling for inflation, trade and foreign direct investment

Human capital (life expectancy and secondary enrolment rate) have insignificant effect on GDP per capita growth in Ghana in the long run. In the long run, this may be due to ineffectiveness and low level of productivity among healthy workers. Another reason is the unsustained labour that healthy people provide and their low educational investment that does not enhance productivity.

On the insignificant effect of public infrastructure (electricity power generation and transmission and fixed telephone subscription) on economic growth in the long term, the explanation is the deterioration in public infrastructure overtime suggests that loss of electricity is counterproductive to Ghana's economic growth. Electricity generation and distribution losses have negative impact on businesses and other infrastructure indices. For accumulation of physical capital the reason is due to low investment in machinery, plant and equipment and the consequential effect of low

electricity production and transmission for businesses and its spill over effect on revenue generation.

Regarding the control variables, the negative and insignificant foreign direct investment is due to the fact that FDI inflows have not gone into productive sectors of the Ghanaian economy. Also it could be due to lack of proper regulatory framework to channel FDI inflows into productive sectors of the Ghanaian economy hence the expected benefits of FDI inflows are not fully realised Inflation has negative relationship with economic growth suggesting that increase in inflation decrease economic growth in Ghana. Thus inflation is dragging the economic growth of Ghana. Insignificant effect of trade on economic growth may be due to excess of import over exports. Ghana is predominantly import driven. This means the terms of trade will always be unfavourable for Ghana.

4.11 Short Run Estimates

Table 10: Short Run Estimates

Dependent Variable: D (GDP)
Selected Model: ARDL(1, 2, 2, 2, 2, 2, 2, 2, 2)

ECM Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (K(-1))	0.008333	0.008811	0.945674	0.3576
D (LEXP(-1))	8.015378	1.073037	7.469808	0.0000***
D (SECENR(-1))	0.010283	0.002617	3.929195	0.0011***
D (ELEC(-1))	-0.028456	0.015269	-1.863685	0.0797*
D (TEL(-1))	-0.008656	0.006756	-1.281309	0.2173
D (TRA(-1))	0.046421	0.017643	2.631166	0.0175***
D (INF(-1))	-0.005179	0.006281	-0.824443	0.4211
D (FDI(-1))	-0.019874	0.006113	-3.251380	0.0047***
ECT (-1)*	0.024535	0.003419	7.175532	0.0000***

R-squared	0.866684	Mean dependent var	0.007104
Adjusted R-squared	0.781361	S.D. dependent var	0.047155

S.E. of regression	0.022049	Akaike info criterion	-4.500363
Sum squared residual	0.012154	Schwarz criterion	-3.797020
Log likelihood	111.5076	Hannan-Quinn criter.	-4.242560
Durbin-Watson stat	2.142138		

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

The Error Correction Model (ECM) of human capital, private physical capital, public infrastructure and economic growth is exhibited in table 10. In the short run, secondary school enrolment has positive and significant effect on GDP per capita growth. 1% increase in secondary school enrolment increases GDP per capita growth by 0.01, all things being equal. This finding corroborates the findings of Nowak and Dahal (2016). In the short run, life expectancy has positive and significant effect on GDP per capita growth. A year increase in life expectancy increases GDP per capita by 8.02, all things being equal.

Also, in the short run, 1% increase in gross capital formation increases GDP per capita by 0.01, all things being equal. On public infrastructure investments, in the short run, a kWh increase in electricity production and transmission per capita decrease GDP per capita by 0.03, all things being equal. This result corroborates the findings of Stupak (2017). Finally, an increase in fixed telephone subscription per capita will decrease GDP per capita by 0.01, all things being equal. In the short run, electricity production and distribution per capita, fixed telephone subscription, and gross capital formation have insignificant effect on GDP per capita growth.

The R-Square of 0.87 indicates that 87% of the variation in GDP per capita growth is explained by the independent variables of the study. 13% of the variation in GDP per capita is explained by other factors. The Durbin Watson (DW) statistics and the adjusted R-Square reveal the model is a

good fit because the DW statistics is greater than the R-square. The coefficient of the error correction term (ECT) of 0.02 indicates that the disequilibrium between the variables of the study would be corrected at an adjustment speed of 2%.

On the control variables, 1% increase in trade increases GDP per capita by 0.05, all things being equal while 1% increase in inflation and foreign direct investment decreases GDP per capita by 0.01 and 0.02 respectively. In the short run, life expectancy and secondary school enrolment are the variables that determine GDP per capita growth in Ghana after controlling for inflation, foreign direct investment and trade,

To provide an explanation for the short term effects of the variables of the study on GDP per capita growth, it has been found that better health and education enrolment improve GDP per capita growth. The possible reason is the nature of short-term health and educational investments in Ghana. Physical capital accumulation is still insignificant. This may also be due to insufficient investment in physical assets needed to increase the production of goods and services. Ghana's challenge with energy production and transmission is also the explanation for the significant negative short term effect of electricity on GDP per capita growth. The energy challenges also have disadvantages for infrastructural indices in the country. This explains also the negative effect of fixed telephone subscription on economic growth. In the short term, Ghana imports more than what it exports and inflation rate effect is still persistent and impeding economic growth. Trade has significant positive effect on GDP per capita growth. The reason is, in the short term, government initiative of reducing the cumbersome procedures in exporting goods and the entrepreneurial drive of most manufacturing companies and individuals may be the cause.

4.12 Long Term Effect of Composite Human Capital, Private Physical Capital and Composite Public Infrastructure on Economic Growth

Table 11: Long Term Effect of Composite Human Capital, Private Physical Capital and Composite Public Infrastructure on Economic Growth

ARDL Long Run Form and Bounds Test
Dependent Variable: D(Y)
Selected Model: ARDL(3, 1, 1, 1, 1, 1, 1)

Levels Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
K	-0.204101	0.205576	-0.992824	0.3940
HC	0.492549	0.638642	0.771244	0.4967
INFRA	0.016180	0.295837	0.054694	0.9598
TRA	3.628419	4.771599	0.760420	0.5023
FDI	-0.104173	0.132346	-0.787125	0.4887
INF	-13.86860	21.71334	-0.638713	0.5684
C	20.10060	32.10555	0.626079	0.5757

EC = Y - (-0.2041*K + 0.4925*PCAHC + 0.0162*PCSINFRA + 3.6284*TRA
-0.1042*FDI -13.8686*INF + 20.1006)

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

After considering the individual effect of the variables of the study on GDP per capita growth, an index was constructed for human capital and public infrastructure using Principal Component Analysis (PCA) (see appendix). The effect of composite human capital and composite public infrastructure on GDP per capita growth is examined in table 11 above. When secondary school enrolment and life expectancy are considered together, they have positive but insignificant effect on GDP per capita growth in the long run. In the long run, a unit change in human capital index increases GDP per capita growth by 0.493, all things being equal.

Again, when fixed telephone subscription and electricity production and distribution per capita are considered together, they have positive and insignificant effect on GDP per capita growth. A unit

increase in infrastructure index leads to 0.016 increase in GDP per capita. Private physical capital has negative and insignificant effect on GDP per capita growth. A percentage increase in gross capital formation leads to 0.204 decrease in GDP per capita, all things being equal. Human capital and public infrastructure have positive and insignificant effect on GDP per capita growth after controlling for trade, foreign direct investment and inflation.

Human capital (life expectancy and secondary enrolment) have insignificant effect due to low level of productivity among healthy workers, lack of sustainability of services provided by labour and low educational investment that does not enhance productivity. Loss of electricity is counterproductive to Ghana's economic growth. Electricity generation and distribution losses are rampant and decreases productivity. For accumulation of physical capital, the reason is due to low investment in machinery, plant and equipment.

4.13 Short Term Effect of Composite Human Capital, Private Physical Capital and Composite Public Infrastructure on Economic Growth

Table 12: Short Term Effect of Composite Human Capital, Private Physical Capital and Composite Public Infrastructure on Economic Growth

ARDL Error Correction Regression
Dependent Variable: D(Y)
Selected Model: ARDL(3, 1, 1, 1, 1, 1, 1)

ECM Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(K)	-0.035600	0.015840	-2.247499	0.1102
D(HC)	0.107298	0.038494	2.787393	0.0686**
D(INFRA)	-0.031915	0.018984	-1.681135	0.1913
D(TRA)	8.857000	1.676102	5.284285	0.0132***
D(FDI)	-0.074697	0.024258	-3.079198	0.0542***

D(INF)	-5.107291	0.917562	-5.566153	0.0114***
CointEq(-1)*	-0.322271	0.069114	-4.662913	0.0186***

R-squared	0.888659	Mean dependent var	0.009996
Adjusted R-squared	0.799585	S.D. dependent var	0.045555
S.E. of regression	0.020394	Akaike info criterion	-4.641648
Sum squared resid	0.004159	Schwarz criterion	-4.194282
Log likelihood	53.09565	Hannan-Quinn criter.	-4.565935
Durbin-Watson stat	3.274890		

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

The Short run effect of composite human capital and composite public infrastructure on GDP per capita growth is also examined in table 12 above. When secondary school enrolment and life expectancy (human capital) are considered together, they have positive and significant effect on GDP per capita growth in the short run. In the short run, a unit change in human capital index increases GDP per capita growth by 0.107, all things being equal. The nature of short-term health and educational investments in Ghana has improved overtime. Change of life style and medication has improved the health of Ghanaians and investment in education has also improved over the years

Again, when fixed telephone subscription and electricity production and distribution per capita (public infrastructure) are considered together, they have negative and insignificant effect on GDP per capita growth. A unit increase in infrastructure index leads to 0.031 decrease in GDP per capita. Ghana's challenge with energy production and transmission is also the explanation for the insignificant negative short term effect of public infrastructure on GDP per capita growth. The energy challenges also have negative impact on infrastructural indices in the country.

Private physical capital has negative and insignificant effect on GDP per capita growth. A percentage increase in gross capital formation leads to 0.035 decrease in GDP per capita, all things being equal. Insufficient investment in physical assets explains the negative effect in the short term. Human capital has positive and significant effect on GDP per capita growth while public infrastructure has negative and insignificant effect on GDP per capita growth after controlling for trade, foreign direct investment and inflation.

The R-Square of 0.88 indicates that 88% of the variation in GDP per capita growth is explained by the independent variables of the study. 12% of the variation in GDP per capita is explained by other factors. The Durbin Watson (DW) statistics and the adjusted R-Square reveal the model is a good fit because the DW statistics is greater than the R-square. The coefficient of the error correction term (ECT) of -0.322 indicates that the disequilibrium between the variables of the study would be corrected at an adjustment speed of 32.2%.

On the control variables, 1% increase in trade increases GDP per capita by 8.86, all things being equal while 1% increase in inflation and foreign direct investment decreases GDP per capita by 5.12 and 0.07 respectively.

4.14 Serial Correlation Test

Table 13: Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.299942	Prob. F(2,15)	0.7452**
Obs*R-squared	1.615084	Prob. Chi-Square(2)	0.4460

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

Residual Serial Correlation was tested using Breusch-Godfrey Serial Correlation LM Test based on null hypothesis: no serial correlation against an alternative hypothesis of serial correlation. Results from Breusch–Godfrey Serial Correlation LM Test in Table 13 shows that the probability value of 0.74 is significant at 5% significance level. The null hypothesis of no serial correlation cannot be rejected at 5% significance level. This means that no serial correlation exists between the variables of the study

4.15 Heteroscedasticity Test

Table 14: Heteroscedasticity Test

Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statis	0.718734	Prob. F(25,16)	0.7766**
Obs*R-squared	22.21688	Prob. Chi-Square(11)	0.6232
Scaled explained SS	7.526733	Prob. Chi-Square(11)	0.9997

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively.*

Residual autocorrelation was tested using Breusch-Pagan-Godfrey heteroscedasticity test. The null hypothesis of no autocorrelation is tested against the alternative hypothesis of autocorrelation. To reject the null hypothesis for the alternative, the probability value must be significant at 5% level otherwise the alternative will hold. The calculated probability value of 0.7766 is significant at 5% level. The null hypothesis of no autocorrelation cannot be rejected for the alternative hypothesis of autocorrelation. Thus, no autocorrelation exists between the variables of the study.

4.16 Stability Test

To ascertain the stability of the best ARDL model employed, the CUSUM and CUSUM of squares (see appendix) test was used. For the ARDL model to be stable, the plots in the CUSUM and

CUSUM of squares must lie within the 5% significance level line. The plots in the CUSUM and CUSUM of Squares tests lie within the 5% significance level. The best ARDL model used is stable

4.17 Pairwise Granger Causality Test

Table 16: Pairwise Granger Causality Test

Pairwise Granger Causality Tests
Sample: 1970 to 2017
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
LEXP does not Granger Cause GDP	44	3.22772	0.0333**
GDP does not Granger Cause LEXP		0.64602	0.5904
SECENR does not Granger Cause GDP	27	0.32087	0.8102
GDP does not Granger Cause SECENR		3.57655	0.0322**
K does not Granger Cause GDP	30	2.59865	0.0767*
GDP does not Granger Cause K		4.29829	0.0151***
ELEC does not Granger Cause GDP	42	3.27824	0.0323**
GDP does not Granger Cause ELEC		2.35001	0.0892*
TEL does not Granger Cause GDP	40	1.49304	0.2345
GDP does not Granger Cause TEL		0.21405	0.8859

*Source: Prepared by the author with data from WDI. Note ***, ** and * implies significance at 1%, 5%, and 10% level respectively*

4.17.1 Human Capital and Economic Growth

The result of the pairwise granger causality test between human capital and economic growth is shown in table 16. The causality between secondary school enrolment and GDP per capita is tested. On SECENR and GDP per capita, the null hypothesis: SECENR does not granger cause

GDP per capita growth is tested against the alternative hypothesis that SECENR granger cause GDP per capita growth. The probability value of 0.8102 is insignificant at 10% level. The null hypothesis SECENR does not granger cause GDP per capita growth cannot be rejected for the alternative hypothesis. This indicates SECENR does not cause GDP per capita growth. On the other hand, the causality between GDP per capita growth and SECENR is tested. The null hypothesis that GDP per capita growth does not granger cause SECENR is tested against the alternative hypothesis that GDP per capita growth cause SECENR. The probability value of 0.0322 is significant at 5% level. The null hypothesis is rejected for the alternative hypothesis. This means there is a unidirectional causality between GDP per capita growth and secondary school enrolment running from GDP per capita to secondary school enrolment. This confirms the findings of Sharma and Sahni (2015).

On life expectancy and GDP per capita growth, the null hypothesis: LEXP does not granger cause GDP per capita growth is tested against the alternative hypothesis LEXP granger cause GDP per capita growth. The probability value of 0.0333 is significant at 5% level. The null hypothesis is rejected for the alternative hypothesis. This indicates LEXP cause GDP per capita growth. On the other hand, the causality between GDP per capita growth and LEXP is tested. The null hypothesis: GDP per capita growth does not granger cause LEXP is tested against the alternative hypothesis that GDP per capita growth cause LEXP. The probability value of 0.5904 is insignificant at 10 % level. The null hypothesis cannot be rejected for the alternative hypothesis. This means there is a unidirectional causality between GDP per capita growth and LEXP running from LEXP to GDP per capita growth. This results confirm the findings of Tsen (2006).

4.17.2 Private Physical Capital and Economic Growth

On the results of the pairwise granger causality test between private physical capital and economic growth, the null hypothesis: K does not granger cause GDP per capita growth is tested against the alternative hypothesis that K granger cause GDP per capita growth. The probability value of 0.0767 is significant at 10% level. The null hypothesis is rejected for the alternative hypothesis. This indicates K cause GDP per capita growth. On the other hand, the causality between GDP per capita growth and K is tested. The null hypothesis that GDP per capita growth does not granger cause K is tested against the alternative hypothesis that GDP per capita growth cause K. The probability value of 0.0151 is significant at 1% level. The null hypothesis is rejected for the alternative hypothesis. This means there is bidirectional causality between GDP per capita growth and gross capital formation (K) running from gross capital formation (K) to GDP per capita growth and from GDP per capita growth to gross capital formation (K)

4.17.3 Public Infrastructure and Economic Growth

Further, the pairwise granger causality between public infrastructure and economic growth is tested. On the results of the pairwise granger causality test between ELEC and GDP per capita growth, the null hypothesis that ELEC does not granger cause GDP per capita growth is tested against the alternative hypothesis ELEC granger cause GDP per capita growth. The probability value of 0.0323 is significant at 5% level. The null hypothesis is rejected for the alternative hypothesis. ELEC granger cause GDP per capita growth. On the other hand, the causality between GDP per capita growth and ELEC is tested. The null hypothesis is tested against the alternative hypothesis. The probability value of 0.0892 is significant at 10 % level. The null hypothesis is rejected for the alternative hypothesis. This means there is bidirectional causality between GDP per capita growth and ELEC running from ELEC to GDP per capita growth and from GDP per capita growth to ELEC. This result confirm the findings of Onakoya et al. (2003)

Finally, the pairwise granger causality test between TEL and GDP per capita growth is tested. The probability value of 0.2345 is insignificant at 10% level. The null hypothesis cannot be rejected for the alternative hypothesis. On the other hand, the causality between GDP per capita growth and TEL is tested. The null hypothesis GDP per capita growth does not granger cause TEL is tested against the alternative hypothesis that GDP per capita growth cause TEL. The probability value of 0.88592 is also insignificant at 10 % level. The null hypothesis cannot be rejected for the alternative hypothesis. This means there is no causality between GDP per capita growth and fixed telephone subscription. This result is unsupported.

4.18 Chapter Summary

In this chapter, unit root test was first conducted to ascertain the stationarity of GDP per capita, secondary school enrolment rate, life expectancy, gross capital formation, electricity production, fixed telephone subscription, trade, foreign direct investment and inflation. Bounds test for cointegration between the variables was also conducted. The pairwise correlation matrix, long run and short run coefficients were established. Further, the serial correlation and heteroscedasticity test was performed. The stability of the model selected was examined with CUSUM and CUSUM of squares. Finally, pairwise granger causality test was conducted on the variable of the study.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This thesis has examined the short run and long run effect of human capital, private physical capital and public infrastructure on economic growth in Ghana. Also, the causality between human capital, private physical capital, public infrastructure and economic growth was assessed. This chapter provides the summary of the findings, conclusions and recommendations, the contribution to literature and suggestions for future research.

5.2 Summary of Findings

This research examined the effect of human capital, private physical capital and public infrastructure on economic growth as well as the causal relationships. Autoregressive Distributive Lag (ARDL) methodology is employed for the analysis with data spanning from 1975 to 2017 obtained from World Development Indicators (WDI). The first objective of the study examines the short run and long run effect of human capital, private physical capital and public infrastructure on economic growth in Ghana. The study found that there is long run cointegration between human capital, private physical capital, public infrastructure and economic growth in Ghana. In the short run, human capital (secondary school enrolment and life expectancy) is the determinant of economic growth in Ghana after controlling for inflation, foreign direct investment and trade. Private physical capital and infrastructure (fixed telephone subscription) have insignificant effect on economic growth in Ghana but public infrastructure (electricity production and distribution per capita) has significant effect on economic growth. In the long run, human capital, private physical

capital and public infrastructure have positive but insignificant effect on economic growth after controlling for inflation, trade and foreign direct investment.

The second objective examined the effect of composite human capital, physical capital and composite public infrastructure on economic growth. In the long term, human capital, public infrastructure and physical capital have positive and insignificant effect on GDP per capita growth. However, in the short run, human capital is the determinant of GDP per capita growth in Ghana. Physical capital and public infrastructure have insignificant effect on GDP per capita growth.

The third, fourth and fifth objectives examined the causality between human capital, private physical capital, public infrastructure and economic growth in Ghana. The evidence found shows there is unidirectional causality between human capital and economic growth, bidirectional causality between private physical capital and economic growth and unidirectional causality between public infrastructure (electricity production and transmission per capita) and economic growth and no causality between public infrastructure (fixed telephone subscription) and economic growth in Ghana.

5.3 Conclusion

The study examined the short run, long run and causality between human capital, private physical capital, public infrastructure and economic growth in Ghana. The first objective of the study examined the short run and long run effect of human capital, private physical capital and public infrastructure on economic growth in Ghana. The Autoregressive Distributive Lag (ARDL) model was employed to establish the short run and long run coefficients at chapter four of the thesis. In the short run, human capital is the determinant of economic growth in Ghana. Private physical capital and public infrastructure have insignificant effect on economic growth. In the long run,

human capital, private physical capital and public infrastructure have positive but insignificant effect on economic growth in Ghana.

The second objective examined the effect of Composite human capital, physical capital and composite public infrastructure on economic growth. In the short run, composite human capital is the determinant of GDP per capita growth in Ghana. Composite public infrastructure and physical capital have insignificant effect on GDP per capita growth. In the long run, composite human capital, composite public infrastructure and physical capital have positive and insignificant effect on GDP per capita growth.

The third, fourth and fifth objective examined the causality between human capital, private physical capital, public infrastructure and economic growth in Ghana. Pairwise granger causality test was used to find the causal relationship at chapter four of the thesis. It was found that there is unidirectional causality between human capital and economic growth, bidirectional causality between private physical capital and economic growth and unidirectional causality between public infrastructures (electricity production and transmission per capita) and economic and no causality between public infrastructure (fixed telephone subscription) and economic growth in Ghana

5.4 Recommendations

The study recommends that government should institute measures to improve secondary school enrolment rate and life expectancy in Ghana. Measures such as increase in government budget allocation for education, subsidies for school fees, reduction in academic and facility user fees, merit-based scholarship etc. can enhance secondary school enrolment rate. Improvement in medical care, access to medication and medical personnel, and making medical services affordable can improve life expectancy in Ghana.

Secondly, economic measures should be put in place to improve economic growth. Reduction in interest rate can facilitate the expansion of entrepreneurial activity and increase private investment in assets. Private sector engagement and assistance from government will reduce operational and investment cost and increase economic growth. Export oriented programmes to encourage export of locally manufactured products will help improve the economic condition of the country

Finally, government investment in public infrastructure must be increased through improvement in budget allocation for infrastructural development. Government can partner with the private sector especially in the telecoms industry to provide telecoms infrastructure. Lasting solution should also be found for the energy challenges the country is facing.

5.5 Contribution to Literature

The study examined the effect of human capital, private physical capital and public infrastructure on economic growth in Ghana. This research contributes to literature by examining the effect of human capital, private physical capital and public infrastructure on economic growth in Ghana by using a composite index of human capital (education and health) and public infrastructure (electricity and telephone). The second original contribution of the study examined is the causality between human capital, private physical capital and public infrastructure in Ghana which has not been examined

5.6 Suggestions for future study

The researcher makes the following suggestions for future study:

1. Future research should be conducted employing different methods to examine human capital, private physical capital, public infrastructure and economic growth nexus

2. Future research should be conducted to determine the linearity and non-linearity of education and health measures of human capital, private physical capital, and public infrastructure on economic growth in Ghana and Sub Saharan Africa.

REFERENCES

Acemoglu, D., & Johnson, S. (2007). Disease and development: the effect of life expectancy on economic growth. *Journal of political economy, 115*(6), 925-985.

Adeniji, S. O. (2015). Telecommunication Infrastructure and Economic Growth in Nigeria: New Evidence From ARDL Bound Testing Approach to Cointegration. .

Afzal, M., Farooq, M. S., Ahmad, H. K., Begum, I., & Quddus, M. A. (2010). Relationship between school education and economic growth in Pakistan: ARDL bounds testing approach to cointegration. *Pakistan Economic and Social Review*, 39-60.

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction, Econometrica60 (2): 323–351.

Aghion, P., Howitt, P., Howitt, P. W., Brant-Collett, M., & García-Peñalosa, C. (1998). *Endogenous growth theory*: MIT press.

Amairia, R., & Amaira, B. (2017). Transport Infrastructure and Economic Growth: New Evidence from Tunisia an ARDL Bounds Testing Approach. *Journal of Infrastructure Development, 9*(2), 98-112.

Anochiwa, L., & Maduka, A. (2014). Human capital, infrastructure and economic growth in Nigeria: An empirical evidence. *IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), 9*(4), 01-06.

Arabi, K. A. M., & Abdalla, S. Z. S. (2013). The impact of human capital on economic growth: Empirical evidence from Sudan. *Research in World Economy, 4*(2), 43.

Arrow, K. J. (1962). The economic implications of learning by doing. *The review of economic studies, 29*(3), 155-173.

Arshad, S., & Munir, K. (2015). Factor Accumulation and Economic Growth in Pakistan: Incorporating Human Capital.

Aryeetey, E., & Tarp, F. (2000). Structural Adjustment and After: Which Way Forward? Economic Reforms in Ghana. *Academy of Management Review, 12*(1), 67-75.

Asghar, N., Awan, A., & ur Rehman, H. (2012). Human capital and economic growth in Pakistan: A cointegration and causality analysis. *International Journal of Economics and Finance, 4*(4), 135.

Asteriou, D., & Agiomirgianakis, G. M. (2001). Human capital and economic growth: time series evidence from Greece. *Journal of Policy Modeling, 23*(5), 481-489.

Awokuse, T. O. (2008). Trade openness and economic growth: is growth export-led or import-led? *Applied economics, 40*(2), 161-173.

Barro, R. J. (1991). Economic growth in a cross section of countries. *The Quarterly Journal of Economics, 106*(2), 407-443.

Becker, G. S. (1994). Human capital revisited *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education (3rd Edition)* (pp. 15-28): The university of Chicago press.

Boachie, M. K. (2015). Effect of health on economic growth in Ghana: An application of ARDL bounds test to cointegration.

Canning, D., & Pedroni, P. (2008). Infrastructure, long-run economic growth and causality tests for cointegrated panels. *The Manchester School, 76*(5), 504-527.

Chaudhry, I. S., Malik, A., & Faridi, M. Z. (2010). Exploring the causality relationship between trade liberalization, human capital and economic growth: Empirical evidence from Pakistan. *Journal of Economics and International Finance, 2*(9), 175-182.

Choudhary, S. A., & Sultana, B. (2018). Effect Of Transportation Infrastructure On Pakistan's Economic Growth: The Gmm Approach. *International Journal of Information, Business*

and Management, 10(3), 126-137.

Co-operation, O. f. E., & Development. (2006). *Infrastructure to 2030: Telecom, land transport, water and electricity*: OECD Publishing.

Dagum, C., & Slottje, D. J. (2000). A new method to estimate the level and distribution of household human capital with application. *Structural change and economic dynamics, 11*(1-2), 67-94.

DBSA. (1998). Infrastructure: a foundation for development: Midrand DBSA.

De Foville, d. A. (1905). Ce que c'est la richesse d'un peuple. *Bulletin de l'Institut International de Statistique, 14*(3), 62-74.

Dewan, E., & Hussein, S. (2001). *Determinants of economic growth (Panel data approach)*: Citeseer.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association, 74*(366a), 427-431.

Ecevit, E. (2013). The impact of life expectancy on economic growth: Panel cointegration and causality analyses for OECD countries. *The International Journal of Social Sciences, 16*(1), 1-14.

Edrees, A. (2016). Human capital, infrastructure and economic growth in Arab world: A panel granger causality analysis.

Eisner, R. (1989). *The total incomes system of accounts*: University of Chicago Press.

Elbadawi, I. A. (1998). *Real exchange rate policy and non-traditional exports in developing countries*: UNU-WIDER.

Engel, E. (1883). *Der Werth des Menschen:¬ Der Kostenwerth des Menschen* (Vol. 1): Simion.

Esfahani, H. S., & Ramírez, M. a. T. (2003). Institutions, infrastructure, and economic growth.

Journal of development Economics, *70*(2), 443-477.

Estache, A. (2005). What do we know about Sub-Saharan Africa's infrastructure and the impact of its 1990s reforms? *World Bank, Washington, DC*.

Frimpong, S., & Adam, A. M. (2010). Does financial Sector Development cause investment and growth? Empirical analysis of the case of Ghana. *J. Bus. Enterp. Dev*, *2*, 67-84.

Galbraith, J. K. (2014). *The end of normal: The great crisis and the future of growth*: Simon and Schuster.

Gebrehiwot, K. G. (2016). The Impact of Human Capital Development on Economic Growth in Ethiopia: Evidence from ARDL Approach to Co-Integration. *Bahir Dar Journal of Education*, *16*(1).

Goode, R. B. (1959). Adding to the Stock of Physical and Human Capital. The American Economic Review *49:147–55.*

Granger, C. W., & Ramanathan, R. (1984). Improved methods of combining forecasts. *Journal of forecasting*, *3*(2), 197-204.

Gyimah-Brempong, K., & Wilson, M. (2004). Health human capital and economic growth in Sub-Saharan African and OECD countries. *The Quarterly Review of Economics and Finance*, *44*(2), 296-320.

Helpman, E., & Krugman, P. R. (1985). *Market structure and foreign trade: Increasing returns, imperfect competition, and the international economy*: MIT press.

Jan, S. A., Chani, M. I., Pervaiz, Z., & Chaudhary, A. R. (2012). Physical infrastructure and economic development in Pakistan.

Jerome, A. (1999). *Infrastructure in Africa: the record*: African Development Bank.

Jihène, S. (2013). The impact of human capital on economic growth: Case of Tunisia, Morocco,

Japan and South KoreaI. *Abstract of Economic, Finance and Management Outlook, 1*, 1-2.

Jorgenson, D. W., & Fraumeni, B. M. (1989). Investment in education. *Educational Researcher, 18*(4), 35-44.

Joshua, O. O. (2016). The Impact of Physical and Human Capital Development on Economic Growth in Developing and Developed Countries: A Comparative Panel Data Approach. *Economy, 3*(1), 1-18.

King, R. G., & Levine, R. (1994). *Capital fundamentalism, economic development, and economic growth.* Paper presented at the Carnegie-Rochester Conference Series on Public Policy..

Koop, G., Pesaran, M. H., & Potter, S. M. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of econometrics, 74*(1), 119-147.

Kruger, R., & Strauss, I. (2015). Africa rising out of itself: The growth of intra-African FDI.

Kuznet, S. (1971). Modern economic growth: findings and reflections, Lecture to the memory of Alfred Nobel, 11 December 1971.

Laroche, M., Mérette, M., & Ruggeri, G. C. (1999). On the concept and dimensions of human capital in a knowledge-based economy context. *Canadian Public Policy/Analyse de Politiques*, 87-100.

Lawanson, A. O. (2015). Economic Growth Experience of West African Region: Does Human Capital Matter?

Li, Y., Wang, X., Westlund, H., & Liu, Y. (2015). Physical Capital, Human Capital, and Social Capital: The Changing Roles in C hina's Economic Growth. *Growth and change, 46*(1), 133-149.

Lucas , R. E. (1988). On the mechanics of economic development. *Journal of monetary economics, 22*(1), 3-42.

Malangeni, L., & Phiri, A. (2018). Education and Economic Growth in Post-apartheid South Africa: An Autoregressive Distributive Lag Approach. *International Journal of Economics and Financial Issues, 8*(2), 101-107.

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

Marx, K. (1867). Das Kapital: kritik der politischen ökonomie. *Germany: Verlag von Otto Meisner, 1885*, 1894.

McWilliams, H. O. A., & Kwamena-Po, M. A. (1975). *The Development of Education in Ghana*. London: Longman.

Mehrara, M., & Musai, M. (2013). The relationship between economic growth and human capital in developing countries. *International Letters of Social and Humanistic Sciences, 5*(55), 55-62. .

Mody, A. (1997). Infrastructure delivery through central guidance. *Infrastructure strategies in East Asia: The untold story*.

Neeliah, H., & Seetanah, B. (2016). Does human capital contribute to economic growth in Mauritius? *European Journal of Training and Development, 40*(4), 248-261.

Nejat, E., & Sanlı, A. (1999). Long-run growth effect of the physical capital-human capital complementarity: An approach by time series techniques.

Ngangue, N., & Manfred, K. (2015). The impact of life expectancy on economic growth in developing countries. *Asian Economic and Financial Review, 5*(4), 653.

Nowak, A., & Dahal, G. (2016). he contribution of education to economic growth: Evidence from Nepal. *International ournal of Economic Sciences, 5*(2), 22-41.

Ogundari, K., & Abdulai, A. (2014). Determinants of household's education and healthcare

spending in Nigeria: Evidence from survey data. *African Development Review, 26*(1), 1-14.

Ogundari, K., & Awokuse, T. (2018). Human capital contribution to economic growth in Sub-Saharan Africa: Does health status matter more than education? *Economic Analysis and Policy, 58*, 131-140.

Ogunkunle, C. O., Opeloyeru, N., Fatoba, P. O., Ziyath, A. M., & Adeniyi, S. A. (2017). Sources, Transport Pathways and Ecological Risks of Heavy Metals Present in Roadside Soil Environment in Urban Areas. *Environmental Research, Engineering & Management, 73*(3).

Onakoya, A., Salisu, A., & Oseni, I. (2012). Infrastructure and economic growth in Nigeria: A multivariate approach. *Research Journal of Business Management and Accounting, 1*(3), 30-39.

Organization, W. H. (2018). *Global tuberculosis report 2018*: World Health Organization.

Outreville, J. F. (1999). *Financial development, human capital and political stability*.

Palei, T. (2015). Assessing the impact of infrastructure on economic growth and global competitiveness. *Procedia Economics and Finance, 23*, 168-175.

Pegkas, P., & Tsamadias, C. (2014). Does higher education affect economic growth? The case of Greece. *International Economic Journal, 28*(3), 425-444.

Pérez, C. (2002). Revoluciones tecnológicas, cambios de paradigma y de modelos socio institucionales. *Página Oficial de Carlota Pérez.[Documento en línea]. Disponible: http://www. carlotaperez. org/Articulos/1-revolucionestecnologicas. htm [Consulta: 2006, junio 27]*.

Pesaran, M. H., & Shin, Y. (1996). Cointegration and speed of convergence to equilibrium. *Journal of econometrics, 71*(1-2), 117-143.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics, 16*(3), 289-326.

Philips, B., & Perron, P. (1988). Mean Reversion in Stock Prices. *Journal of Financial Economics*, 27-59.

Pradhan, R. P., & Bagchi, T. P. (2013). Effect of transportation infrastructure on economic growth in India: the VECM approach. *Research in Transportation Economics, 38*(1), 139-148.

Pradhan, R. P., Norman, N. R., Badir, Y., & Samadhan, B. (2013). Transport infrastructure, foreign direct investment and economic growth interactions in India: the ARDL bounds testing approach. *Procedia-Social and Behavioral Sciences, 104*, 914-921.

Pradhan, R. P., Norman, N. R., Badir, Y., & Samadhan, B. (2013). Transport infrastructure, foreign direct investment and economic growth interactions in India: the ARDL bounds testing approach. *Procedia-Social and Behavioral Sciences, 104*, 914-921.

Ricardo, D. (1817). On the principles of political economy and taxation: London: John Murray.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of political Economy, 94*(5), 1002-1037.

Sahoo, P., Dash, R. K., & Nataraj, G. (2010). Infrastructure development and economic growth in China. *Institute of Developing Economies Discussion Paper, 261*.

Sala-i-Martin, B. a. (Ed.). (2004). *Economic Growth* (Vol. Second Edition).

Schultz, T. P. (1999). Health and schooling investments in Africa. *Journal of economic perspectives, 13*(3), 67-88.

Shahbaz, M., & Lean, H. H. (2012). Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. *Energy policy, 40*, 473-479.

Shaihani, M., Harisb, A., Ismaila, N., & Saida, R. (2011). Long run and short run effects on

education levels: Case in Malaysia. *International Journal of Economic Research, 2*(6), 77-87.

Sharma, P., & Sahni, P. (2015). Human Capital and Economic Growth in India: A Co-integration and Causality Analysis. *Ushus-Journal of Business Management, 14*(2), 1-18.

Shultz, T. W. (1961a). Investments in human Capital. *American Economic Review, 51(1):1-7.*

Sims, C. A. (1972). Money, income, and causality. *The American economic review, 62*(4), 540-552.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics, 70*(1), 65-94.

Sookha, K. (2018). *The impact of mobile communications infrastructure investment on economic growth in South Africa.* University of Cape Town.

Stupak, J. M. (2017). Economic Impact of Infrastructure Investment.

Swan, T. W. (1956). Economic growth and capital accumulation. *Economic record, 32*(2), 334-361.

Takumah, W., & Njindan Iyke, B. (2015). The links between economic growth and tax revenue in Ghana: an empirical investigation.

Tang, Z. (2011). Physical and human capital formation, exports, and long-term economic growth: A causality analysis for China.

Temple, J. (1999). The new growth evidence. *Journal of economic Literature, 37*(1), 112-156.

Todaro, M. P., & Smith, S. (2005). *Economic Development. 9 th Edition Pearsen, Addision Wesley.*

Tsen, W. H. (2006). Granger causality tests among openness to international trade, human capital accumulation and economic growth in China: 1952–1999. *International Economic Journal,*

20(3), 285-302.

Turgot, A. (1770). Extracts from ‘Paper on Lending at Interest.”.

Wang, Y., & Liu, S. (2016). Education, Human Capital and Economic Growth: Empirical Research on 55 Countries and Regions (1960-2009). *Theoretical Economics Letters*, *6*(02), 347.

Yang, W., & Zhao, J. (2018). Sources of China's Economic Growth: A Case for Green Accounting. *Advances in Management and Applied Economics*, *8*(2), 33-59.

Younis, F. (2014). Significance of Infrastructure Investment for Economic Growth.

Zivengwa, T., Hazvina, F., Ndedzu, D., & Mavesere, I. M. (2013). Investigating the causal relationship between education and economic growth in Zimbabwe. *Asian Journal of Humanities and Social Studies (ISSN: 2321-2799)*, *1*(05).

APPENDIX 1: Optimal Lag Selection

VAR Lag Order Selection Criteria
Endogenous variables: GDP K SECENR LEXP TEL ELEC
Sample: 1970 to 2017
Included observations: 40

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-292.0026	NA	0.119186	14.90013	15.15346	14.99173
1	-20.19479	448.4830	9.23e-07	3.109740	4.883063*	3.750917*
2	15.57708	48.29203	1.06e-06	3.121146	6.414461	4.311905
3	68.61604	55.69091*	6.41e-07*	2.269198*	7.082504	4.009538

APPENDIX 2: PCA of human capital measures (life Expectancy and Secondary school enrolement

Component	Eigenvalue	Difference	Proportion	Cumulative
LEXP	1.740	1.479	0.870	0.870
SECENR	0.260	.	0.130	1.000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Unexplained
LEXP	0.707	0.707	0
SECENR	0.707	-0.707	0

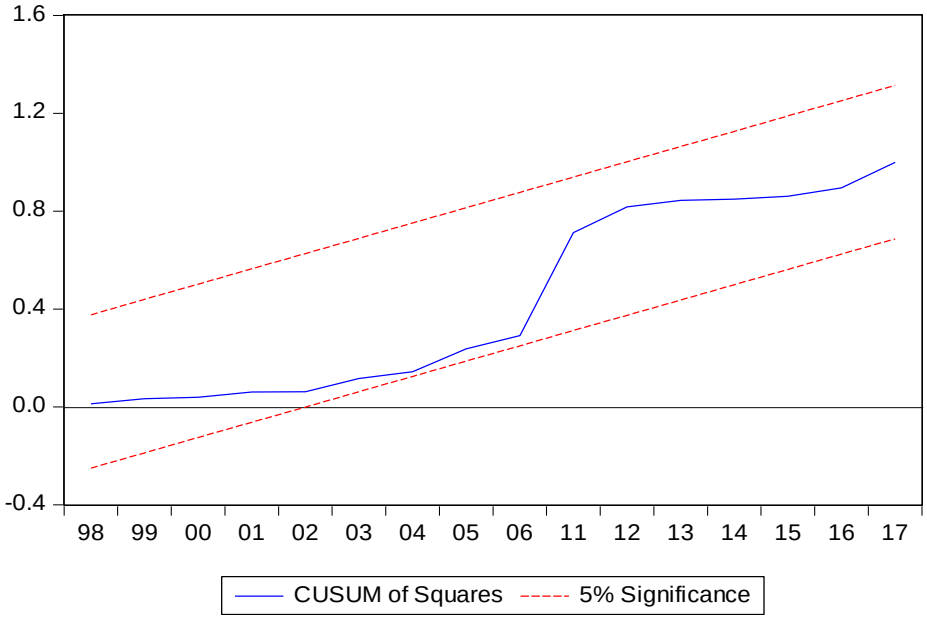
APPENDIX 3: PCA of Public Infrastructure measures (electricity and fixed telephone Subscription

Component	Eigenvalue	Difference	Proportion	Cumulative
FTS	1.852	1.703	0.926	0.926
ELEC	0.148	.	0.074	1.000

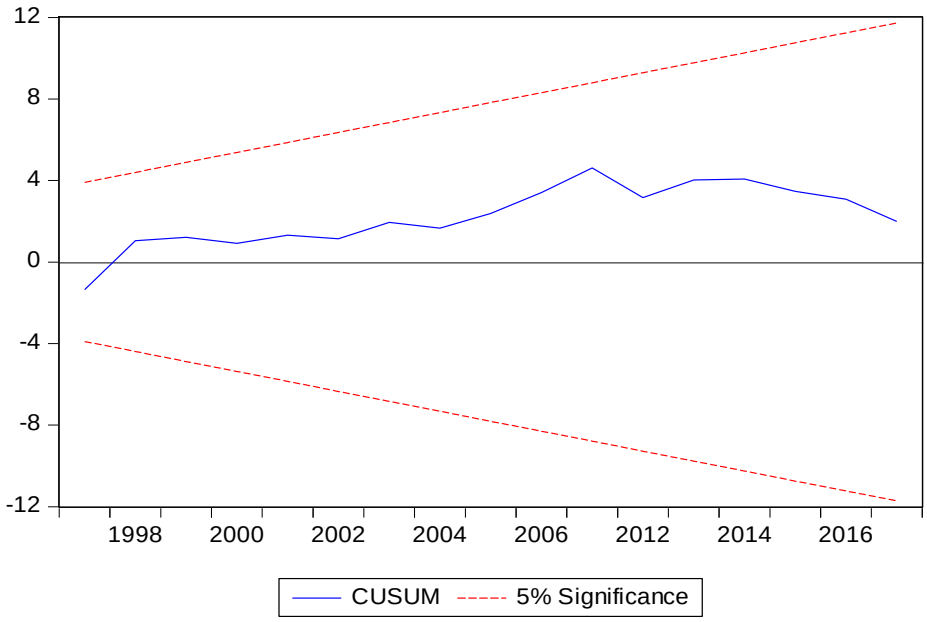
Principal components (eigenvectors)

Variable	Comp1	Comp2	Unexplained
FTS	-0.707	0.707	0
ELEC	0.707	0.707	0

APPENDIX 4: CUSUM of Squares



APPENDIX 5: CUSUM



Arshad, S. and K. Munir (2015). "Factor Accumulation and Economic Growth in Pakistan: Incorporating Human Capital."

Becker, G. S. (1994). Human capital revisited. Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education (3rd Edition), The university of Chicago press**:** 15-28.

Choudhary, S. A. and B. Sultana (2018). "EFFECT OF TRANSPORTATION INFRASTRUCTURE ON PAKISTAN'S ECONOMIC GROWTH: THE GMM APPROACH." Business and Management **10**(3).

Dickey, D. A. and W. A. Fuller (1979). "Distribution of the estimators for autoregressive time series with a unit root." Journal of the American statistical association **74**(366a): 427-431.

Freire-Seren, M. J. (2001). "R&D-expenditure in an endogenous growth model." Journal of Economics **74**(1): 39-62.

Galbraith, J. K. (2014). The end of normal: The great crisis and the future of growth, Simon and Schuster.

Koop, G., M. H. Pesaran, et al. (1996). "Impulse response analysis in nonlinear multivariate models." Journal of econometrics **74**(1): 119-147.

Neeliah, H. and B. Seetanah (2016). "Does human capital contribute to economic growth in Mauritius?" European Journal of Training and Development **40**(4): 248-261.

Ogundari, K. and T. Awokuse (2018). "Human capital contribution to economic growth in Sub-Saharan Africa: Does health status matter more than education?" Economic Analysis and Policy **58**: 131-140.

Pesaran, M. H. and Y. Shin (1996). "Cointegration and speed of convergence to equilibrium." Journal of econometrics **71**(1-2): 117-143.

Pesaran, M. H., Y. Shin, et al. (2001). "Bounds testing approaches to the analysis of level relationships." Journal of applied econometrics **16**(3): 289-326.

Philips, B. and P. Perron (1988). "Mean Reversion in Stock Prices." Journal of Financial Economics: 27-59.

Shultz, T. W. (1961a). "Investments in human Capital." American Economic Review **51(1):1-7**.

Solow, R. M. (1956). "A contribution to the theory of economic growth." The Quarterly Journal of Economics **70**(1): 65-94.

Stupak, J. M. (2017). "Economic Impact of Infrastructure Investment."

Tsen, W. H. (2006). "Granger causality tests among openness to international trade, human capital accumulation and economic growth in China: 1952–1999." International Economic Journal **20**(3): 285-302.