CHRISTIAN SERVICE UNIVERSITY COLLEGE

DEPARTMENT OF ACCOUNTING AND FINANCE

"THE EFFECT OF INFLATION, EXCHANGE RATE, AND INTEREST RATE ON ECONOMIC GROWTH IN GHANA"

BY

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A dissertation submitted to the department of accounting and finance in partial fulfillment of the requirement for the award of the degree of Master of Science in accounting and finance

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DECLARATION

Candidate's Declaration

I hereby declare that this dissertation is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature……..Date……

Name……

Supervisor's Declaration

I hereby declare that the preparation and presentation of the dissertation were supervised in accordance with the guidelines on supervision of dissertation laid down by the Christian service University.

Supervisor's Signature…….……..Date……..

Name……

ABSTRACT

Several studies have explored the impact of macroeconomic variables on economic growth. Such works have often established a significant relationship between these variables (Agyapong et'al, 2016; Mensah and Okyere, 2015; Agalega and Antwi, 2013; Khan and Senhadji, 2011; Hausmann et'al, 2005). The main purpose of this study is to find the effect of exchange rate, inflation, and interest rate on economic growth in Ghana. The general objective of the study is to determine if these three macroeconomic variables have a significant impact on economic growth. Using data from world development indicators (World Bank) for the period 1980 to 2015, the study applied autoregressive distributed lag model (ARDL) for the estimation of the model. The results revealed that exchange rate depreciation has a statistically significant positive impact on economic growth in the long-run and a negative and a statistically insignificant impact in the short-run. Unlike exchange rate, the study suggests a statistically insignificant effect of inflation on economic growth in the long-run but a negative and statistically significant impact in the short-run. Interest rate however exerted a negative and significant effect in both the long and short run. The study recommended that the Bank of Ghana (BoG) and the Ministry of Finance continue the implementation and reduction of the Monetary Policy Rate (MPR) and Inflation Targeting (IT) to very low levels practicably possible to stimulate investment. It also recommended that Ministry of Finance, Ministry of Trade, the Ministry of Food and Agriculture, the export promotion center, and the Ghana investment promotion center put programs and projects in place to encourage the processing and production of goods and services for the export market.

KEY WORDS

Monetary Policy Rate (MPR)

Error correction term (ECT)

Vector error correction model (VECM)

Heteroskedasticity

Serial correlation

Multicollinearity

Unit root

Robustness

Autoregressive distributed lag (ARDL)

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DEDICATION

I dedicate this work to my parents Mr. and Mrs. Jawula and all my siblings.

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CHAPTER ONE

INTRODUCTION

Economic growth in any country reflects its capacity to produce goods and services. It is a long-run process that occurs as an economy's potential output increases (Perkins et al, 2006). Ghana's economic growth has been relatively low since independence. The economy experienced very low growth[1] during the periods 1980 to 1985. Generally, the per capita GDP of Ghana is relatively low compared to other developing economies like South Africa, India, and Mauritius.

Recently, the Ghanaian economy witnessed a downward growth trend; 6.69% in 2012, 4.81% in 2013, 1.60% in 2014, 1.57% in 2015 and 1.28% in 2016 (African Economic Outlook, 2016). The slowdown resulted from a number of economic challenges, most of which occurred in 2014. These include a 3-year power crisis, rising fiscal deficit and public debt levels, a significant external sector deficit and unpredictably low world market prices for the country's oil and gold exports (African Economic Outlook, 2016).

The studies of Semuel and Nurina (2015) and Saymeh and Orabi (2013) have brought to bear the importance of macroeconomic variables such as exchange rate, inflation and interest rate on economic growth. Less developed countries are mostly characterized by high rate of unemployment, low life expectancy at birth, high illiteracy rates, etc. (Todaro and Smith 2015). According to Rodrik (2008) and Di Nino at al. (2011) exchange rate depreciation has a positive and significant effect on economic growth. Mensah and Okyere (2015) found a negative and significant effect of interest rate on economic growth. In a related study, Khan and Senhadji (2011) argued that, inflation has a negative impact on economic growth.

[1] Low economic growth averaging; -3.19%

This study specifies a model for the estimation of the effect of exchange rate, inflation, and interest rate using the Solow growth model. Furthermore, the transmission mechanism of these variables on economic growth is theoretically explained by the Keynes absorption theory of currency depreciation, the classical theory of interest rate determination, and the Sidrauski, Tobin, and Stockman's effect of inflation on economic growth.

Basically, the trend of the economic growth of Ghana raises a critical question; what are the more fundamental characteristics that explain Ghana's ability to attract investment and accumulate capital, increase efficiency, and enhance economic growth?

1.0 Background to the study

The foremost priority of every economy is to ensure economic stability and growth, and improve the wellbeing of its citizenry. Most countries especially less developed countries (LDCs) place much interest on unemployment and inflation. Economic growth refers to a rise in national per capita income (Todaro and Smith, 2015). Again, according to Todaro and Smith (2015), economic growth is measured by the increase in the amount of goods and services produced in a country. Also, Jhingan (2001) describes economic growth as a process whereby the real per capita income of a country increases over a long period of time. This clearly means that if the production of goods and services increases along with average income, the country will achieve economic growth.

Inflation, exchange rate, and interest rate are amongst the most important indicators used in measuring the macroeconomic performance of a country. Increases in prices of goods and services and foreign exchange are two important aspects which are deemed responsible for fluctuations in economic growth (Madesha et al., 2013). To understand the relationship between economic growth and exchange rate, inflation, and interest rate, the trend between these variables in Ghana are described and displayed graphically below.

1.0.1 Economic growth and exchange rate

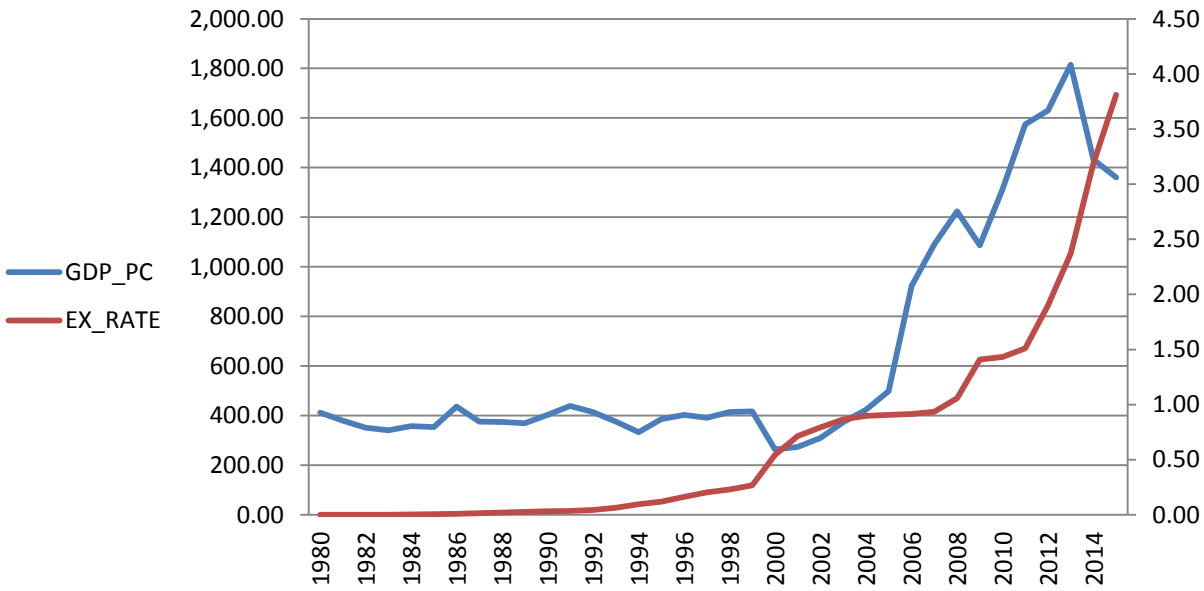
Currency devaluations in the early 1980s, while enhancing exports, have increased both the cost of living and prices of imports (World Development Indicators, 2016). As indicated in figure 1.0, during 1980 through to 1982, the exchange rate was fixed at 0.000275 cedis to a dollar. This period witnessed a negative economic growth as shown in the graph. Generally, exchange rate was relatively stable from 1980 to 1999 and depreciating at a low rate with an average of 0.0104 cedis during this period, while economic growth was also relatively poor growing at an average of -0.87%. Graphically, a positive relationship between exchange rate depreciation and economic growth was established within the period.

In the year 2000, however, the cedi witnessed massive depreciation whilst economic growth also fell as shown in figure 1.0. Could this inverse relationship be as a result of government increased expenditure on foreign goods and services that are unproductive? Between the year 2000 and 2007, the currency depreciated slightly but relatively stable at an average of 0.82 cedis per dollar. This saw the economy growing at an average of 2.58% within the period.

Again, noting from figure 1.0, from the year 2008 to 2013, the cedi depreciated drastically. While the period witnessed an average exchange rate of 1.61 cedis per dollar, economic growth increased averagely at 6.09% till 2013. The cedi continued to depreciate between 2013 and 2015 but economic growth dropped within this period. Could the power crisis in the country during this period[2] be a reason for this unusual negative relationship between economic growth and currency depreciation? The relationship between economic growth and exchange rate is shown graphically below.

[2] From 2013 to 2015

Figure. 1.0: Economic growth and exchange rate



Source; Author's construct, 2017 using data from World Bank

Graphically, apart from the period 2013 to 2015, Figure 1.0 clearly shows a positive relationship between cedi depreciation and economic growth. As shown by Rodrik (2008), at least for developing countries, an undervalued real exchange rate predicts stronger growth. Thus, while eyeballing may indicate a positive relationship between exchange rate and economic growth, it may not imply such relationship exists quantitatively. The study therefore applies a quantitative technique to estimate the effect of exchange rate depreciation on economic growth since the graphical view might just be a spurious relationship.

Generally, the above argument may indicate the existence of a positive relationship between economic growth and exchange rate depreciation in Ghana. This may suggest the need to implement currency-depreciation measures to ensure economic growth through increased utilization of idle resources. Alternatively, there may also be the need to develop import-substitution goods and services. Such goods and services have the potential of increasing investment amidst currency depreciation and enhancing economic growth.

1.0.2 Economic growth and interest rate

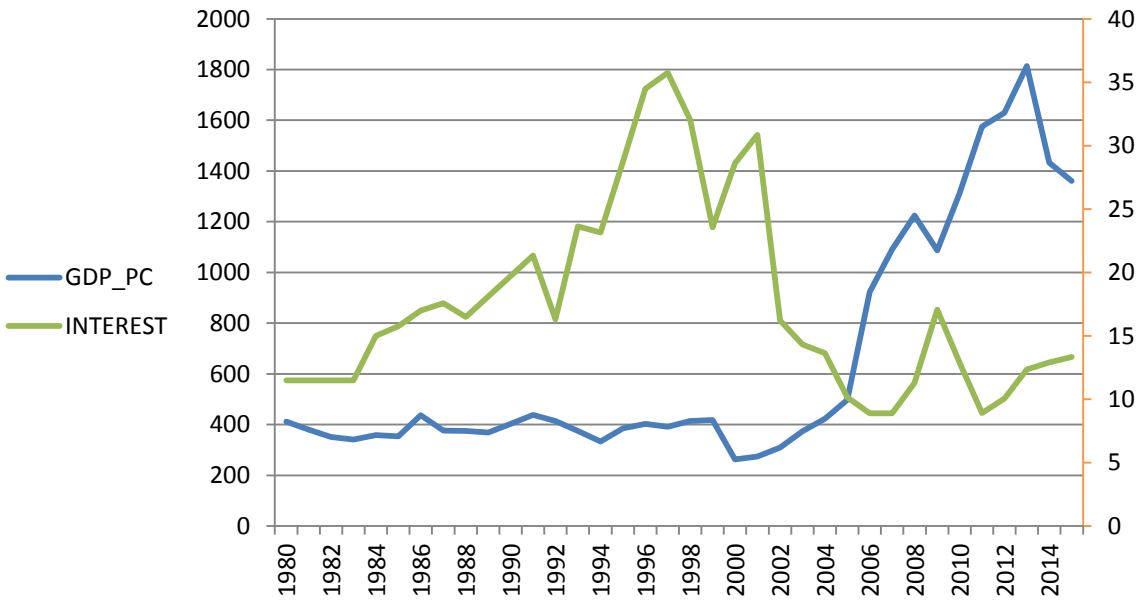
Interest rate according to Ibimodo (2005) is the rental payment for the use of credit by borrowers and return for parting with liquidity by lenders. Bernhardsen (2008) defines the interest rate as the rate at which inflation is stable and the production gap equals zero. However, Irving Fisher (1936) states that interest rates are charged for a number of reasons, one is to ensure that the creditor lowers his or her exposure to inflation. Inflation causes the nominal amount of money in the present to have less purchasing power in the future. Expected inflation rates are an integral part of determining whether or not an interest rate is high enough for the creditor.

For the purpose of this study, an interest rate is the payment made for the use of money, expressed as a percentage of the amount borrowed. Thus, an increase in the rate of interest may have a negative effect on economic growth.

Referring from Figure 1.1, while interest rate increased from 1980 to 1997 growing at an average of 17.29%, economic growth maintained a relatively stable trend averaging 0.099% during this period. From 1997 to 1999 however, interest rate fell from 35.75% to 23.56% with economic growth increasing marginally from 1.83% to 2.04%. Graphically, this suggests a negative relationship between interest rate and economic growth in Ghana.

Economic growth continued its upward trend as interest rate fell during the period 2001 to 2013. The drop in interest rate between 2001 and 2013 may be attributable to a boost in investor confidence especially in the banking sector which saw an influx of banks into the Ghanaian economy. However after 2013, interest rate increased marginally from 12.35% in 2013 to 13.34% in 2015. This was accompanied by a corresponding decrease in economic growth over the period as indicated in the diagram below.

Figure 1.1. Economic growth and interest rate



Source; Author's construct, 2017 with data from World Bank

As indicated in figure 1.2, from 1980 to 2015, the general trend of economic growth and interest rate was a negative relationship. Pictorially, one might be tempted to expect a negative relationship between these two variables. This might not necessarily be the case as it might be a spurious relationship which does not imply causality from interest rate to economic growth.

1.0.3 Economic growth and inflation

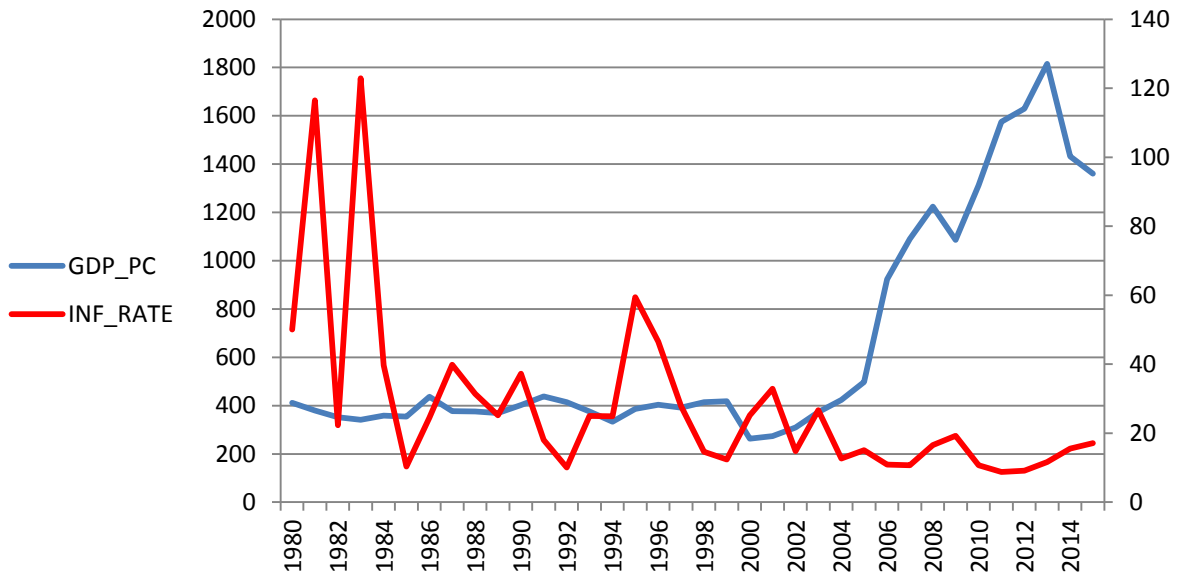
The monetary policy rate (MPR) is meant to ensure price stability through inflation targeting (IT). A lower MPR is expected to bring down inflation through low cost of borrowing particularly by the productive sector of the economy[3]. Ghana formally adopted IT framework as its monetary policy in May, 2007. Following this, the central bank announced price stability as its primary objective. However implicit (without formal announcement) inflation targeting actually started in January 2002. The Bank of Ghana (BoG) Act 2002 (Act 612)

[3] Low cost of borrowing might result in high inflation if excessive borrowing is done purposely for consumption as opposed to production.

gave operational independence to the central bank, established an implicit IT framework and Monetary Policy Committee (MPC) for the implementation of the new policy. IT is a policy with the potential of enhancing economic growth[4].

It is interesting to note that, the adoption of the IT policy saw domestic debt to GDP decrease from about 31% in 2001 to 13.5% in 2006 and inflation decreasing from about 41.9% in 2001 to 12.7% in 2006 (Maureen, 2008). Ghana's five-year success with implicit IT policy encouraged the country to formally adopt the policy in 2007 which made it the second country (after South Africa) in sub-Saharan Africa. The diagram below explains further.

Figure. 1.2 Economic growth and inflation



Source; Author's construct, 2017 with data from World Bank

In figure 1.2, Ghana experienced negative economic growth from 1980 to 1983 i.e. -1.9%, -6.2%, -9.9%, -7.8% respectively. This may have been as a result of the excessively high rates

[4] The design, implementation and evaluation of IT regimes can usefully be guided by the following key principles.

(i) The primary role of monetary policy is to provide a nominal anchor for the economy
(ii) An effective inflation-targeting regime will have beneficial first-order effects on welfare by reducing uncertainty, anchoring inflation expectations and reducing the incidence and severity of boom-bust cycles.

of inflation during this period. The inflation rate from 1980 to1983 was 50%, 117%, 22%, 123% respectively However, economic growth showed a relatively upward trend after 1984 when inflation fell drastically to 10% in 1985. Between 1985 and 2001, Inflation maintained an average of about 28.4% whilst economic growth showed an improved average of 1.76% during this period. The relationship between inflation and economic growth during this period is not very clear. However, it seems to suggest the presence of a negative relationship between these two variables.

Again, from Figure 1.2, inflation was relatively stable between 2001 and 2015 whilst the economic growth portrayed and increasing trend till 2013 when it decreased between 2013 and 2015. The unsystematic movement between these two variables can be seen clearly in the graph thus suggesting the possibility of an insignificant impact of inflation on economic growth in Ghana. A causal relationship may exist but this cannot be seen graphically hence the application of a quantitative approach will help establish this.

Does the unsystematic relationship between economic growth and inflation rate in Ghana justify the need for an effective implementation of an IT mechanism that is aimed at maintaining an inflation band of eight per cent plus two or minus two (8%±2%)?

According to Agyapong et'al (2016), Macroeconomic variables such as inflation, interest rate, exchange rate, money supply, stock prices etc. have been established considerably to be some of the principal determinants of economic growth in developed economies. Successive governments in Ghana have initiated several monetary[5] policies aimed at stabilizing inflation interest rate and exchange rate to enhance economic growth. As indicated in Figure 1.0, Figure 1.1 and Figure 1.2, the effects of exchange rate, inflation, and interest rate on the

[5] Monetary policy rate (MPR) and inflation targeting

economic growth on the Ghanaian economy cannot be confidently determined by means of only the above graphs. Thus, the need to apply co-integration technique to determine both the long-run effects and short-run dynamics of these variables on economic growth. Based on the above analysis, the core of this study is to determine whether inflation, exchange rate, and interest rate significantly affects economic growth in Ghana.

1.1 Research Problem

It is important to understand how changes and variations in exchange rate, inflation, and interest rate affect a country's ability to accumulate capital and improve factor productivity to achieve economic growth. Ghana has implemented monetary policies aimed at bringing inflation and interest rate down as well as ensuring stable exchange rate with the view to boosting investment, trade, and ultimately economic growth. Though these policies are targeted at stimulating economic growth, their effect on the Ghanaian economy is unclear and uncertain merely by the use of only graphs as discussed in the background to the study above. Due to the prominence of this problem in most developing economies and especially Ghana, several studies have been conducted on this subject matter across the globe.

Whilst the work of Agalega and Antwi (2013), Havi et al (2013), and Khan and Senhadji (2011) have methodological deficiencies such as wrong estimation and analytical technique[6], others including Mensah and Okyere (2015) and Frimpong and Oteng (2010) investigated the impact of interest rate and inflation on economic growth without considering the effect of exchange rate on economic growth. However, other studies including Semuel and Nurina (2015), Munir and Mansur (2009), Luppu (2007), Di Nino et'al (2011), Rodrik (2008), Saymeh and Orabi (2013), and Shahzad and Al Swidi (2013) were limited to Asia, Europe,

[6] The use of OLS to estimate time series data instead of a more robust approach like co-integration approach

and Middle East. Conversely, the works of Thaddeus and Nuneka (2014) and Obamuyi (2006) centered on Africa, however, the country of interest was Nigeria.

To the researcher's knowledge, the only exception is the work by Agyapong et al. (2016) that used co-integration (Johansen approach) to determine the effect of exchange rate, inflation and interest rate on the economic growth of Ghana using transformed quarterly data from 1980Q1 to 2013Q4. Transforming data may result in heteroskasticity and serial correlation and its resultant consequences. This may result in large standard errors and invalid inferences. Despite the close similarities, this current study employs ARDL co-integration using raw annual data from 1980 to 2015.

Based on the above, this current study seeks to investigate the effect of interest rate, inflation, and exchange rate on economic growth in Ghana using co-integration (ARDL) that has the tendency to estimate the short-run and long-run parameters of the model at the same time.

1.2 Purpose of the study

The purpose of the study is to determine the effect of exchange rate, inflation and interest rate on the growth of the Ghanaian economy and make policy recommendations.

1.3 Research Questions

The research problem above triggers the following research questions.

i. To what extent does inflation affect GDP growth in Ghana?

ii. What is the effect of interest rate on GDP in Ghana?

iii. What is the impact of exchange rate on GDP growth in Ghana?

1.4 Objectives of the Study

Based on the above research questions, the general objective of the study is to investigate the impact of macroeconomics variables on economic growth of Ghana. However, the following are the specific objectives;

i. Determine the effect of inflation on GDP growth in Ghana.

ii. Investigate the impact of interest rate on GDP in Ghana.

iii. Estimate the effect of exchange rate on GDP growth in Ghana.

1.5 Significance of the Study

This study examines the effects of inflation, exchange rate, and inflation on economic growth in Ghana. The findings of this study would help in the field of academia. It will fill the gap regarding the impact of inflation, exchange rate, and interest rate in Ghana and developing countries in general.

Again, it will help the government in effective policy formulation and implementation. In effect, government would be guided on the targeting of these macroeconomic variables to stimulate and enhance economic growth. It will also help investors and other stakeholders in making investment decisions.

1.6 Delimitation

Several factors affect economic growth. They include; financial sector development, education, stock market development, life expectancy, openness, exchange rate, inflation, interest rate etc. However, this study is only limited to three major macroeconomic variables- inflation, interest rate, and exchange rate but controlled for technology, labor force, and capital formation. Data from 1980-2015 for Ghana was used.

1.7 Limitation

The study was modeled using the exogenous economic growth model. Because of the difficulty in applying ordinary least squares (OLS) in analyzing time series data, as a result of its non-stationary nature; appropriate[7] tests were conducted to determine the appropriate model estimation technique. Considering the small sample size and the order of integration of the variables, ARDL co-integration approach was used to estimate the model. Interpolation was applied to fill in data for interest rate and primary school completion rate that had some missing values using Eviews. This may affect the results of the estimated model.

Labor force was not included in the model because there was no sufficient data for the period. Again, an important determinant of economic growth; life expectancy at birth was not included in the model because it was not stationary at level and first difference. It was only stationary after second difference and ARDL does not allow for the inclusion of such variables. The study conducted the unit root test, autocorrelation test, heteroskedasticity test, normality test, misspecification test, and stability test to determine the reliability of the model. The study applied the ARDL co-integration test in analyzing the data using Eviews.

1.8 Definition of Terms and Measurement of Variables

This section defines and measures both the dependent and independent variables. It also indicates the apriori signs of the independent variables are based on the theories reviewed in chapter two.

[7] The unit root test was conducted to determine the order of integration and this served as the fundamental requirement for determining the model estimation techniques.

Variables	Proxy variables and measurement	Expected sign
Dependent variable		
GDP per capita	GDP per capita is gross domestic product divided by midyear population. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant local currency.	
Independent variables		
Interest rate	The interest rate is defined as the amount which is charged by lender from borrower for use of asset. Interest rate is measured by the bank lending rate. It is the rate paid by commercial or similar banks for demand, time, or savings deposits. The terms and conditions attached to these rates differ by country, however, limiting their comparability.	Negative
Inflation rate	Inflation refers to continual rise in general price level or the rate at which regularly prices of goods and services increase and purchasing power of people is low. Inflation affects the distribution of income. The study used the consumer price index (CPI) to represent inflation.	Positive Negative Neutral
Exchange rate	Price of one currency in comparison to another currency is referred to as exchange rate. The direct quote between the Ghana cedi and US dollar was used. The US dollar is a good measure because of the huge trade volume between Ghana cedi and the US dollar.	Positive

Human capital	Human capital is proxied by the level of education. Primary completion rate, or gross intake ratio to the last grade of primary education, is the number of new entrants (enrollments minus repeaters) in the last grade of primary education, regardless of age, divided by the population at the entrance age for the last grade of primary education. Data limitations preclude adjusting for students who drop out during the final year of primary education.	Positive
Capital accumulation	Gross capital formation or gross domestic investment consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress.	Positive
Technological progress	Computer, communications and other services (percent of commercial service imports) include such activities as international telecommunications, and postal and courier services; computer data; news-related service transactions between residents and nonresidents; construction services; royalties and license fees; miscellaneous business, professional, and technical services; and personal, cultural, and recreational services.	Positive
Lagged economic growth	The essence of this is to measure conditional convergence. To measure if GDP per capita growth will converge back to the growth path.	Negative

1.9 Organization of the Study

The study is divided into five chapters; chapter one comprises the background to the study, statement of the problem, objectives of the study, research questions, significance of the study, delimitations, limitations, definition of terms and variables and organization of the study. In chapter two, literature was reviewed on previous works done by other researchers. A Theoretical review was also conducted to guide and ensure proper specification of the model that explains the relationship among the variables of interest.

Chapter three includes methodology which dealt with the data source, data collection technique, diagnostic tests, and data analysis technique. Subsequently, chapter four analysis the data and presents and discusses the results.

Summary of the findings of the study, conclusion and recommendation are presented in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews theoretical and empirical literature on exchange rate depreciation, interest rate, inflation, and economic growth. This serves as a premise upon which the gap in existing literature is exposed and more so appropriate model built for empirical analysis.

2.1 Theoretical Review

A broad range of factors could plausibly be important to growth, including the amount and type of investment, education and health-care systems, natural resources and geographical endowments, the quality of government institutions and the choice of public policy.

At the core of most theories of economic growth is a relationship between the basic factors of production; capital and labor and total economic production. A country's total output is determined by how much capital and labor it has available and how productively it uses these assets (Perkins et al, 2006). Thus, increasing the amount of production; that is economic growth. This therefore means that economic growth depends on increasing the amount of capital and labor available and increasing the productivity of those assets. The effect of exchange rate, interest rate, and inflation on economic growth is explained by various growth theories. These theories explain how changes in economic variables affect economic growth. It is important to know whether macroeconomic variables in Ghana are consistent with the exogenous growth model. The Solow exogenous growth model is explained below.

2.1.2 Exogenous Growth Model

The early neo-classical growth models are based on the exogenous growth theory where long-run output growth is mainly driven by two factors; labor and capital. In this framework, technological progress is incorporated with labor to allow for positive long-run growth. Solow (1956) presents the neo-classical model where technological possibilities are represented by a production function of the form

$Y_t = f(K_{t,} L_t)$ … . . … … … .1.1

Where; Y is output, K is capital and L is labor. Solow assumes the function exhibits constant returns to scale and the entire inputs exhibit decreasing returns to scale. Individuals save a constant proportion, s of the income and physical capital accumulation can be expressed as; $K = sY$. The long-run growth is only possible through external technological changes that influence the slope of the production function.

Uzawa (1965) modifies this neo-classical production function by explicitly incorporating the technological knowledge (A) in this model. The modified production function becomes;

$Y_t = f(K_{t,} L_{t,} A_t)$ … . … … … 1.2

A is the level of innovation, technology, knowledge, and efficiency of work. It incorporates the effects of the organization of production and of markets on the efficiency with which the factors of production are utilized. It also includes a matrix of institutional measures such as an efficient legal system etc. that reflect the extent to which these measures affect economic growth. It therefore represents variables such as exchange rate, inflation, financial sector development, skills, health, technology etc. such that an improvement in these variables will cause an outward shift in the production function. The technological expertise improves the

efficiency of labor. This efficiency can be determined by the number of people employed in education sector and accordingly, can be improved by more recruitment in this sector.

In earlier models, human capital does not appear as an independent factor of production. Mankiw et al. (1992) present an augmented Solow model specified in a Cobb-Douglas form where human capital is introduced as a separate input in the production function. Their Cobb-Douglas production function takes the following form;

$$Y_t = f\left(K_t^{\alpha}, L_t^{\Upsilon}, A_t^{\beta}, H_t^{\pi}\right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. \ldots \ldots . \ldots \ldots 1.3$$

Here, H is the stock of human capital, along with the other factors of production of the Solow model. The key characteristic of their model is the fact that human capital requires an investment for its development and depreciates at the same constant rate as physical capital. Where; α, π, β, ϒ are elasticities of economic growth with respect to K, H, A, and L respectively.

Various growth models have shown how key macroeconomic variables affect economic growth. The Solow model of growth provides a means of determining the effect of economic variables on economic growth through factor accumulation and productivity as shown in the diagram 2.1. The growth model mathematically is specified below;

$$Y_t = f\left(K_t, H_{t,}A_{t,}L_t\right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 1.4$$

Transforming equation 1.4 into the Cobb Douglas production function, it becomes;

$$Y_t = f\left(K_t^{\alpha}, H_t^{\pi}, A_t^{\beta}, L_t^{\Upsilon}\right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .1.5$$

Mathematically, A is expressed below;

$$A_t = f(exc.inf, int, Technology) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. \ldots \ldots \ldots 1.6$$

By substituting equation (1.6) into (1.5) and by specifying an extended Cobb-Douglas production function to represent the production of innovation and technology of an economy, the study obtained:

$Y = f((exc, inf, int, T)^{\beta_i} L^{\gamma} H^{\pi} K^{\alpha}$ ……1.7

Where i = 1, 2, 3, 4; then equation 1.7 becomes;

$Y_t = f\left(exc^{\beta 1}, inf^{\beta 2}, int^{\beta 3}, T^{\beta 4}, L^{\gamma}, H^{\pi}, K^{\alpha}\right)$ …… 1.8

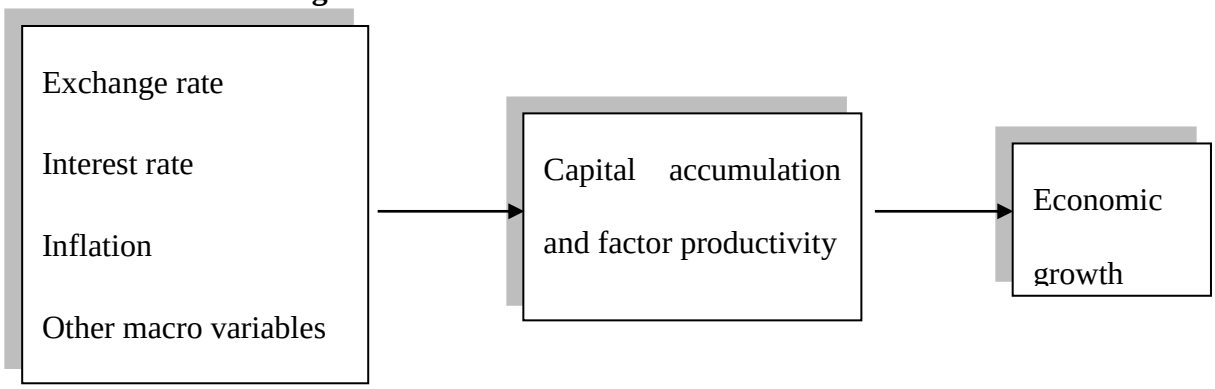
From equation (1.7) and (1.8), a change in any of the independent variables is expected to affect economic growth.

2.1.3 The transmission mechanism of inflation, exchange rate, and interest rate on economic growth

A difficulty in determining the impact of exchange rate, interest rate, and inflation on the rate of economic growth is that most of the important macroeconomic effects are indirect. The interaction among the exchange rate (the local price of foreign currency), inflation (increase in domestic prices), interest rate (cost of borrowing), and economic growth (change in real national income) are especially important.

Figure 2.1 below depicts the transmission mechanism of exchange rate, interest rate, inflation, and other macro indicators on economic growth through factor accumulation and factor productivity. The diagram illustrates that, macroeconomic variables usually affect economic growth through capital accumulation and factor productivity.

Figure.2.1 Conceptual framework: Transmission mechanism of macroeconomic variables on economic growth



Source; Author's construct, 2017

From Figure 2.1, the effect of an appreciation or depreciation in exchange rate is transmitted to economic growth through capital accumulation and labor productivity. When the currency depreciates, prices of goods and services in Ghana become cheaper relative to its trading partners. Relatively low prices of goods results in increased production through investment in both physical and human capital. In other words, firms' output will increase as a result of efficient utilization of idle resources by an improved and enhanced human and physical capital. Ultimately, the aggregation of firm's output translates into increased economic growth.

Similar to exchange rate, capital accumulation and factor productivity is the channel through which interest rate affects economic growth as indicated in Figure 2.1. During periods of high interest rates, the cost of borrowing becomes high for the manufacturing sector. This leads to low investment by firms in both physical and human capital leading to decreased output. It is worth noting that high interest rates crowds out the private sector thereby negatively affecting productivity. The end result is a decrease in economic growth. Hence, when interest rate increases, economic growth decreases suggesting an inverse relationship.

Inflation means a persistent increase in the prices of goods and services. This implies that, when prices of goods and services become high, household demand for these goods and services falls. In other words, aggregate demand decreases causing aggregate supply to decrease. To reduce aggregate supply, firms' will reduce investment in both physical and human capital. Consequently, high inflation will affect economic growth negatively. Hence, as shown in Figure 2.1, a common channel through which exchange rate, inflation, and interest rate affects economic growth is capital accumulation and factor productivity. Theoretically, the relationship between inflation and economic growth is explained below.

2.1.4. Inflation, physical capital accumulation, and economic growth

It is important to know how inflation influences physical capital accumulation and economic growth. The effects of inflation on the accumulation of these factors provide a channel through which these effects can appear as displayed in Figure 2.1 above. According to Barro (1995) a reduction in economic growth occurs due to a reduction in the propensity to investment which is an outcome of inflation. To this end, theoretically literature presents three possibilities of the effects of inflation; the positive effects of Tobin (1965), the super-neutrality effects of Sidrauski (1967) and the negative effects of Stockman (1981). Here the study briefly focuses on the direct relationship between inflation and capital accumulation and the relevant theoretical and empirical support to all of these opposing views.

Mundell (1963) and Tobin (1965) have successfully explained the effect of inflation on economic growth based on neo-classical growth theory. They believe increased nominal interest caused by inflation will make household invest instead of consume. This results in increasing capital accumulation which stimulates economic growth. This is the Mundell-Tobin Effect. Mundell (1963) and Tobin (1965) suggest a positive relationship between inflation and economic growth.

Sidrauski (1967) links monetary factors with neo-classical growth model with the assumption of neutrality of money. Sidrauski tries to testify how the model will react to the change of growth rate of money supply. In the model of Sidrauski (1967), although it does not give a distinct path as to how the new steady state is achieved upon the change of growth rate of money supply, it concludes that inflation will have no relation with output growth rate in the long run.

Contrary to the conclusion of the Mundell-Tobin Effect, Stockman (1981) develops a long-run equilibrium growth model with assumption of "cash-in-advance constraint". In the model of Mundell (1963) and Tobin (1965), real money balances and investment are substitutes. According to the model of Stockman (1981), inflation will reduce both real money balances and investment. And then inflation will negatively influence economic growth. These negative effects of inflation in Stockman's model are essentially valid for the steady state. Fischer (1983) confirms the negative effects of inflation on the capital accumulation in a model where money serves as an input in the production function, namely, money in the production function (MIPF) model.

2.1.5 Keynesian Absorption Approach and currency depreciation- exchange rate, trade balance and economic growth

The absorption approach to balance of payments is general equilibrium in nature and is based on the Keynesian national income relationships. It is therefore also known as the Keynesian approach. The theory states that if a country has a deficit in its balance of payments, it means that individuals are 'absorbing' more than they produce. Domestic expenditure on consumption and investment is greater than national income.

If they have a surplus in the balance of payments (BOP), they are absorbing less. Expenditure on consumption and investment is less than national income. Here the BOP is defined as the difference between national income and domestic expenditure.

This approach was developed by Sydney Alexander (1952). The analysis can be explained in the following form

$Y = C + Id + G + X - M$ ……. 1.9

Where Y is national income, C is consumption expenditure, Id total domestic investment, G is autonomous government expenditure, X represents exports and M is imports.

The sum of $(C + Id + G)$ is the total absorption designated as A, and the balance of payments $(X - M)$ is designated as B. Thus Equation (1.9) becomes

$Y = A + B$ ……. 1.10

Equation (1.10) can be rewritten as;

$B = Y - A$ ……. 1.11

This means that BOP on current account is the difference between national income (Y) and total absorption (A). BOP can be improved by either increasing domestic income or reducing the absorption. For this purpose, Alexander (1952) advocates devaluation because it acts both ways.

First, if the Marshall-Lerner conditions are met, devaluation increases exports and reduces imports, thereby increasing the national income. The additional income generated will further increase income via the multiplier effect. This will lead to an increase in domestic consumption. Thus the net effect of the increase in national income on the balance of payments is the difference between the total increase in income and the induced increase in absorption, i.e.;

$\Delta B = \Delta Y - \Delta A$ ……1.12

Increase in absorption (ΔA) depends on the marginal propensity to absorb when there is devaluation. Devaluation also directly affects absorption through the change in direct absorption which is written as ΔD. Thus;

$\Delta A = a\Delta Y + \Delta D$ ……1.13

From the above, a is marginal propensity to absorb.

Substituting equation (1.13) into equation (1.12), it becomes;

$\Delta B = \Delta Y - a\Delta Y - \Delta D$ ……1.14

Simplifying further,

$\Delta B = (1 - a)\Delta Y - \Delta D$ ……1.15

The equation points toward three factors which explain the effects of depreciation/devaluation on BOP. They are: (i) the marginal propensity to absorb (a), (ii) change in income (ΔY), and (iii) change in direct absorption (ΔD). It may be noted that, (1-a) is the propensity to hoard or save. These factors, in turn, are influenced by the existence of unemployed or idle resources and fully employed resources in the devaluing country.

If marginal propensity to absorb is less than unity and with idle resources in the country, depreciation/devaluation will increase exports and reduce imports. Output and income will rise and BOP on current account will improve. If, on the other hand, marginal propensity to absorb is greater than unity, there will be an adverse effect of depreciation/devaluation on BOP. It means that individuals are absorbing more or spending more on consumption and investing more. In other words, they are spending more than the country is producing. In such

a situation, depreciation will not increase exports and reduce imports, and BOP situation will worsen affecting economic growth negatively.

Under conditions of full employment if marginal propensity to absorb is greater than unity, the government will have to follow expenditure reduction policy measures along with depreciation/devaluation whereby the resources of the economy are so reallocated as to increase exports and reduce imports. Ultimately, the BOP and economic growth situation will improve.

Again, if there are idle resources, depreciation/devaluation increases exports and reduces imports of the devaluing country. Hence, with the expansion of export and import- competing industries' income increases. The additional income generated in the economy will further increase income via the multiplier effect. This will lead to improvement in BOP situation and consequently economic growth. If resources are fully employed in the economy, devaluation cannot correct an adverse BOP because national income cannot increase. Rather, prices may increase thereby reducing exports and increasing imports, thereby worsening the BOP situation and economic growth.

The effect of devaluation on national income can also be explained through its effects on the terms of trade. Under conditions where devaluation worsens the terms of trade, national income will be adversely affected, and vice versa. Generally, devaluation worsens the terms of trade because the devaluing country has to export more goods in order to import the same quantity as before. Consequently, the trade balance deteriorates and national income declines. If prices are fixed in buyer's (other country's) currency after depreciation/devaluation, the terms of trade improve because exports increase and imports decline. The importing country pays more for increased exports of the devaluing country than it receives from its imports. Thus the trade balance of the devaluing country improves and its national income increases.

Devaluation affects direct absorption in a number of ways. If the devaluing country has idle resources, an expansionary process will start with exports increasing and imports declining. Consequently, income will rise and so will absorption. If the increase in absorption is less than the rise in income, BOP will improve. Generally, according to the Keynes absorption theory, the effect of devaluation on direct absorption is not significant in a country with idle resources. If the economy is fully employed and has also a BOP deficit, national income cannot be increased by devaluing the currency. So an improvement in BOP can be brought about by reduction in direct absorption. Domestic absorption can fall automatically as a result of devaluation due to real cash balance effect, money illusion and income redistribution.

When a country devalues its currency, its domestic prices increase. If the money supply remains constant, the real value of cash balances held by the individuals falls. To replenish their cash balances, they start saving more. This can be possible only by reducing their expenditure or absorption. This is the real cash balance effect of devaluation. If individuals hold assets and when devaluation reduces their real cash balances, they sell them. This reduces the prices of assets and increases the interest rate. This, in turn, will reduce investment and consumption, given the constant money supply. As a result, absorption will be reduced. This is the asset effect of real cash balance effect of devaluation.

Direct absorption falls automatically if devaluation redistributes income in favor of individuals with high marginal propensity to save and against those with high marginal propensity to consume. If the marginal propensity to consume of workers is higher than those of profit earners, absorption will be reduced. Further, when money incomes of lower income groups increase with devaluation, they enter the income tax bracket. When they start paying income tax, they reduce their consumption as compared with higher income groups which are already paying the tax.

Income redistribution also takes place between production sectors after devaluation. Those sectors whose prices rise more than their costs of production earn more profits than the other sectors whose costs rise more than their prices. Thus the effect of devaluation will be to redistribute income in favor of those whose prices rises more than their cost of production. Devaluation will also redistribute income in favor of sectors producing and selling traded goods and against non-traded goods sectors. Prices of traded goods rise more than that of non-traded goods. As a result, profits of producers and traders and wages of workers producing traded goods increases more as compared to those engaged in non-traded goods.

2.1.6 The Classical Theory of Interest- interest rate, investment, and economic growth

According to the classical theory, rate of interest is determined by the supply and demand for capital. The supply of capital is governed by the time preference and the demand for capital by the expected productivity of capital. Both time preference and productivity of capital depend upon waiting or saving or thrift. The theory is, therefore, also known as the supply and demand theory of saving.

The demand for capital consists of the demand for production and consumption purposes. Ignoring the latter, capital is demanded by the investors because it is productive. But the productivity of capital is subject to the law of variable proportions. Additional units of capital are not as productive as the earlier units.

A stage comes, when the employment of an additional unit of capital in the business is just worthwhile and no more. Investors borrow up to the level where the rate of interest is just equal to the marginal productivity of capital. This means that at a higher rate of interest, the demand for capital will reduce and will increase at a lower rate of interest.

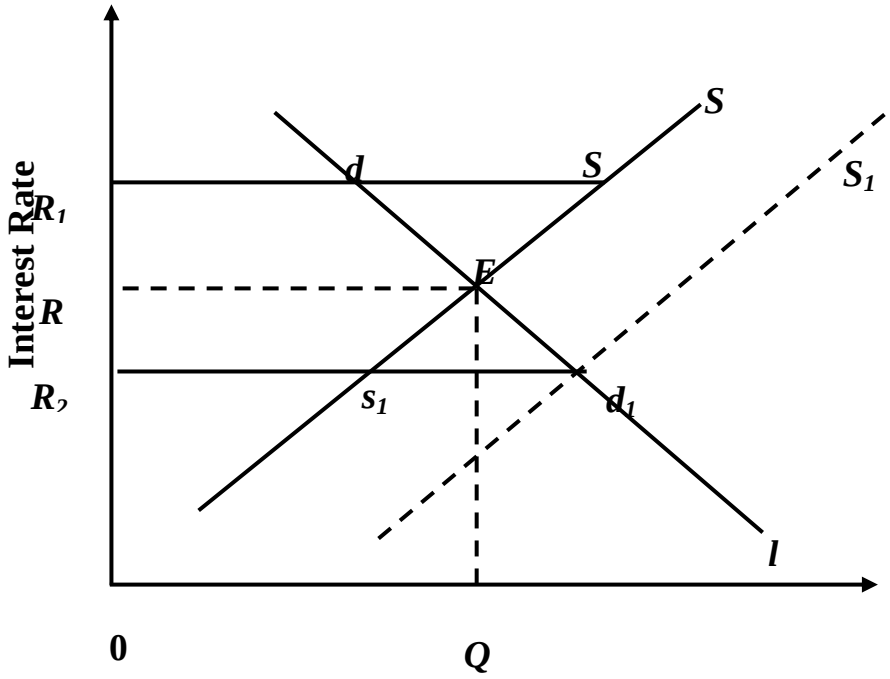
Thus the demand for capital is inversely related to the rate of interest, and the demand schedule for capital or investment curve slopes downward from left to right. There are however certain other factors which govern the demand for capital, such as the growth of population, technical progress, process of rationalization, the standard of living of households, etc.

The supply of capital depends upon not only savings, but also upon the will and power to save of the individuals. Some individuals save irrespective of the rate of the interest. They would continue to save even if the rate of interest were zero. There are others who save because the current rate of interest is just enough to induce them to save. They would reduce their savings if the rate of interest falls below this level. Still there are the potential savers who would be induced to save if the rate of interest were raised. To the last two categories of savers, saving involves a sacrifice, abstinence or waiting when they forgo present consumption in order to earn interest. The higher the rate of interest, the larger will be the household savings and the more will be the supply of funds. The supply curve of capital or the saving curve thus moves upward to the right as indicated in figure 2.2.

Assuming the level of income to be given, the rate of interest is determined by the interaction of the demand curve and the supply curve of saving. This is shown in Figure 2.2 where investment (I) and savings (S) curves intersect at E which is the equilibrium point when OQ quantity of capital is demanded and supplied at R rate of interest.

As indicated in Figure 2.2, if at any time the rate of interest rises above R, the demand for investment funds will fall and the supply of savings will increase. Since the supply of savings is more than the demand ($s > d$), the rate of interest will come down to the equilibrium level R. The opposite will be the case if the rate of interest falls to R_2.

Figure. 2.2 The relationship between interest rate and investment



The demand for investment funds is greater than the supply of savings ($d_1 > s_1$) rate of interest will rise to R. The ultimate situation is one of equality between saving and investment brought about by the equilibrium or the natural rate of interest.

If at any time households become thrifty and save more than Q, the rate of interest would fall below R because the demand for capital remains the same. This is shown by the downward shift of the saving curve to S_1, where it intersects the I curve at d, and the rate of interest falls to R_2. At the lower rate of interest, individuals will save less but the demand for investment funds will increase which will tend to raise the rate of interest to the equilibrium level R. Hence, when interest rate increases, investment decreases resulting in worsening economic growth. On the other hand, when interest rate falls, investment increases and the economy grows.

2.2 Empirical Review

All over the world studies have been conducted to determine the effect and relationship between macroeconomic variables; e.g., studies have been conducted to determine the effect of exchange rate on inflation, the effect of interest rate, exchange rate, and inflation on the stock market development, the impact of exchange rate and interest rate on inflation, the causality between exchange rate, inflation, interest rate and economic growth. Despite the wide scope of literature on this subject matter, this study concentrates on literature that relates the effect of exchange rate, inflation, and interest rate on economic growth.

2.2.1 The effect of exchange rate, inflation, and interest rate on economic growth

Ascertaining the behavior of some major macroeconomic factors that drives Ghana's economic growth, Agalega and Acheampong (2013), Agyapong et'al (2016), Agalega and Antwi (2013), and Mensah and Okyere (2015) using time series data confirmed the existence of a statistically significant effect of these variables on economic growth.

Employing quarterly data from 1980Q1 to 2013Q4 and by applying Johansen approach to co-integration, Agalega and Acheampong (2013) found that in the long run physical capital, real effective exchange rate, have positive effects on economic growth while consumer price index, and interest rate, have negative effects on real economic growth. Similarly, in the short run, physical capital, real effective exchange rate, have positive effects on economic growth while consumer price index and interest rate still had negative effects on economic growth. It recommended that the Government together with the Bank of Ghana should develop and pursue prudent both fiscal and monetary policies that would aim at stabilizing the macroeconomic indicators.

Agyapong et al (2016) also using data for the same period and the same analytical technique as Agalega and Acheampong (2013) concluded that; exchange rate has a positive and significant effect on economic growth whilst interest rate and inflation have a negative effect on economic growth. Their findings support the results of Agalega and Acheampong (2013). In a similar study in Ghana using a smaller sample[8] compared to Agalega and Acheampong (2013) and Agyapong et al (2016) and applying Ordinary Least Square (OLS), Agalega and Antwi (2013) concluded that, inflation has a positive and significant impact on economic growth whilst interest rate has a negative and significant effect.

The positive effect of inflation on economic growth as indicated by Agalega and Antwi (2013) contradicts the findings of Agyapong et al (2016) and Agalega and Acheampong (2013). However, the findings of Mensah and Okyere (2015) using co-integration approach do not support both the positive and negative effect of inflation on economic growth in Ghana. Though their study suggests the negative and statistical significant effect of interest rate on economic growth, it established an insignificant impact of inflation on economic growth.

The impact of inflation on oil producing economies has often been positive as indicated by the studies of Gillman et al (2004) and Luppu (2007). Gillman et al (2004) study conducted on the impact of inflation on economic growth for the period; 1961 to 1997 for organization for economic co-operation and development (OECD) and organization for oil exporting countries (OPEC). Using fixed effects, they found a negative effect of inflation on economic growth. Luppu (2007) established that there is a positive relationship between inflation and economic growth in Romania in the short run. This implies that, as inflation increases

[8] From 1980 to 2010

economic growth also increases in the short run. However, when inflation decreases, economic growth also decreases.

Contrary to the findings of Gillman et al (2004) and Luppu (2007), Ifeanyi (2016) found an insignificant relationship between inflation and the economic growth of Nigeria. The study concluded that exchange rate and interest rate are positively related with economic growth. The study recommends that the interplay of fiscal instruments and monetary instruments backed with political will of the government on genuine implementation of well-thought out programs is the only antidote to ensure that the macroeconomic objectives are achieved both in the short and long-run.

Sidrauski (1967) suggests the super-neutrality of money with the conclusion that inflation has no relationship with growth in the long run. Some empirical studies which suggest the insignificant effect of inflation on economic growth especially in the long run support Sidrauski (1967) argument. Bruno and Easterly (1995) demonstrates a non-relationship between inflation and economic growth when they delete observations of high inflation cases. Additionally, Roa and Yesigat using data from 1974 to 2012 examined the effect of inflation on economic growth of Ethiopia. Using the vector error correction model (VECM), their study revealed that inflation has no significant effect on economic growth.

Furthermore, Semuel and Nurina (2015), Faria and Carneiro (2001) also found same result of non-relationship in the long run as concluded by Sidrauski (1967) though still finding a short-run negative relationship. Similarly, Kasidi and Mwakanemela (2013) used time series data for the period 1990 to 2011 and established that inflation has a negative impact on economic growth in the short-run. The study also revealed that there was no long-run relationship between inflation and economic growth in Tanzania. The two extreme studies give a strong support to the super-neutrality of money in the long run

But contrary to the conclusion of Faria and Carneiro (2001) as well as Kasidi and Mwakanemela (2013), Gregorio (1992) found a negative relationship between inflation and economic growth in the long run based on a study conducted on 12 Latin American Countries. Gregorio (1996) furthers the study in the study of Gregorio (1992) and again concludes a significant negative relationship between inflation and economic growth in the long-run. Using annual data set on real economic growth and inflation for the period of 1985 to 2005 for Kuwait, Saeed (2007) through co-integration and error correction model demonstrates that there exist a statistically significant long-run negative relationship between inflation and economic growth.

Recent studies suggesting a negative effect of inflation on economic growth include Madurapperuma (2016). Examining the impact of inflation on economic growth in Sri Lanka for the period of 1988 to 2015 using the framework of Johansen co-integration test and Error Correction model, Madurapperuma (2016) revealed that there is a long run negative and significant relationship between economic growth and inflation in Sri Lanka. These results support the model of a negative long-run effect of inflation on economic growth as suggested by Stockman (1981), Fischer (1979), De Gregorio (1993), and Bruno and Easterly (1998) but disagree with the findings of Sidrauski (1967) super neutrality of money in the long run.

Unlike Fischer (1979), De Gregorio (1993), Bruno and Easterly (1998), and Sidrauski (1967), Majumder (2016) using error correction model to investigate the relationship between economic growth and inflation in Bangladesh during the period of 1975 to 2013 found a positive effect of inflation on economic growth in the long-run.

Much of the available empirical literature has often shown either positive or negative effect of inflation on economic growth in the long-run without indicating the threshold level. Some studies have tried to distinguish these two opposing effects using threshold analysis.

Frimpong and Oteng (2010) as well as Drukker and Gomis-Porqueras (2005) investigated the threshold effect of inflation on economic growth and found a positive effect of inflation on economic growth. Using threshold regression model and data for the period; 1960-2008 for Ghana, Frimpong and Oteng concluded that inflation below 11% positively impacted economic growth. The study of Drukker and Gomis-Porqueras also found a positive impact of inflation below 19.16% on economic growth. Using fixed effects, their study used data from 149 countries for the period, 1950-2000. Beyond the thresholds, inflation affected economic growth negatively.

Furthermore, Munir and Mansur (2009) established the non-linearity between inflation rate and GDP growth rate in Malaysia. The study analyzed the relationship between inflation rate and economic growth rate in the period 1970-2005 in Malaysia. A specific question that was addressed in this study is what the threshold inflation rate for Malaysia was. Evidence from the study indicated a strong support for the view that, the relationship between inflation rate and economic growth is non-linear. The estimated threshold regression model suggested 3.89% as the threshold value of inflation rate above which inflation significantly retards economic growth.

According to the classical theory, rate of interest is determined by the supply and demand for capital. This implies that, when interest rate falls, investment increases and the economy booms. Semuel and Nurina (2015) analyzed the effect of inflation, interest rate, and exchange rate on economic growth in Indonesia from 2005 to 2013 using Partial Least Squares (PLS). The study found a negative and significant impact of interest rate on economic growth. It also found a positive and significant impact of exchange rate on economic growth but found no significant impact of inflation on economic growth.

Determining the effect of interest rate, inflation, and economic growth on real economic growth of Jordan, Saymeh and Orabi (2013) analyzed data from 2000 to 2010 using co-integration approach and concluded that these macroeconomic variables have a significant negative effect on real economic growth. Similar to Saymeh and Orabi (2013), Obamuyi (2006) established that interest rates have a significant effect on economic growth; this implies that there exists a unique long run relationship between economic growth and interest rates and that the relationship is negative. This means when interest rate reduces, economic growth in the short run increases, but when interest rate declines economic growth increases.

Jilan et al (2010) also determines the impact of macroeconomic variable on economic growth by using OLS. Annual data was used from 1980-2011. From their study, they concluded that if interest rate is low, economic growth increase. Hence, interest rate negatively affects economic growth in the long-run.

Much of the literature on exchange rate shows that devalued exchange rates foster economic growth. In one of the most widely cited papers, Rodrik (2008) constructed an index of undervaluation based on a purchasing power parity real exchange rate for countries, and demonstrates robust evidence of growth-enhancing effect of undervalued currencies. The study argues that tradable sectors are more severely affected by bad institutions and market failures, resulting in their size being smaller than optimal. Devaluation of domestic currencies helps overcome these problems. According to Berg and Miao (2010), the successful experiences of East Asian countries in general and China in particular, seem to extend support to this finding. This is in contrast to the so called Washington Consensus view that devaluation will lead to overheating and excessive inflation to harm the economy (Berg and Miao, 2010).

Subsequently, studies such as Gluzmann et al (2012), Mario et al (2011), Mbaye (2012) and Rapetti et al (2011) have generally confirmed the positive effect of devalued exchange rate on economic growth. However, the mechanism through which devaluation works remains a subject matter of debate as stated by Magud and Sosa (2010). Gulzmann et al (2012) provides results to argue that depreciated exchange rate does not influence the tradable sectors as suggested by Rodrik (2008), but it is through increased saving and investment that economic growth is achieved. In contrast, Mbaye (2012) finds total factor productivity growth as the transmission mechanism of exchange rate on economic growth.

A different channel is proposed by Gluzmann et al. (2012) where a weak exchange rate leads to higher saving and investment through lower labor costs and income re-distribution. By shifting resources from consumers to financially-constrained firms, real devaluation boosts investment and economic growth.

Di Nino et al (2011), revealed how nominal exchange rate depreciation has persistent real effects on output growth in a model with Bertrand competition and increasing returns to scale. The study concluded that there is a positive relationship between devaluation and economic growth for a panel dataset covering the period; 1861 to 2011. In addition, the authors showed that devaluation supported growth by increasing exports, especially from high-productivity sectors in Italy.

Maurizio et al (2015) unlike Di Nino et al (2011) finds a weak real exchange rate compensates for institutional weaknesses and market failures (e.g. knowledge spillovers, credit market imperfections, etc.) which lead to underinvestment in the traded goods sector in developing countries. This contradicts Rodrik (2008) who explains that the growth acceleration takes place, on average, after ten years of steady increase in devaluation in developing countries.

Still on the effects of exchange rate depreciation and economic growth, Dollar (1992) shows that appreciation/overvaluation harms growth, whereas Razin and Collins (1997) and Aguirre and Calderon (2005) found that large overvaluation and devaluation hurt growth, while modest devaluation enhances growth but failed to indicate the exchange rate depreciation threshold necessary for economic growth. Similarly, Hausmann et al. (2005) demonstrate that rapid growth accelerations are often correlated with real exchange rate depreciations. Contrary to the bulk of empirical literature discussed above, Kappler et al (2011) with a sample of 128 countries from 1960 to 2008 revealed that exchange rate depreciation has a negative and a statistically insignificant effect on economic growth in the long-run.

It is argued that by expanding the production of the traded sector in general and exports in particular, devaluation should have an expansionary effect on the overall economy. However, although nominal devaluations help achieve the goal of relative price adjustment along with an improvement in trade balance, they might do so at a high cost. There are concerns that indirect costs of devaluation can actually outweigh its benefits adversely affecting the overall output growth. This is what is known as the contractionary effect of devaluation.

There are a number of theoretical reasons for a contractionary effect of devaluation. First, devaluation increases the price of imported goods, which feeds into the general price level rendering a negative real balance effect. This, in turn, will result in lower aggregate demand and output (Edwards, 1986). Second, the contractionary effect might also result from income distributional effect of devaluation. This point was first mentioned by Diaz-Alezandro (1963) who argued that devaluation could lead to a redistribution of income from individuals with high marginal propensity to consumption to high propensity to save rendering a negative effect on the aggregate demand.

According to the Keynes absorption theory and the Marshall-Lerner conditions, devaluation improves the balance of payments of the domestic economy if both imports and exports are elastic. If the Marshall-Lerner condition holds, i.e., the devaluing economy's demand for imports and demand for its exports are elastic then devaluation will cause economic growth. In fact, Marshall-Lerner condition specifies that the sum of both elasticities, in absolute term, must be greater than one.

If imports are inelastic due to the dominance of capital and essential intermediate and consumer goods in a country's import basket, then devaluation may be contractionary (Upadhaya and Upadhaya; 1999). Apart from these demand side channels, contractionary effects can also arise from the supply side as suggested by Edwards (1986), Upadhaya and Upadhaya (1999). The increased cost of imported inputs might affect production and output adversely. Thus, while Hanson (1983) emphasized on the importance of imported inputs even in the production of non-traded goods, Lizondo and Montiel (1989) maintained that reduced profits in the non-traded sector caused by increased costs of imported inputs (e.g., oil) leads to contraction in aggregate supply after devaluation. Besides, the real balance effect of devaluation might raise the interest rate thus reducing the demand for working capital by firms.

There are numerous studies that have assessed the relationship between exchange rate movements and economic growth. In general, earlier studies such as Connolly (1983), Gylfason and Schmid (1983), Krueger (1978), Taylor and Rosensweig (1984), and Kamin (1988) tended to provide support for expansionary effects of devaluations. Subsequently, the contractionary effects became prominent in several studies such as Gylfason and Radetzki (1985), Atkins (2000), Kamin and Roger (2000), Odusola and Akinlo (2001), Berument and Pasaogullari (2003), El-Ramly and Abdel-Haleim (2008). Mixed results have also been reported in a number of studies. For example, Edwards (1986) and Rhodd (1993) found

negative short-run effects on economic growth but in the long-run the output response to devaluation appeared to be positive. El-Ramly and Abdel-Haleim (2008) reveals negative response for several years before expansionary effects can show up.

Interestingly, there are also studies that do not find any significant effect of exchange rate movements such as Bahmani-Oskooee (1998) and Upadhyaya and Upadhyaya (1999). Studies considering multiple countries have often reported differing findings. For instance, Bahmani-Oskooee and Miteza (2006) using a panel of 42 countries find that in the long-run devaluations are contractionary in non-OECD countries, while for OECD economies the results are mixed i.e. positive effect in the long-run and insignificant effect in the short-run.

A plethora of studies have been conducted on this subject matter. Whilst the work of Agalega and Antwi (2013), Havi et al (2013), and Khan and Senhadji (2011) have methodological deficiencies such as wrong estimation and analytical technique[9], others including Mensah and Okyere (2015) and Frimpong and Oteng (2010) investigated the impact of interest rate and inflation without looking at the effect of exchange rate on economic growth. However, some studies including Semuel and Nurina (2015), Munir and Mansur (2009), Luppu (2007), Di Nino et'al (2011), Rodrik (2008), Saymeh and Orabi (2013), and Shahzad and Al Swidi (2013) concentrated on Asia, Europe, and Middle East. Conversely, whilst the works of Thaddeus and Nuneka (2014) and Obamuyi (2006) centered on Africa, the country of interest was Nigeria.

To the researcher's knowledge, the only exception is the work by Agyapong et al. (2016) that used co-integration (Johansen approach) to determine the effect of macroeconomic variables on the economic growth of Ghana. Despite the close similarities, this current study employs

[9] The use of OLS to estimate time series data instead of more robust approach like co-integration

ARDL. The advantage of ARDL over Johansen and Juselius co-integration approach is that the ARDL procedure is a statistically more convenient approach in determining the co-integration relation in small[10] samples compared to Johansen and Juselius co-integration procedure (Pesaran and Shin, 1999). Again, under the ARDL, the error correction term (ECT) can be derived through a simple linear transformation which integrates short-run adjustments with long-run equilibrium without losing long-run information (Nkoro and Uko, 2016).

Again, because it is not possible for VECM to estimate small sample size, Agyapong et al transformed annual[11] data to quarterly data. This has the tendency to cause heteroskedasticity which may consequently result in large standard errors leading to invalid T-statistics and F-statistics results. Without altering the frequency of data, this study uses annual data from 1980 to 2015 to determine the effect of exchange rate, inflation and interest rate on economic growth.

[10] This is particularly the case of the Ghanaian economy since most annual macroeconomic data comes in small samples usually less than 60 years

[11] From 1980 to 2013

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter deals with the data sources and model specification. It also describes the diagnostic tests and robustness tests applied in chapter four.

3.1 Diagnostic Tests

Various diagnostic tests are applied. They include; the normality test, heteroskedasticity test, autocorrelation test, specification test, and parameter stability test.

3.1.1 Normality Test

In literature, there are several tests for normality such as histogram of residuals normal probability plot (NPP), Anderson–Darling and Jarque–Bera tests (JB). The JB test for normality is employed in this research.

The JB test is a test based on OLS residuals mainly used in a large sample test. First, it requires calculating the Skewness and Kurtosis and then measures the OLS residuals as:

$$JB = n\left(\frac{S^2}{6} + \frac{k-3^2}{24}\right) \quad \text{.......... 3.1}$$

Where, *n* is the sample size, *S* is the skewness coefficient, and *K* is the kurtosis of the coefficient.

In this case, the study applied the JB test to determine whether the residuals of the model are normally distributed or not. The JB test is a two-sided goodness-of-fit test suitable when a fully specified null distribution is unknown and its parameters must be estimated. The null hypothesis and the alternative hypothesis are given as;

H_0: Residuals are normally distributed

H_1: Residuals are not normally distributed

The null hypotheses states that the residuals are normally distributed. If the *p*-value of the statistics is sufficiently low or lower or equal to the level of significance, then it will be rejected.

But if the *p*-value is found to be reasonably higher, then the normality assumption will not be rejected. In other words, the normality assumption is not rejected mostly when the value of the statistic is close to zero. The Jarque–Bera test statistic follows the chi square distribution with two degrees of freedom (Jarque and Bera 1987: 167 – 71).

3.1.2 Homoscedasticity Test

Heteroskedasticity test is conducted to ascertain if variance of the error terms or residuals do not differ across observations. Basically, heteroskedasticity may be present if a model is wrongly specified, omission of important variables, and the presence of outliers. Though its presence may not result in biased estimated coefficients, it leads to biased standard errors, test statistics and confidence interval. The Park, Harvey, Glejser, White, and Breusch-Pagan-Godfrey test are amongst the numerous tests for heteroskedasticity.

The Breusch-Pagan (BP) test developed in 1979 by Trevor Breusch and Adrian Pagan is applied in this study to test for heteroskedasticity. An advantage of the BP test is that it allows the inclusion of the vector of all independent variables. That notwithstanding, a drawback of this test is that it is sensitive to any violation of the normality assumption.

It begins by allowing the heteroskedasticity process to be a function of one or more of your independent variables, and it's usually applied by assuming that heteroskedasticity may be a linear function of all the independent variables in the model. This assumption can be expressed as

Generally, the BP test is based on the estimation of the dependent variable using OLS as shown in the equation below;

$$Y = \beta_0 + \beta_1 X_{i1} + \cdots + \beta_p X_{ip} + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots 3.2$$

Where; Y is the dependent variable and X is the vector of independent variables.

The estimated Y values are obtained after estimating the model. The auxiliary regression is estimated using OLS:

$$\hat{\varepsilon}_i^2 = \delta_0 + \delta_1 \hat{Y}_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.3$$

From this auxiliary regression, the R-squared value is retained:

the *F*-statistic or the chi-squared statistic is calculated as shown below:

$$F = \frac{\frac{R^2_{\varepsilon^2}}{1}}{\frac{(1-R^2_{\varepsilon^2})}{n-2}} \; or \; x^2 = nR^2_{\varepsilon^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.4$$

The degrees of freedom for the *F*-test are equal to 1 in the numerator and $n - 2$ in the denominator. The degrees of freedom for the chi-squared test are equal to 1. If either of these test statistics is significant, then there is evidence of heteroskedasticity. If not, fail to reject the null hypothesis of homoscedasticity. The hypothesis for heteroskasticity is stated below;

H_0: Homoskedasticity

H_1: Heteroskedasticity

3.1.3 Autocorrelation Test

This is a correlation among members of the series of error terms ordered in time. It is mainly caused by incorrect functional forms, auto regressions, manipulation of data, data transformation and non-stationarity of the data (Wooldridge 2009: 274).

The problem of serial correlation can be detected using the graphical method, Geary test, Durbin Watson *d* test and Breusch–Godfrey (BG) test. In this study, the BG test that is based on the Lagrange Multiplier principle is chosen since other tests have drawbacks that made the BG test to be favored. Though the graphical method is powerful and suggestive, its detection power is more of a qualitative nature than others making it less preferred.

The drawback of the Geary test is that it has no assumptions about the probability distribution from which the observations are drawn. The Durbin-Watson test on the other hand, is not applicable when a lagged dependent variable is used as one of the explanatory variables. For the reason that the lagged value of GDP per capita growth is used as one of the explanatory variables in the model, the Durbin –Watson test cannot be applied (Gujarati 2003: 462-71). Due to these reasons the Breusch–Godfrey (BG) test of serial correlation is the best option at hand.

3.1.4 Specification test.

A functional form misspecification generally means that the model does not account for some important variables and nonlinearities. It usually causes biasedness in the coefficients, heteroskedasticity, and autocorrelation. There are fundamentally four techniques of testing specification errors namely: BAMSET, WSET, Q – Sum test and the RESET test. Among these tests, RESET is found to be robust to non-linearity, heteroskedasticity and autocorrelation problems. However, other tests such as BAMSET are robust against the heteroskedasticity problem only. On the other hand, WSET is robust only for non-normality problem. Finally, the Box Jenkins Q-sum test is robust only against autocorrelation problem (Ramsey and Alexander 1982: 2). Accordingly in this paper, Ramsey RESET (Regression Specification Error Test) suggested by Ramsey (1969) is used to detect if the model is properly specified.

3.1.5 Multicollinearity test

Multicollinearity is a high degree of correlation (linear dependency) among several independent variables. It commonly occurs when a large number of independent variables are incorporated in a regression model. This may be because some of them measure the same concept or phenomena. It is important to note that high correlation does not necessarily imply multicollinearity.

The mere existence of multicollinearity does not violate the assumption of OLS. However, perfect multicollinearity does. According to Greene (2000), the consequences of multicollinearity include; it inflates the variances of the model and coefficients resulting in unreliable inferences. The coefficients may also have the wrong signs or implausible magnitude as a result. The variance inflation factor and Belsley, Kuh and Welsch (BKW), 2000 coefficient variance decomposition (Eigenvalue and condition number) are common tests for multicollinearity. This study however adopted the BKW coefficient variance decomposition.

The coefficient decomposition provides information on the eigenvector decomposition of the coefficient covariance matrix. This decomposition is a useful tool to help diagnose potential collinearity problems amongst the regressors. The decomposition estimation follows those given in BKW, 2000. Although the BKW uses the singular-value decomposition as their method to decompose the variance-covariance matrix, since this matrix is a square positive semi-definite matrix using the eigenvalue decomposition will yield the same results.

In simple OLS regression, the coefficient variance-covariance matrix can be decomposed as follows;

$$var(\beta) = \sigma^2(X'X)^{-1} = \sigma^2 VS^{-1}V' \quad \text{......} 3.5$$

Where S is a diagonal matrix containing the eigenvalues of X' X, and V is a matrix whose columns are equal to the corresponding eigenvectors.

The variance of an individual coefficient estimate is then;

$var(\beta) = \sigma^2 \sum_j v_{ij}^2$ 3.6

Where μ_j is the j-th eigenvalue, and v_{ij} is the (i, j)-th element of V. the j-th condition number of the covariance matrix, k_j is the termed; $k_j \equiv \frac{\min(\mu_m)}{\mu_j}$

Let $\emptyset_{ij} \equiv \frac{v_{ij}^2}{\mu_j}$ and $\emptyset_i \equiv \sum_i \emptyset_{ij}$

The variance decomposition proportion is the termed as; $\pi_{ji} \equiv \frac{\emptyset_{ij}}{\emptyset_i}$

The above proportion, together with the condition numbers, can then be used as a diagnostic tool for determining collinearity between each of the coefficients.

According to BKW, the following procedure must be followed;

Check the condition numbers of the matrix. A condition number smaller than 1/900 (0.001) could signify the presence of collinearity. Note that BKW use a rule of any number greater than 30, but base it on the condition numbers of X, rather than $X^{'} X^{-1}$.

Again, if there are one or more small condition numbers, then the variance-decomposition proportions should be investigated. Two or more variables with values greater than 0.5 associated with a small condition number indicate the possibility of collinearity between those two variables.

3.1.6 Parameter Stability Test

It is imperative to test for model stability. If in fact the co-integrating vectors and therefore the exogenous variables are unstable over time, policy prescription based on the estimated elasticities would be unwarranted, or at least risky. It may be caused by the omission of an important variable. There are many possible methods for testing the stability of the co-integrating vector(s).

The study applies at least two tests for the stability of the error-correction model, the cumulative sum of recursive residuals (CUSUM) and cumulative sum of the square of the recursive residuals (CUSUMSQ), due to Brown et al. (1975). These tests are visual and require plotting the test statistic, which is a function of time, and the appropriate confidence interval. If the test statistic meanders outside the confidence interval it suggests a possible structural break or non-constancy of the parameters. The CUSUM test the null hypothesis that the parameters do not change or the model is stable. This hypothesis is rejected if the given P-value obtained from the test is less than the 5% significance level.

3.2 Model Specification and Hypothesis

Before any equation can be estimated, it must be completely specified. Specifying an econometric equation consists of three parts: choosing the correct independent variables, the correct functional form, and the correct form of the stochastic error term. A specification error results when any one of these choices is made incorrectly.

As shown by previous studies, a variety of factors can influence long-run economic growth of a country. López-Villavicencio and Mignon (2011) have shown that all of these variables significantly affect output growth of the developed and emerging economies. The researcher followed the same tradition regarding the selection of covariates in the econometric analysis.

The primary consideration in deciding whether an independent variable belongs to an equation is whether the variable is essential to the regression on the basis of theory. Leaving a relevant variable out of an equation is likely to bias the remaining estimates, but including an irrelevant variable leads to higher variances of the estimated coefficients.

The selected control variables include initial level of economic growth in order to account for the conditional convergence in a spirit of the neoclassical growth theory (Solow, 1956; Barro and Sala-i-Martin, 1995). Following the development on endogenous growth theory, additional control variables were used: technological advancement, gross capital formation, and human capital. The main variables of interest; the interest rate, exchange rate, and inflation rate (CPI) to measure effect of price instability on the output growth. The endogenous variable is GDP per capita growth. Various growth models including the Harrod-Domar, Solow growth model etc. have shown how key macroeconomic variables affect economic growth.

To formalize the discussion regarding the effects of macroeconomic variables on economic growth in Ghana, this study follows closely in the empirical methodology of Nandeeswara and Abate (2015). The study investigates the effect of three key macroeconomic variables on economic growth in Ghana using the Solow growth model. The Solow growth model theoretically is specified below. It follows the Cobb Douglas production function and therefore will be specified in a log-log functional form. A log-log function allows for the estimation of a model that is non-linear in variables but linear in parameters.

Thus, Cobb-Douglas form is specified mathematically below;

$$Y_t = f(K_t H_t A_t) \quad \ldots\ldots 3.7$$

$$Y_t = f\left(K_t^{\alpha}, H_t^{\pi}, A_t^{\beta}\right) \quad \ldots\ldots 3.8$$

$$A = f\left(exr_t^{\beta 1}, inf_t^{\beta 2}, int_t^{\beta 3}, T_t^{\beta 4}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.9$$

$$Y_t = f\left(K_t^{\alpha}, H_t^{\pi}, \left(exr_t^{\beta 1}, inf_t^{\beta 2}, int_t^{\beta 3}, T_t^{\beta 4}\right)\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.10$$

$$Y_t = f\left(exr_t^{\beta 1}, inf_t^{\beta 2}, int_t^{\beta 3}, T^{\beta 4}, K_t^{\alpha}, H_t^{\pi}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.11$$

By taking the logarithm of both sides in equation (3.11);

$$\ln Y_t = \Omega + \beta_1 \ln exr_t + \beta_2 \ln inf_t + \beta_3 \ln int_t + \beta_4 \ln T_t + \alpha \ln K_t + \pi H_t + \varepsilon_t \ldots 3.12$$

For the purpose of estimation and in line with the objective of the study, modifying the production function in equation (3.12) to a growth equation is very useful. Again, because of the non-stationary nature of time series data, the study differenced equation (3.14) to make it stationary. This becomes:

$$\Delta \ln Y_t = \Omega + \alpha \Delta \ln Y_{t-1} + \beta_1 \Delta \ln exr_t + \beta_2 \Delta \ln inf_t + \beta_3 \Delta \ln int_t + \beta_4 \Delta \ln T_t + \alpha \Delta \ln K_t + \pi \Delta H_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.14$$

Equation (3.15) gives the growth in output. Where; ln and Δ are the natural logarithmic operator and difference operators respectively. The coefficients; α, β_1, β_2, β_3, β_4, ɤ, α, π are the elasticities of the respective variables, Ω is the intercept and ε_t is the error term.

Though various macroeconomic variables influence economic growth, the variables of interest to the researcher were; exchange rate, inflation, and interest rate. However, variables such as human capital, capital accumulation, and technological progress are included in the model as control variables. Based on equation 3.14, the following hypotheses are tested.

H_0: Exchange rate has no significant effect on economic growth; $\beta_1 = 0$

H_1: Exchange rate has a significant effect on economic growth; $\beta_1 \neq 0$

H_0: Inflation has no significant effect on economic growth; $\beta_2 = 0$

H_1: Inflation has a significant effect on economic growth; $\beta_2 \neq 0$

H_0: Interest rate has no significant effect on economic growth; $\beta_3 = 0$

H_1: Interest rate has a significant effect on economic growth; $\beta_3 \neq 0$

3.3 Estimation Procedures

Before the estimation of the economic growth model, unit root test is conducted to determine the order of integration of the variables. ARDL is applied in estimating the model if the order of integration of the variables are mixed (I(0) and I(1)).

3.3.1 Unit Root Test

Time series data may exhibit one or two of the following characteristics; trends, seasonal and non-seasonal cycles, pulses and steps, and outliers. These features of time series data may make it non-stationary. A non-stationary time series is a stochastic process with unit roots or structural breaks. In other words, the presence of a unit root implies that a time series under consideration is non-stationary while the absence of it implies that the time series is stationary.

The presence of a unit root in a series leads to the violation of the assumptions of constant means and variances of the Ordinary Least Squares (OLS). The major purpose for conducting unit root test is that if data is used without checking their stationarity properties, the results derived from the regression models would produce the so called spurious results (Datta and Kumar, 2011). A series with unit root have no tendency to return to long-run deterministic path and the variance of the series is time dependent. A series with unit root suffers permanent effects from random shocks, thus, follow a random walk.

This study began by testing for the stationarity properties of variables within the frameworks of Augmented-Dickey-Fuller (ADF) and Phillips-Perron (PP) test procedures. The ADF test tests the null hypothesis that the variables have unit root (meaning the variables of interest are non-stationary) as against the alternative hypothesis that the variables are stationary.

The PP also tests the null hypothesis that the variables are non-stationary as against the alternative hypothesis that the variables are stationary. Before estimating our model, it was very important to test out stochastic properties of the variables to be estimated. This is realized by conducting unit root test. However, one of the weaknesses of unit root test is related to small number of observations and that a minimum number of 20 observations are required so as to get reliable results which can make inference (Gujarati and Porter, 2009).

In testing the unit root, the researcher employed ADF instead of DF test because the ADF took care of possible serial correlation in the error terms by including the lagged difference of the dependent variable. Moreover, Phillips-Perron was used to test for the presence of unit root because it also took care of serial correlation in the error terms by using the non-parametric statistical method without addition of lagged difference terms (Hussain 2011). If the order of integration is I(0) and I(1), then ARDL can be applied, otherwise, the fully modified OLS (FMOLS) is appropriate.

3.3.2 Autoregressive Distributed Lag (ARDL) and Error Correction Model (ECM)

Many time series variables are stationary only after differencing. Hence, using differenced variables for regressions imply loss of relevant long run properties or information of the equilibrium relationship between the variables under consideration. Co-integration makes it possible to retrieve the relevant long run information of the relationship between the considered variables that had been lost after differencing. That is, it integrates short run dynamics with long run equilibrium.

Two variables are said to be co-integrated if they have a long-run equilibrium relationship between them. If the dependent and independent variables are individually non-stationary but their residual combination is stationary, those variables are co-integrated in the long-run (Gujarati, 2009). Non-stationary residuals violate the standard assumptions that are required to apply OLS methods. In this case, Phillips (1986) pointed out that co-integration techniques must be applied.

Under the conventional Granger (1981) and Engle and Granger (1987), co-integration analysis is not applicable in cases of variables that are integrated of different orders. However, in the Johansen (1990), and ARDL Co-integration procedure, it is applicable.

This study employed the ARDL. The ARDL bounds testing procedure introduced by Pesaran et al. (2001) and Pesaran and shin (1999) used to test the long run equilibrium relationship between economic growth and the exchange rate, interest rate, and inflation. The advantages of applying ARDL are: Firstly, even where a portion of the model regressors are endogenous, the bounds testing approach for the most part gives unbiased long-run estimates and valid t-statistics (Narayan, 2005), so endogeneity problems on the estimated coefficients over the long-run associated with the Engle-Granger method are avoided. Secondly, the short-run and long-run parameters of the model being referred to are evaluated in the same time.

Thirdly, it can be applied regardless of whether the fundamental variables are I(0), I(1) or a combination of both (Pesaran and Pesaran, 1997). Fourthly, the ARDL procedure is a statistically more significant approach in determining the co-integration relation in small samples to those of the Johansen and Juselius co-integration procedure (Pesaran and Shin, 1999). Fifthly, the model takes an adequate number of lags to catch the data generating process in a general to specific modeling frameworks (Laurenceson and Chai, 2003). Sixthly, the error correction model (ECM) can be derived from ARDL through a simple linear

transformation, which integrates short run modification with long run equilibrium without losing long run data (Pesaran and Shin, 1999).

Basically, the ARDL approach to co-integration includes two stages for assessing long-run relationship. The first step is to explore the presence of long-run relationship among all variables. If there is an evidence of co-integration between variables, the second step is to estimate the long-run and short-run models. Basically, for estimating long-run relationship, the ARDL bounds test approach of co-integration involves two steps: The first step is to examine the existence of long run relationship among all variables in the equation. In particular, The ARDL model can be expressed as the following:

$$\Delta lnY_t =$$

$$\beta_0 + \sum_{i=1}^{p} \alpha\, \Delta lnY_{t-i} + \sum_{i=1}^{p} \beta_1\, \Delta lnexr_{t-i} + \sum_{i=1}^{p} \beta_2\, \Delta lninf_{t-i} + \sum_{i=1}^{p} \beta_3\, \Delta lnint_{t-i} +$$

$$\sum_{i=1}^{p} \beta_4\, \Delta lnT_{t-i} + \sum_{i=1}^{p} \alpha\, \Delta lnK_{t-i} + \sum_{i=1}^{p} \pi\, \Delta lnH_{t-i} + \lambda_1 Y_{t-1} + \lambda_2 exr_{t-1} + \lambda_3 inf_{t-1} +$$

$$\lambda_4 int_{t-1} + \lambda_5 T_{t-1} + \lambda_6 L_{t-1} + \lambda_7 K_{t-1} + \lambda_8 H_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.15$$

Where Δ and ε_t are the first difference operator and the residual term, respectively. B_0 is the intercept component, and the variable Y, exr, inf, int, T, L, K, and H have been defined already. The summation signs represent the error correction dynamics, while this part of the equation;

$$(\lambda_1 Y_{t-1} + \lambda_2 exr_{t-1} + \lambda_3 inf_{t-1} + \lambda_4 int_{t-1} + \lambda_5 T_{t-1} + +\lambda_7 K_{t-1} + \lambda_8 H_{t-1}) \ldots 3.16$$

Equation 3.16 corresponds to the long run relationship. This equation includes the time trend variable to capture the autonomous time-related changes. The selection of lag is based on a criterion such as Akaike information criterion (AIC) and Schwarz Bayesian Criterion (SBC).

The bounds testing procedure is based on the joint F-statistic or Wald statistic that test the null hypothesis, which means there is no co-integration. If the value of F statistics is higher

than the upper level of the band, the null hypothesis is rejected, and so there is co-integration. If the value of F-statistics is lower than the upper level of the band, then we cannot reject the null hypothesis and so there is no co-integration.

Narayan (2005) argues that existing critical values which are based on large sample sizes cannot be used for small sample sizes. Therefore, the author regenerates the set of critical values for the limited data ranging from 30 to 80 observations by using the Pesaran et al. (2001). Since this study employs limited annual time series data then the critical values of Narayan (2005) can be used for the bounds F-test instead of Pesaran et al. (2001). If a long-run relationship exists between variables, the next step is to estimate the error-correction model:

$$\Delta lnY_t = \beta_0 + \sum_{i=1}^{p} \alpha\, \Delta lnY_{t-i} + \sum_{i=1}^{p} \beta_1\, \Delta lnexr_{t-i} + \sum_{i=1}^{p} \beta_2\, \Delta lninf_{t-i} + \sum_{i=1}^{p} \beta_3\, \Delta lnint_{t-i} + \sum_{i=1}^{p} \beta_4\, \Delta lnT_{t-i} + \sum_{i=1}^{p} \beta_6\, \Delta lnK_{t-i} + \sum_{i=1}^{p} \beta_7\, \Delta lnH_{t-i} + \eta_1 ECT_{t-1} + \varepsilon_t \quad \ldots 3.17$$

Where η measures the speed of adjustment to obtain equilibrium in the event of shock(s) to the system, and ECT_{t-1} are the residuals obtained from the estimated co-integration model of equation 3.17.

3.4 Robustness Checks

To authenticate and confirm the estimation results of the ARDL, the Dynamic Ordinary Least Squares (DOLS) and Robust Least squares (RLS) are applied. Both the DOLS and RLS results serve as evidence to strengthen the ARDL estimates and also confirm that the model results did not occur by chance.

3.4.1 DOLS Co-integration

Firstly, the DOLS proposed by Stock and Watson (1993) is a technique for estimating time series data. It has an advantage of copping with small samples. The Johansen approach of co-integration being a full information technique is exposed to the problem that parameter estimates in one equation are affected by any misspecification in other equations. The DOLS by contrast is a robust single equation approach which corrects for regressor endogeneity by the inclusion of the leads and lags of first differences of the regressors, and serially correlated errors by the Generalized Least Square (GLS) procedure. Interestingly, it has the same asymptotic optimality properties as the Johansen distribution. The economic growth model using the DOLS is shown below.

$$Economic\ growth =$$

$$X_{,}\, M' + \sum_{i=-m}^{i=m} \emptyset_{,} \Delta\, logexr_{t-i} + \sum_{i=-m}^{i=m} \emptyset_{,} \Delta\, loginf_{t-i} + \sum_{i=-m}^{i=m} \emptyset_{,} \Delta\, logint_{t-i} +$$

$$\sum_{i=-m}^{i=m} \emptyset_{,} \Delta\, logT_{t-i} + \sum_{i=-m}^{i=m} \emptyset_{,} \Delta\, logK_{t-i} + \sum_{i=-m}^{i=m} \emptyset_{,} \Delta\, logH_{t-i} + \varepsilon_t$$

Where;

M= β_0, β_1, β_2, β_3, β_4, γ , α, π and X = 1, exr, inf, int, T, L, K, H and m, n and l are the leads and lags of the regressors.

If economic growth is I(1) and at least some of the independent variables are I(1) or I(0), then DOLS can be applied.

3.4.2 RLS Regression and Time series analysis

RLS is an estimation technique designed to be robust or less sensitive to outliers. The RLS circumvents some of the limitations of traditional parametric and non-parametric methods. Simple Ordinary Least Squares (OLS) have favorable properties if their underlying

assumptions are not violated but can give misleading results if these assumptions are violated. Thus, OLS are not robust to violations of its assumptions,

RLS on the other hand are designed to be robust against the violations of the assumptions of OLS.

3.5 Data Sources and Collection Procedure

This study employed secondary data. The data was collected from the period of 1980-2015. Data for all the variables were sourced from the World Development Indicators (World Bank). Time series data for all the variables spanned 1980 – 2015 thus covering a 36 – year period. This period is particularly relevant for the study as it captures Ghana's pre-transition period from fixed to a fairly floating regime. The period also coincides with the launch of the economic recovery program (ERP). Data for interest rate and labor (primary education) had some missing values and thus the need to solve this deficiency using interpolation.

3.6 Interpolating interest rate and primary completion rate

Missing data are a common occurrence and can have a significant effect on the conclusions that can be drawn from the data. They may lead to biasedness of results. Missing data may be caused by the researcher or the data source. In this study, missing data for interest rate and primary education completion rate were caused by the data source but not the researcher.

Missing data for interest rate and human capital (primary education) were some of the challenges posed by the data. Interest rate data for the years 1989 and 1990 were missing. Again, data for primary completion rate was missing for the periods; 1982-1990, 1993-1998, and 2010. However, these missing data were filled using interpolation in Eviews. The next section deals with the definition and measurement of variables.

CHAPTER FOUR

EMPIRICAL RESULTS, ANALYSIS AND DISCUSSIONS

This chapter presents the results of the estimated economic growth function. It starts with the summary of analytical techniques, presentation of the descriptive statistics, followed by the diagnostic test results, the unit root test, short-run and long-run results, and robustness checks.

4.0 Summary of analytical techniques

The purpose of this study is to determine the effect of exchange rate, inflation and interest rate on economic growth in Ghana. It sourced data from world development indicators (World Bank) spanning from 1980 to 2015. Missing values for interest rate and human capital were interpolated using Eviews as indicated in appendix VII and IX. The study applied the following analytical techniques; diagnostic tests, unit root test, model specification and estimation, and robustness checks.

The normality test is conducted to determine if the residuals are normally distributed. The Jarque-Bera (JB) test which is based on ordinary least square (OLS) residuals was applied. The hypothesis tested is stated below;

H_0: Residuals are normally distributed

H_1: Residuals are not normally distributed

The null hypothesis cannot be rejected if the JB probability value is greater than five percent.

To determine if the variance of the error terms or residuals do not differ across observations, the heteroskedasticity test is conducted. The presence of heteroskedasticity may result in very

large standard errors. This study employed the Breusch-Pagan (BP) test and tested the following hypothesis;

H_0: Homoskedasticity

H_1: Heteroskedasticity

If the probability value of the BP test is greater than five percent, then the null hypothesis cannot be rejected.

The correlation among members of series ordered in time is termed serial correlation. Similar to heteroskedasticity, the presence of serial correlation may also result in large standard errors. The Breusch-Godfrey (BG) test is applied and tested the following hypothesis;

H_0: No serial correlation

H_1: Serial correlation

If the probability value of the BG test is greater than five percent, then the null hypothesis cannot be rejected.

A model is said to be misspecified if important variables are omitted or the functional form of the model is incorrect. To determine whether the model is properly specified, the Ramsey RESET test is applied and tested the hypothesis below.

H_0: Correctly specified

H_1: Incorrectly specified

If the probability value of the Ramsey RESET test is greater than five percent, then the null hypothesis cannot be rejected.

A high correlation among the independent variables is termed multicollinearity. The consequence is that it inflates the variance of the model resulting in unreliable inference. The coefficient variance decomposition is applied and if the condition numbers are less than 0.5, it signifies the absence of near perfect multicollinearity.

The parameter stability test is conducted to determine if the exogenous variables are stable over time. The CUSUM and CUSUM of square are employed.

The study adopted the Cobb-Douglas production function and specified into a log-log function as shown below.

$$\Delta \ln Y_t = \Omega + \alpha \Delta \ln Y_{t-1} + \beta_1 \Delta \ln exr_t + \beta_2 \Delta \ln inf_t + \beta_3 \Delta \ln int_t + \beta_4 \Delta \ln T_t + \alpha \Delta \ln K_t + \pi \Delta H_t + \varepsilon_t \quad \ldots\ldots 4.0$$

And tested the following hypothesis;

H_0: Exchange rate has no significant effect on economic growth; $\beta_1 = 0$

H_1: Exchange rate has a significant effect on economic growth; $\beta_1 \neq 0$

H_0: Inflation has no significant effect on economic growth; $\beta_2 = 0$

H_1: Inflation has a significant effect on economic growth; $\beta_2 \neq 0$

H_0: Interest rate has no significant effect on economic growth; $\beta_3 = 0$

H_1: Interest rate has a significant effect on economic growth; $\beta_3 \neq 0$

If the probability value is greater than five percent, then the null hypothesis cannot be rejected.

Because of the non-stationary nature of time series data, the unit root test is applied to determine the order of integration. The Augmented Dickey Fuller (ADF) and Phillip and

Perron (PP) test is applied. If the order of integration is mixed, the Autoregressive Distributed Lag (ARDL) can be applied.

The study applied ARDL model to estimate equation 4.0 to determine both the long-run and short-run estimates. Additionally, to ascertain if the ARDL results are robust, the Dynamic Ordinary Least Square (DOLS) and the Robust Least Square (RLS) are applied. The next section gives a brief description of the statistics of the variables in the model.

4.1 Descriptive statistics

From Table 4.1, economic growth recorded a maximum value of $1814.5 and a minimum value of $263.11 over the entire period. Its average and standard deviation are 647.85 and 462.33 respectively. The maximum and minimum rates for exchange rate are GHC3.81 and GHC0.000275 respectively implying a very wide range. Its mean and standard deviation are 0.683311 and 0.09306. The average inflation rate for the period is 28.23% whilst it reported a maximum of 122.87% and a minimum of 8.73%.

Table 4.0 Descriptive Statistic

Variable (%)	Obs	Mean	Std. Dev.	Min.	Max.
Economic growth	36	647.855	462.329	263.113	1814.49
Exchange rate	36	0.68331	0.09306	0.00028	3.81000
Interest rate	36	17.6394	7.6092	8.88542	35.7592
Inflation rate	36	28.2331	25.7628	8.72684	122.875
Human capital	36	73.6832	11.2653	62.9745	101.100
Technological advancement	36	23.8244	6.10141	13.9011	42.3933
Capital formation	36	18.7695	8.04761	3.37764	31.7848

Source; Author's construct, 2017

This excessively high maximum inflation rate may suggest the possibility of outliers since it is very wide away from the mean value. Interest rate recorded a maximum rate of 35.76% and a minimum of 8.89%. On the average however, it reported a rate of 17.56% and a standard deviation of 7.6092.

4.2 Diagnostic test results

Diagnostic tests conducted included the serial correlation test, heteroskedasticity test, normality test, specification test, and multicollinearity test. The test results are displayed in the table below.

As depicted in the Table 4.1, serial correlation was conducted using the Breusch-Godfrey LM test. Since the probability value is greater than 5%, the null hypothesis of no serial correlation cannot be rejected. Hence, it can be concluded that there is no serial correlation. Again, the Breusch-Pagan-Godfrey test recorded probability value of 0.8239 which is greater than 5% and thus, the null hypothesis of homoscedasticity cannot be rejected. In other words, there is the absence of heteroskedasticity. For the normal distribution of the errors, the Jarque-Bera test shows a probability value of 0.687953. This suggests that the errors are normally distributed as shown in the table below.

Table 4.1. Diagnostic Test Results

Test statistics	Results	P-value	Test
Serial correlation	F(2,8)=0.600498	(0.5715)	Breusch-Godfrey LM
Heteroskedasticity	F(18,10)=0.613265	(0.8239)	Breusch-Pagan-Godfrey
Normality	JB=0.748068	(0.687953)	Jarque-Bera
Functional form	F(2,8)=2.748997	(0.1234)	Ramsey RESET
Multicollinearity	Small proportions not close to one (1)		BKW coefficient variance decomposition

Source; Author's construct, 2017

The Ramsey RESET test results depicts that the model is properly specified. This is evidenced by its probability value which is greater than 5% as shown in the above table. The CUSUM and CUSUM sum of square test in appendix VII reveals that the coefficients and the residual variance are stable respectively. Finally, from appendix XI, the smallest condition number of 1.07E-08 indicates the possibility of multicollinearity. The proportions associated with the smallest condition number greater than 0.5 are only two out of the eighteen regressors (i.e. 0.508749 and 0.634079). However, these proportions are not very close to one. This clearly indicates the absence of near perfect multicollinearity. In other words, there is very low level of collinearity among the regressors.

The heteroskedasticity, autocorrelation, and multicollinearity test results signifies that the standard errors are not biased. This means that the model may not suffer from type II error.

4.3 Unit root results

As indicated in the table below, the unit root test was conducted using the ADF and PP tests. The variables were tested at level with intercept and with intercept and trend. All variables were tested at log levels. Both test showed that exchange rate and inflation were stationary at levels. This implies that there is no volatility clustering[12]. Economic growth, capital formation, human capital, and interest rate were all stationary only after first differencing with both the ADF and PP test. The PP test indicated that computer and communication imports were stationary at levels while ADF test depicts its stationarity only after first differencing.

[12] That is, high variation from the mean

Table 4.2 Unit root test

VARIABLE	ADF STATISTICS	ADF STATISTICS	PP STATISTICS	PP STATISTICS
	Intercept	Intercept and trend	Intercept	Intercept and trend
Economic growth	I(1)	I(1)	I(1)	I(1)
Capital formation	I(1)	I(1)	I(1)	I(1)
Human capital	I(1)	I(1)	I(1)	I(1)
Interest rate	I(1)	I(1)	I(1)	I(1)
Exchange rate	I(0)	I(0)	I(0)	I(0)
Inflation	I(0)	I(0)	I(0)	I(0)
Technological advancement	I(1)	I(1)	I(0)	I(0)

Source; Author's construct using Eviews

From Table 4.2, it is explicit that the variables are integrated of different orders. Some of the variables are I(0) whilst others are I(1). The long-run relationship will be lost if the variables are first differenced. Under the conventional Granger (1981) and Engle and Granger (1987), co-integration analysis is not applicable in cases of variables that are integrated of different orders. However, the ARDL Co-integration procedure is applicable. Below is the test and results of the ARDL co-integration test.

4.4 Results of co-integration

The unit root test conducted above showed that some of the variables were integrated of order I(0) and I(1) and thus, the study went further to determine the presence of co-integration. The bounds test was conducted to determine the presence of co-integration. The bounds test results as shown in the table below indicates the presence of long-run co-integration. The F-statistic value of 11.56 is greater than the maximum upper bound value of 4.43 as indicated in Table 4.3 below.

Table 4.3 ARDL Bounds Test Results

Included observations: 29		
Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	k
F-statistic	11.56	6
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.50%	2.75	3.99
1%	3.15	4.43

Source; Author's construct, 2017 using Eviews

Since the existence of long-run co-integration has been established, the study estimated the long-run co-integration estimates as shown in Table 4.4.

4.5 Analysis of long-run results

As indicated in Table 4.4, exchange rate has a positive and statistically significant effect on economic growth. The elasticity obtained is 0.041975 implying that an increase or decrease in exchange rate will result in a less than proportionate increase or decrease in economic growth. In other words, a 1% increase in exchange rate will cause economic growth to increase by 0.042%. While this result is consistent with the Keynesian absorption theory of currency depreciation, it also corroborates the findings of Agyapong et al (2016), Di Nino et al (2011) and Hausmann et al (2005).

As suggested by the Keynesian absorption theory of currency depreciation, a depreciating currency is only effective in enhancing economic growth if there are idle resources in the economy. When the currency depreciates and the marginal propensity to absorb is less than

unity, income will increase. Again, if as a result of currency depreciation the increase is income is greater than increase in direct absorption, then the excess income may be invested in capital projects. Since capital accumulation has a positive effect on economic growth, this will lead to the growth of the economy. This may explain the positive effect of the depreciating Ghana cedi on the growth of the Ghanaian economy in the long-run. Empirically, though the findings of this study do not support the results of Kappler et al (2012), it is consistent with the findings of Maurizio et al (2016) which contend that exchange rate has a positive and statistically significant impact on economic growth in the long-run. Maurizio et al (2016) using panel data of 150 countries from 1970 to 2010 revealed that a 10% depreciation of the home currency will result in 0.15% increase in economic growth.

Referring from Table 4.4, inflation shows a positive impact on economic growth though not statistically significant at 1%, 5% and 10%. The result indicates a positive coefficient of 0.013676 suggesting that a 1% increase in inflation will lead to 0.014% increase in economic growth in the long-run. The insignificant results mean that the Ghanaian economy may be insensitive to changes in inflation in the long-run. The results are similar to the empirical findings of Roa and Yesigat (2015), Mensah and Okyere (2015) as well as Semuel and Nurina (2015) but contradicts the findings of Agyapong et al who found a negative and significant impact of inflation on economic growth in Ghana.

Roa and Yesigat applying vector error correction model (VECM) and using data from 1974 to 2012 examined the effect of inflation on economic growth of Ethiopia. Their study revealed that inflation has no significant effect on economic growth. This study is also consistent with theory as shown by the super-neutrality effects of Sidrauski (1967) which concludes that inflation has no relation with output growth rate in the long run. According to Sidrauski, economic growth at the steady state is dependent on the behavior of households

towards inflation. This may imply that Ghanaians do not have a specific reaction towards inflation- households behave differently at different time periods towards inflation. The study argued that, during periods of inflation, individuals may hold government bonds or invest in capital. This implies that inflation does not affect real variables in the long-run in Ghana.

Like exchange rate, interest rate shows the expected sign and it is statistically significant at 5% significance level as well. It revealed a negative coefficient of -0.0414 indicating that there is a negative relationship between interest rate and economic growth in Ghana in the long-run. It shows that, a 10% increase in interest rate will result in 0.41% decrease in economic growth. This supports the classical theory of interest rate which shows a negative relationship between interest rate and investment (with a long-run effect on economic growth). The result also lays support to the empirical studies of Agyapong et al (2016) and Agalega and Antwi (2013). Agalega and Antwi predicted that a 1% increase in interest rate will cause a 3.05% decrease in economic growth in Ghana.

The classical theory of interest rate explains that an increase in interest rate serves as an incentive to save and a disincentive to invest by investors. Thus, increases in interest rate results in a reduction in capital accumulation and economic growth. This explains the negative effect of interest rate on economic growth in Ghana in the long-run as indicated in Table 4.4.

Table 4.4 Estimates of long-run co-integration results of GDP Per Capita

Variable	Coefficient	Std Error	T-Ratio	Prob-value
Exchange rate	0.04197	0.00449	9.34012	0.0000
inflation	0.01367	0.00971	1.40811	0.1894
Interest rate	-0.04139	0.01045	-3.96122	0.0027
Human capital	1.19656	0.11009	10.86846	0.0000
Capital accumulation	0.02400	0.01779	1.34932	0.2070
Technological advancement	0.07407	0.01954	3.78909	0.0035
C	1.37117	0.47789	2.86922	0.0167

Source; Author's construct, 2017 using Eviews

Primary school completion rate a proxy for human capital also showed positive and significant results. This was expected. This means that an increase in the primary school completion rate will result in an increase in economic growth. It revealed a coefficient of 1.196561 meaning that, a 1% increase in primary completion rate will result in 1.2% increase in economic growth in Ghana. An increase in primary school completion rate means an improvement in the human capital and its subsequent positive effect on economic growth in Ghana.

Capital accumulation also displayed a positive and expected sign but was insignificant in the long-run. This may mean that Ghanaian economy may not be sensitive to changes in capital accumulation. Its coefficient is 0.024004 meaning that; a 10% increase in capital accumulation will cause economic growth to increase by 0.24%.

Computer, communications and other services (per cent of commercial service imports) a proxy for technological advancement recorded a positive and significant effect on economic growth in Ghana. It reported a coefficient of 0.07407 indicating that, a 10% improvement in technological advancement will result in 0.74% increase in economic growth in the long-run.

Improvement in technology enhances the efficiency of labor hence impacting positively on economic growth. This is consistent with the Solow growth model which includes technological advancement as one of the major determinants of economic growth.

In conclusion, the effect of exchange rate, inflation and interest rate on economic growth which is the core of this study have all shown expected signs. Exchange rate showed a positive impact of economic growth in Ghana in the long-run. Inflation in the long-run exhibited a neutral or insignificant effect on economic growth. Lastly, interest rate which displayed consistency with the classical theory of interest rate indicated a negative effect on economic growth in Ghana. This section shows the long-run effect of some macroeconomic variables on economic growth in Ghana. The section below establishes the short-run effect of the discussed explanatory variables on economic growth.

4.6 The Error Correction Model (ECM) and analysis of short-run results

The ECM gives the short-run dynamics between the dependent and independent variables. The maximum lags were 5, 2 and ARDL selected the optimum lags for the regressors and regressed automatically as displayed in the criteria graph in appendix X. The ARDL results for the short-run relationship are shown in the table below.

The short-run results as indicated in Table 4.5 shows a negative but insignificant effect of exchange rate on economic growth. Exchange rate recorded a coefficient of -0.007349. This means that a 10% increase in exchange rate will result in 0.073% decrease in economic growth. This however is not statistically significant meaning that the Ghanaian economy does not respond to changes in exchange rate in the short-run. This may be as a result of the inelastic nature of Ghana's imports and exports. The effects of changes in exchange rate takes a relatively longer time to manifest thus resulting in only significant positive long-run impact on the economy as shown in the long-run dynamics discussed in the previous section.

Inflation though showed no statistical significance results in the long-run, has exhibited a negative and statistically significant effect in the short-run. This means that a rise in inflation will cause a decrease in economic growth. The inflation elasticity is -0.012935 meaning that; a 10% rise in inflation in the short-run will result in a 0.13% decrease in economic growth at 5% confidence level. Theoretically, this lays support to the negative effects of inflation by Stockman (1981) and Fischer (1983). Empirically, the above result is consistent with the works of Khan and Senhadji (2011), Gillman et al (2004) as well as Roa and Yesigat (2015) but contradicts the findings of Agalega and Acheampong (2013). Agalega and Acheampong found that a 1% increase in inflation leads to 1.8% increase in economic growth in the short-run.

Based on Stockman's cash-in-advance constraint, cash is held in advance before consuming or investing in capital. According to Stockman, an increase in inflation causes a reduction in the real wealth of money holders resulting in low investment in capital goods. A reduction in investment negatively affects economic growth. This theoretically explains the negative effect of inflation on economic growth in Ghana in the short-run as indicated in Table 4.5. The findings of Roa and Yesigat (2015) find a negative effect of inflation on economic growth in the short-run. According to their study, a 1% increase in inflation will result in a 0.23% decrease in economic growth of Ethiopia.

Unlike inflation and exchange rate, Interest rate recorded a negative and significant impact on economic growth at lag 1. This means that, interest rate in Ghana has no contemporaneous effect on economic growth in the short-run. Its effect is only significant after the first year. Its coefficient is -0.04127 meaning that an increase in interest rate will result in a decrease in economic growth. In other words, 10% increase in interest rate will cause a 0.41% decrease in economic growth. As indicated in the long-run, the short-run result is also consistent with

the classical theory of interest rate. Empirically, the result corroborates the works of Jilan et al (2010) and Obamuyi (2006).

As shown in the table below, human capital is also positive and statistically significant suggesting that, an improvement in the human capital will cause economic growth to increase. It recorded a coefficient of 0.41464; hence in the short-run, a 1% increase in human capital will cause economic growth to increase by 0.041%.

Table 4.5 Estimates of Short-run economic growth results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(Economic growth (-1))	0.210669	0.235375	0.895037	0.3918
D(Economic growth (-2))	0.117535	0.089202	1.317624	0.2170
D(Economic growth (-3))	0.110946	0.065904	1.683444	0.1232
D(Economic growth (-4))	-0.16367	0.05738	-2.852394	0.0172
D(Exchange rate)	-0.00735	0.014003	-0.52482	0.6111
D(Inflation rate)	-0.01294	0.00481	-2.689283	0.0227
D(Interest rate)	-0.02025	0.012002	-1.6871	0.1225
D(Interest rate(-1))	-0.04127	0.008736	-4.724206	0.0008
D(Human capital)	0.414637	0.08716	4.757185	0.0008
D(Capital accumulation)	0.015808	0.011362	1.391318	0.1943
D(Technological advancement)	0.025125	0.009692	2.592322	0.0268
D(Technological advancement (-1))	-0.03486	0.014687	-2.373512	0.0390
ECT(-1)	-0.65854	0.184725	-3.564995	0.0051

R-squared	0.99974
Adjusted R-squared	0.99927
S.E of regression	0.00588
F-statistic	2140.51
Durbin-Watson stat	2.43802
Prob(F-statistic)	0.0000

Source; Author's construct, 2017 using Eviews

Capital formation as a percentage of GDP displayed a positive but insignificant effect on GDP per capita. This means that, an increase in capital formation will lead to an increase in

economic growth. The coefficient reported is 0.015808 meaning that; a 1% increase in capital formation will result in 0.015% increase in economic growth in Ghana.

Technological advancement proxied by computer and communication services exerts a positive and significant effect on economic growth. Economic growth will increase if technology grows. The coefficient for this variable is 0.0251. On average, if technology increases by 10%, economic growth will increase by 0.25%. Technological advancement is expected to improve the efficiency of labor and other factors of production in both the short-run and long-run. This eventually leads to an increase in economic growth in Ghana.

The lagged coefficients of economic growth indicate the conditional convergence to the growth path. The coefficient at lag 4 of economic growth is negative and significant reflecting the presence of conditional convergence. This measures the rate at which economic growth converges back to the growth path when the economy experiences a shock in the short-run. The above results shows conditional convergence at lag 4 meaning that, economic growth converges to the growth path at a rate of 16.367%. In other words, it converges to the growth path at a speed of 0.1636.

Similarly, the Error Correction Term (ECT) shows the speed of adjustment to equilibrium. It measures the rate at which the model restores back or adjusts to equilibrium when there is a shock. The ECT recorded a negative and significant coefficient. This means that, it takes the economy less than one year to adjust to equilibrium when a shock hits the economy in the short-run. It is therefore clear from the above results that, in times of disequilibrium, the model adjust back at a speed of 0.6585. Stated differently, the model restores back to equilibrium at a rate of 65.9% within eight months.

The adjusted R square is 0.999273. This implies that, 99.93% of the variations in economic growth are explained by the explanatory variables. The entire model is statistically

significant, and all the variables also showed the expected signs and significance except exchange rate and inflation which are insensitive to the Ghanaian economy in the short-run and long-run respectively. Interest rate and all the control variables respectively however exhibited significantly negative and positive effects as expected.

4.7 Hypothesis tested

This section compares the findings of the model to the hypothesis. Below is a detailed comparison.

(i) H_0: Exchange rate has no significant effect on economic growth

H_1: Exchange rate has a significant effect on economic growth

In the short-run, exchange rate showed an insignificant effect on economic growth. However, the long-run effect showed positive and significant effect on economic growth. The null hypothesis cannot be rejected for the short-run results whilst the alternate hypothesis is accepted for the long-run effects.

(ii) H_0: Inflation has no significant effect on economic growth

H_1: Inflation has a significant effect on economic growth

In the short-run, inflation showed significant effect on economic growth. However, the long-run effect showed an insignificant effect on economic growth. The null hypothesis cannot be rejected for the long-run results whilst the alternative hypothesis is accepted for the short-run effects.

(iii) H_0: Interest rate has no significant effect on economic growth

H_1: interest rate has a significant effect on economic growth

Interest rate showed a significant effect on economic growth both in the long-run and short-run. The alternative hypothesis is accepted for both the long-run and short-run results.

4.8 Robustness Checks

To confirm and authenticate the ARDL results, the study conducted both the Dynamic Ordinary Least Square (DOLS) and Robust Least Square (RLS). The results are shown below in Table 4.7. From the table, though the magnitudes of the DOLS and RLS coefficients are slightly different, they portray the same signs and level of significance as the ARDL estimates. Clearly, both the DOLS and RLS results corroborate the results of the ARDL meaning that, the model estimate for exchange rate, inflation, and interest rate was not by chance.

Table 4.6. Robustness Check using DOLS and RLS

Variable	DOLS Coefficient	P-Value	RLS Coefficient	P-Value
Exchange rate	0.053076	0.0005	0.052063	0.0000
Inflation	0.015028	0.2334	-0.004752	0.5941
Interest rate	-0.037575	0.0377	-0.043244	0.0058
Human capital	1.215449	0.0000	0.97033	0.0000
Capital formation	-0.046102	0.3220	0.007592	0.7822
Technological advancement	0.090296	0.0425	0.059225	0.0052
C	1.454696	0.0005	2.490115	0.0000

Source; Author's Construct using Eviews

They reflect the true long-run effect of exchange rate, inflation, and interest rate on economic growth in Ghana and thus inferences and policies can be drawn from this study.

CHAPTER FIVE

CONCLUSION AND POLICY RECOMMENDATIONSS

5.0 Overview of the study

The behavior of macroeconomic variables is an important determinant of economic growth of a country. In the early 1980s, the Ghanaian economy witnessed massive over-valuation of the cedi since the country was under the fixed exchange rate regime. This period witnessed very volatile and excessively high rates of inflation which led to negative economic growth. Nonetheless, interest rate was relatively stable during this period.

During the mid to late periods of the 1980s, structural adjustment and economic recovery programs were put in place that brought about relative improvement in economic growth. Economic growth witnessed positive growth while inflation and exchange rate improved marginally.

The economy implemented several other economic policies during the early 2000. This includes the monetary policy rate and inflation targeting in 2007. The essence of these policies was to stimulate economic growth through private sector investment and public-private partnerships. Economic growth increased to $1092.68 while inflation and interest rate dropped drastically to 10.7% and 8.9% respectively.

The main objective of this study is to find out if exchange rate, inflation, and exchange rate have significant effect on economic growth in Ghana. Some studies have shown an insignificant impact of inflation on economic growth. Several studies have depicted exchange rate depreciation as having a positive and significant effect of economic growth.

In estimating the model, the ARDL bounds test was applied. This was used to estimate the economic growth model that was specified in a Cobb-Douglas production function form and log-linearized

Data was collected from the world economic indicators- world bank. Consumer price index was used to measure inflation. Nominal exchange rate was used instead of real exchange rate because under the flexible exchange rate they both move together. Similarly, nominal interest rates were used since both real and nominal interest rates move in the same direction. The major findings are discussed below.

5.1 Summary of major findings

The model was estimated using the ARDL model. Both long-run and short-run results were estimated. The study revealed that exchange rate has a positive and significant effect on economic growth in the long-run. It further indicated that, inflation even though has a positive effect in the long-run, this effect is insignificant. However, interest rate has proven to have a negative and significant impact on the growth of the economy in the long-run.

In the short-run, the result indicates that exchange rate exerts a negative but insignificant impact on economic growth. Unlike in the long-run, the short-run effect of inflation on economic growth is negative and significant. Interest rate shows consistency in both long-run and short-run results. Similar to the long-run effect, interest rate shows a negative and significant effect on economic growth in Ghana in the short-run. The negative and significant coefficient of economic growth at lag 4 means that there is conditional convergence to the growth path. In case of any shock, economic growth of Ghana converges back to its long term growth path.

The ECT of the model is negative and significant meaning that, any deviation from the long-run equilibrium resulting from a shock will be corrected. In other words, the model restores back to long-run equilibrium in the event of a deviation. The coefficient of adjustment is 0.658544 implying that, it will take less than two years to adjust to its long term path.

Based on the findings above, the researcher made the following recommendations as suggested by the classical theory of interest rate, Keynesian absorption theory of currency depreciation, and the effect of inflation on economic growth as viewed by Sidrauski, Stockman, and Mundell and Tobin.

5.2 Policy recommendations

This research revealed that exchange rate depreciation in Ghana has a positive and significant effect on economic growth in the long-run. To improve economic performance, government through the appropriate ministries, departments and agencies should take advantage of the idle resources in the economy through;

(a) Construction of roads to link farms and farming communities to enhance transportation of farm produce to the marketplace/government warehouses (b) construction of irrigation dams at farming communities to enable all-year farming(c) the ministry of agriculture should buy surplus farm produce and storing at national warehouses (buffers) (d) development of improved seeds and supply of farming equipment and implements to farmers on credit and allowed to repay with farm produce over a period of time (e) training of more agriculture officers with the potential of enhancing agriculture production (f) target the production of crops that can survive in almost every part of Ghana like maize, millet, sorghum, beans, rice etc. and cash crops with high foreign demand like cocoa, coffee etc. (g) set-up processing factories and train the necessary technical officers to process and add value to the farm produce for both the local and international markets.

Ghanaian goods and services will become relatively cheap as a result of the depreciating currency thereby increasing the demand for the locally produced goods. This will eventually result in increased economic growth.

It can be suggested from the above analysis that, for the economy to witness growth, production must increase through the effective utilization of idle resources. In other words, for exchange rate depreciation to impact economic growth positively, the economy must be operating below full employment of economic resources. However, for countries operating at full employment, exchange rate depreciation will not promote growth. The government should formulate, implement and promote export promotion programs and projects to enhance economic growth through cedi depreciation. The effectiveness of the above guideline depends on the elasticity of the locally produced goods meant for export. Goods and services meant for export must be highly elastic.

Export promotion programs through the Ghana export promotion center, Ghana investment promotion center, and the Ministry of Trade should encourage the production of highly elastic good and services using the idle resources. This increases the economy's marginal propensity to absorb foreign demand for Ghanaian goods and services. Hence, with idle resources in the country, depreciation will increase exports and reduce imports (assuming inelastic imports). Output and income will rise and BOP on current account will improve.

The findings indicated that interest rate has a negative effect on economic growth both in the long-run and short-run. This implies that an increase in interest rate will result in a decrease in economic growth of Ghana. Practically, investors will borrow till the level where the cost of capital is equal to the marginal productivity of capital i.e. investors demand capital because it is productive.

Inflation has proven to have a negative and significant effect on economic growth in the short-run though not significant in the long-run. High inflation rate reduces the propensity to invest because it erodes capital. It also leads to high prices of goods and services resulting in low demand for final goods and services produced by investors. The farm produce processed and sold in the domestic market will bring down the prices of goods and services in Ghana thereby reducing the consumer price index (CPI). This will result in increased economic growth in the short-run as suggested by the findings of this study in chapter four.

From the findings in chapter four, interest rate indicated a negative effect on economic growth. Hence, interest rate must be maintained at relatively low levels to make cost of capital lower than the marginal productivity of capital. To achieve this, the Bank of Ghana (BOG) must continue pursuing the Monetary Policy Rate (MPR). The BOG should also reduce domestic borrowing. The implication of reduced domestic borrowing is a low Treasury bill rate. Treasury bill rate should fall to a level where investment in fixed deposit is more attractive than investment in treasury bills.

An increased investment in fixed deposit leads to a high supply of loanable funds to the private sector. On the other hand, an increase in interest rate leads to the crowding-out of the private sector as government competes with the private sector for the limited loanable funds available. Conversely, a reduction in the MPR will reduce the cost of borrowing thereby easing funds for the development and improvement of the private sector investment.

Individuals with surplus funds will invest in fixed deposits whilst individuals with deficit of funds and ideas will borrow at low interest rate and invest in the production of goods and services. These firms will invest areas where the marginal revenue from production is greater than the marginal cost of capital. The production of goods and services will increase propelling economic growth in both the short-run and long-run.

It is therefore the responsibility of government through the Ministry of Finance, Ministry of Trade, the BOG, the export promotion center, and the Ghana investment promotion center to implement the respective policies consistent with the findings and recommendation of this study to enhance economic growth.

5.3 Areas for further research

Considering some of the findings of this current study, the following areas could be explored in possible future research studies. A study on the optimum MPR essential for the economic growth of Ghana. Again, a study may be conducted to determine the effect of the MPR on private sector investment.

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APPENDICES

APPENDIX I. ARDL Bounds Test

ARDL Bounds Test
Date: 07/29/17 Time: 23:25
Sample: 1985 2013
Included observations: 29
Null Hypothesis: No long-run relationships exist

Test Statisti	Value	k
F-statistic	11.55768	6

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Test Equation:
Dependent Variable: D(GDP_PC)
Method: Least Squares
Date: 07/29/17 Time: 23:25
Sample: 1985 2013
Included observations: 29

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP_PC(-1))	0.071267	0.249182	0.286003	0.7807
D(GDP_PC(-2))	0.112127	0.097149	1.154180	0.2753
D(GDP_PC(-3))	0.078963	0.067993	1.161339	0.2725
D(GDP_PC(-4))	-0.158142	0.067223	-2.352511	0.0405
D(EX_RATE)	-0.004824	0.015296	-0.315340	0.7590
D(INF_RATE)	-0.013445	0.006183	-2.174742	0.0547
D(INTINTERPO)	-0.012707	0.014387	-0.883246	0.3978
D(INTINTERPO(-1))	-0.040077	0.010688	-3.749623	0.0038
D(PRMINTERPO)	0.416286	0.095006	4.381698	0.0014
D(COMPUTER)	0.031154	0.012673	2.458226	0.0338
D(COMPUTER(-1))	-0.026531	0.016784	-1.580741	0.1450
C	0.773937	0.588574	1.314935	0.2179
EX_RATE(-1)	0.028009	0.011594	2.415891	0.0363
INF_RATE(-1)	0.007703	0.006955	1.107615	0.2940
INTINTERPO(-1)	-0.023703	0.008000	-2.962896	0.0142
PRMINTERPO(-1)	0.772533	0.176938	4.366116	0.0014
GCAP_GDP(-1)	0.004087	0.019467	0.209934	0.8379
COMPUTER(-1)	0.049354	0.031233	1.580193	0.1451
GDP_PC(-1)	-0.624289	0.201421	-3.099419	0.0113

R-squared	0.965158	Mean dependent var	0.028528
Adjusted R-squared	0.902442	S.D. dependent var	0.020530
S.E. of regression	0.006412	Akaike info criterion	-7.015582
Sum squared resid	0.000411	Schwarz criterion	-6.119767
Log likelihood	120.7259	Hannan-Quinn criter.	-6.735024
F-statistic	15.38944	Durbin-Watson stat	2.533188
Prob(F-statistic)	0.000052		

APPENDIX II. ARDL Co-integrating and Long Run Form

ARDL Co-integrating And Long Run Form
Dependent Variable: GDP_PC
Selected Model: ARDL(5, 1, 1, 2, 1, 0, 2)
Date: 07/29/17 Time: 23:23
Sample: 1980 2015
Included observations: 29

Co-integrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP_PC(-1))	0.210669	0.235375	0.895037	0.3918
D(GDP_PC(-2))	0.117535	0.089202	1.317624	0.2170
D(GDP_PC(-3))	0.110946	0.065904	1.683444	0.1232
D(GDP_PC(-4))	-0.163670	0.057380	-2.852394	0.0172
D(EX_RATE)	-0.012935	0.014003	-0.923756	0.3774
D(INF_RATE)	-0.020248	0.004810	-4.209645	0.0018
D(INTINTERPO)	0.041270	0.012002	3.438625	0.0063
D(INTINTERPO(-1))	-0.034991	0.008736	-4.005480	0.0025
D(PRMINTERPO)	0.025125	0.087160	0.288268	0.7790
D(GCAP_GDP)	0.034861	0.011362	3.068270	0.0119
D(COMPUTER)	0.015808	0.009692	1.630961	0.1340
D(COMPUTER(-1))	-0.373351	0.014687	-25.419808	0.0000
CointEq(-1)	-0.658544	0.184725	-3.564995	0.0051

Cointeq = GDP_PC - (0.0137*EX_RATE -0.1041*INF_RATE + 0.1046 *INTINTERPO + 0.0211*PRMINTERPO + 0.0529*GCAP_GDP + 1.2206 *COMPUTER + 1.3712)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EX_RATE	0.013676	0.010921	1.252277	0.2390
INF_RATE	-0.104065	0.030994	-3.357617	0.0073
INTINTERPO	0.104643	0.037634	2.780519	0.0194
PRMINTERPO	0.021134	0.238077	0.088771	0.9310
GCAP_GDP	0.052936	0.021440	2.469069	0.0332
COMPUTER	1.220565	0.320196	3.811931	0.0034
C	1.371173	0.477890	2.869223	0.0167

APPENDIX III. Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.600498	Prob. F(2,8)	0.5715
Obs*R-squared	3.785338	Prob. Chi-Square(2)	0.1507

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 07/29/17 Time: 23:43
Sample: 1985 2013
Included observations: 29
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP_PC(-1)	0.065240	0.214190	0.304588	0.7685
GDP_PC(-2)	0.022145	0.269282	0.082239	0.9365
GDP_PC(-3)	0.014106	0.126677	0.111353	0.9141
GDP_PC(-4)	0.046143	0.117867	0.391487	0.7057
GDP_PC(-5)	-0.023150	0.063958	-0.361953	0.7268
EX_RATE	0.006549	0.019448	0.336756	0.7450
EX_RATE(-1)	-0.010985	0.022376	-0.490946	0.6366
INF_RATE	0.001577	0.006158	0.256147	0.8043
INF_RATE(-1)	-0.000728	0.005777	-0.125940	0.9029
INTINTERPO	0.002307	0.014235	0.162060	0.8753
INTINTERPO(-1)	0.003958	0.015149	0.261275	0.8005
INTINTERPO(-2)	-0.002208	0.009867	-0.223809	0.8285
PRMINTERPO	-0.053474	0.106076	-0.504110	0.6278
PRMINTERPO(-1)	-0.055902	0.114550	-0.488016	0.6386
GCAP_GDP	-0.009476	0.015832	-0.598521	0.5660
COMPUTER	0.002918	0.013729	0.212512	0.8370
COMPUTER(-1)	-0.004487	0.012467	-0.359918	0.7282
COMPUTER(-2)	-0.003841	0.017549	-0.218879	0.8322
C	-0.330659	0.646634	-0.511355	0.6229
RESID(-1)	-0.564336	0.547502	-1.030747	0.3328
RESID(-2)	-0.085379	0.690318	-0.123681	0.9046

R-squared	0.130529	Mean dependent var	-1.45E-16
Adjusted R-squared	-2.043149	S.D. dependent var	0.003515
S.E. of regression	0.006132	Akaike info criterion	-7.190078
Sum squared resid	0.000301	Schwarz criterion	-6.199967
Log likelihood	125.2561	Hannan-Quinn criter.	-6.879987
F-statistic	0.060050	Durbin-Watson stat	2.149226
Prob(F-statistic)	1.000000		

APPENDIX IV. Heteroskedasticity Test: Breusch-Pagan-Godfrey

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.613265	Prob. F(18,10)	0.8239
Obs*R-squared	15.21592	Prob. Chi-Square(18)	0.6471
Scaled explained SS	1.212675	Prob. Chi-Square(18)	1.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 07/29/17 Time: 23:27
Sample: 1985 2013
Included observations: 29

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001313	0.001508	0.870397	0.4045
GDP_PC(-1)	-0.000114	0.000459	-0.248642	0.8087
GDP_PC(-2)	-9.67E-05	0.000589	-0.164106	0.8729
GDP_PC(-3)	4.78E-05	0.000316	0.151360	0.8827
GDP_PC(-4)	8.18E-05	0.000289	0.283090	0.7829
GDP_PC(-5)	-0.000166	0.000158	-1.050504	0.3182
EX_RATE	-4.03E-05	3.86E-05	-1.042670	0.3217
EX_RATE(-1)	5.37E-05	4.63E-05	1.159796	0.2731
INF_RATE	-1.51E-05	1.33E-05	-1.136698	0.2822
INF_RATE(-1)	-1.41E-05	1.50E-05	-0.935887	0.3714
INTINTERPO	5.81E-05	3.31E-05	1.756379	0.1095
INTINTERPO(-1)	-3.69E-05	3.31E-05	-1.115886	0.2906
INTINTERPO(-2)	-2.42E-06	2.41E-05	-0.100455	0.9220
PRMINTERPO	-2.80E-05	0.000240	-0.116483	0.9096
PRMINTERPO(-1)	0.000160	0.000267	0.598353	0.5629
GCAP_GDP	-5.24E-06	3.13E-05	-0.167357	0.8704
COMPUTER	-1.27E-05	2.67E-05	-0.473757	0.6458
COMPUTER(-1)	-1.68E-05	3.11E-05	-0.541170	0.6002
COMPUTER(-2)	-1.92E-05	4.05E-05	-0.474294	0.6455

R-squared	0.524687	Mean dependent var	1.19E-05
Adjusted R-squared	-0.330876	S.D. dependent var	1.41E-05
S.E. of regression	1.62E-05	Akaike info criterion	-18.97523
Sum squared resid	2.63E-09	Schwarz criterion	-18.07941
Log likelihood	294.1408	Hannan-Quinn criter.	-18.69467
F-statistic	0.613265	Durbin-Watson stat	2.647697
Prob(F-statistic)	0.823915		

APPENDIX V. Ramsey RESET Test

Ramsey RESET Test
Equation: FINALRESULTSCSUC
Specification: GDP_PC GDP_PC(-1) GDP_PC(-2) GDP_PC(-3) GDP_PC(-4) GDP_PC(-5) EX_RATE EX_RATE(-1) INF_RATE INF_RATE(-1) INTINTERPO INTINTERPO(-1) INTINTERPO(-2) PRMINTERPO PRMINTERPO(-1) GCAP_GDP COMPUTER COMPUTER(-1) COMPUTER(-2) C
Omitted Variables: Powers of fitted values from 2 to 3

	Value	df	Probability
F-statistic	2.748997	(2, 8)	0.1234

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.000141	2	7.05E-05
Restricted SSR	0.000346	10	3.46E-05
Unrestricted SSR	0.000205	8	2.56E-05

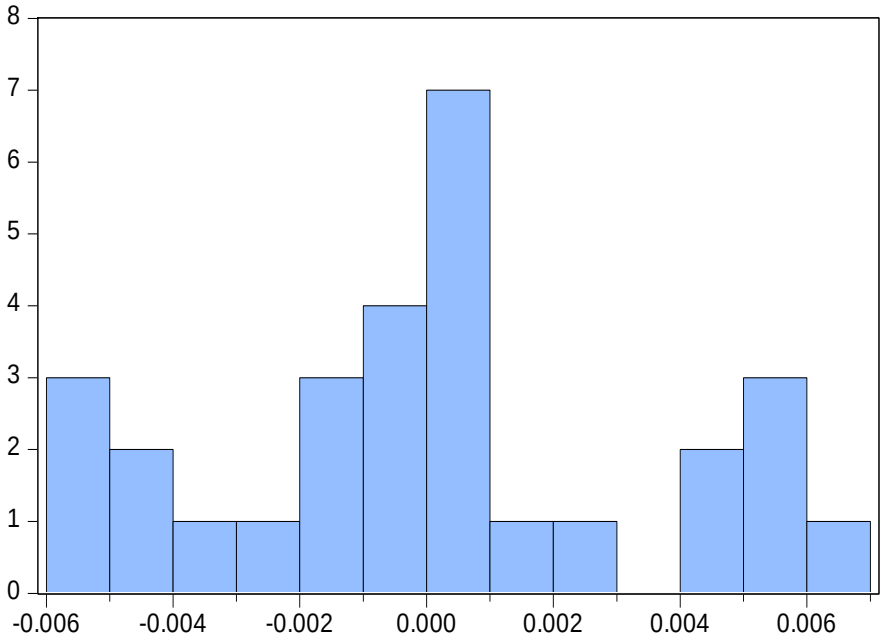
Unrestricted Test Equation:
Dependent Variable: GDP_PC
Method: ARDL
Date: 07/29/17 Time: 23:29
Sample: 1985 2013
Included observations: 29
Maximum dependent lags: 5 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic):
Fixed regressors: C

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDP_PC(-1)	-37.89158	40.36205	-0.938792	0.3753
GDP_PC(-2)	6.422681	6.897265	0.931192	0.3790
GDP_PC(-3)	0.429635	0.510028	0.842376	0.4240
GDP_PC(-4)	18.59978	20.10792	0.924998	0.3820
GDP_PC(-5)	-11.14295	12.01251	-0.927613	0.3807
EX_RATE	0.500001	0.540522	0.925034	0.3820
EX_RATE(-1)	-2.336863	2.563359	-0.911641	0.3886
INF_RATE	0.869636	0.946940	0.918364	0.3853
INF_RATE(-1)	-1.495771	1.606134	-0.931287	0.3790
INTINTERPO	1.398551	1.486843	0.940618	0.3744
INTINTERPO(-1)	3.269541	3.534878	0.924937	0.3821
INTINTERPO(-2)	-2.813101	3.017728	-0.932192	0.3785
PRMINTERPO	-28.00650	30.37872	-0.921912	0.3835
PRMINTERPO(-1)	-25.33367	27.37187	-0.925536	0.3818
GCAP_GDP	-1.085497	1.155386	-0.939510	0.3750
COMPUTER	-1.695430	1.832537	-0.925181	0.3819
COMPUTER(-1)	0.782566	0.820802	0.953417	0.3683
COMPUTER(-2)	-2.367066	2.550056	-0.928241	0.3804
C	102.1420	99.57839	1.025744	0.3350
FITTED^2	9.774302	10.74927	0.909299	0.3898
FITTED^3	-0.461025	0.526372	-0.875854	0.4066

R-squared	0.999846	Mean dependent var	6.643012
Adjusted R-squared	0.999462	S.D. dependent var	0.218229
S.E. of regression	0.005063	Akaike info criterion	-7.573307
Sum squared resid	0.000205	Schwarz criterion	-6.583196
Log likelihood	130.8130	Hannan-Quinn criter.	-7.263217
F-statistic	2600.610	Durbin-Watson stat	2.715844
Prob(F-statistic)	0.000000		

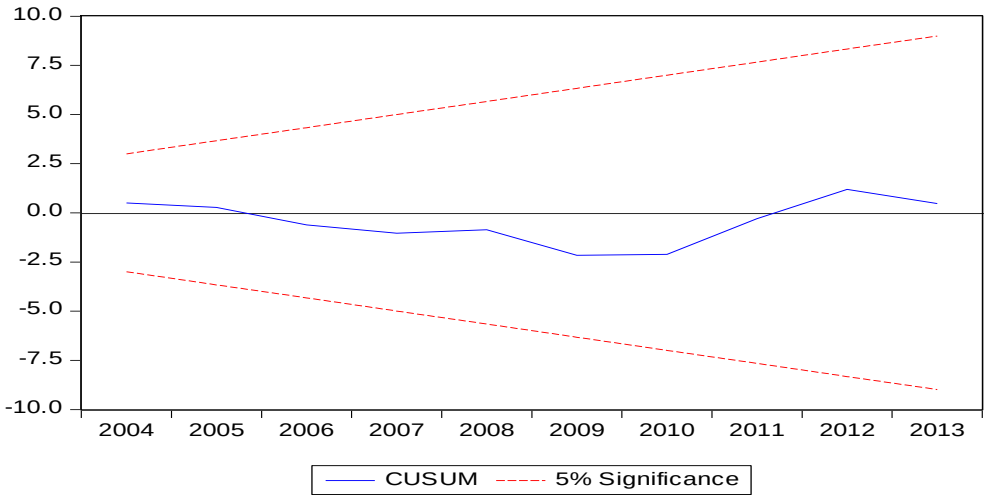
*Note: p-values and any subsequent tests do not account for model selection.

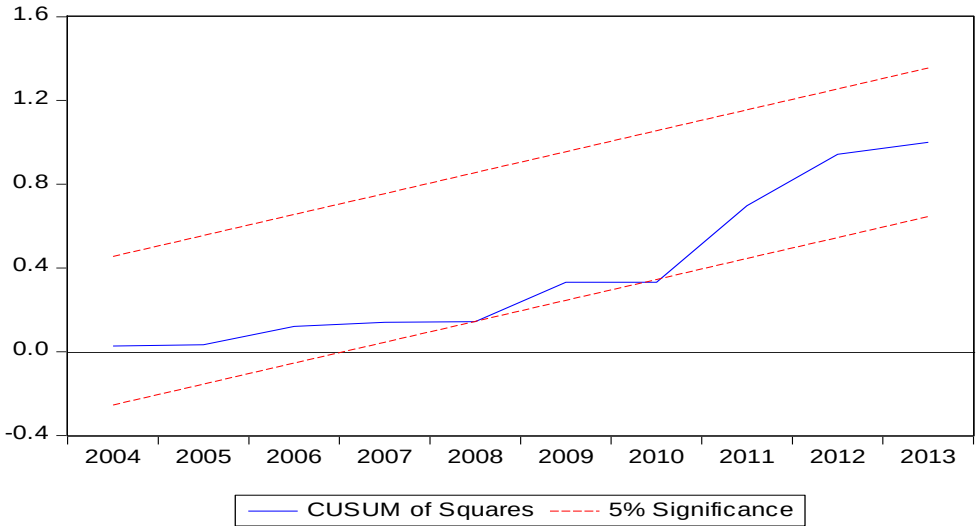
APPENDIX VI. Jarque-Bera Normality test



Series: Residuals	
Sample 1985 2013	
Observations 29	
Mean	-1.45e-16
Median	2.53e-05
Maximum	0.006821
Minimum	-0.005874
Std. Dev.	0.003515
Skewness	0.214577
Kurtosis	2.340517
Jarque-Bera	0.748068
Probability	0.687953

APPENDIX VII. CUSUM and CUSUM sum of squares





APPENDIX VIII. Ghana raw data on GDP Per capita, inflation rate, exchange rate, interest rate, primary school completion rate, computer and communication imports as a % of GDP, and capital formation

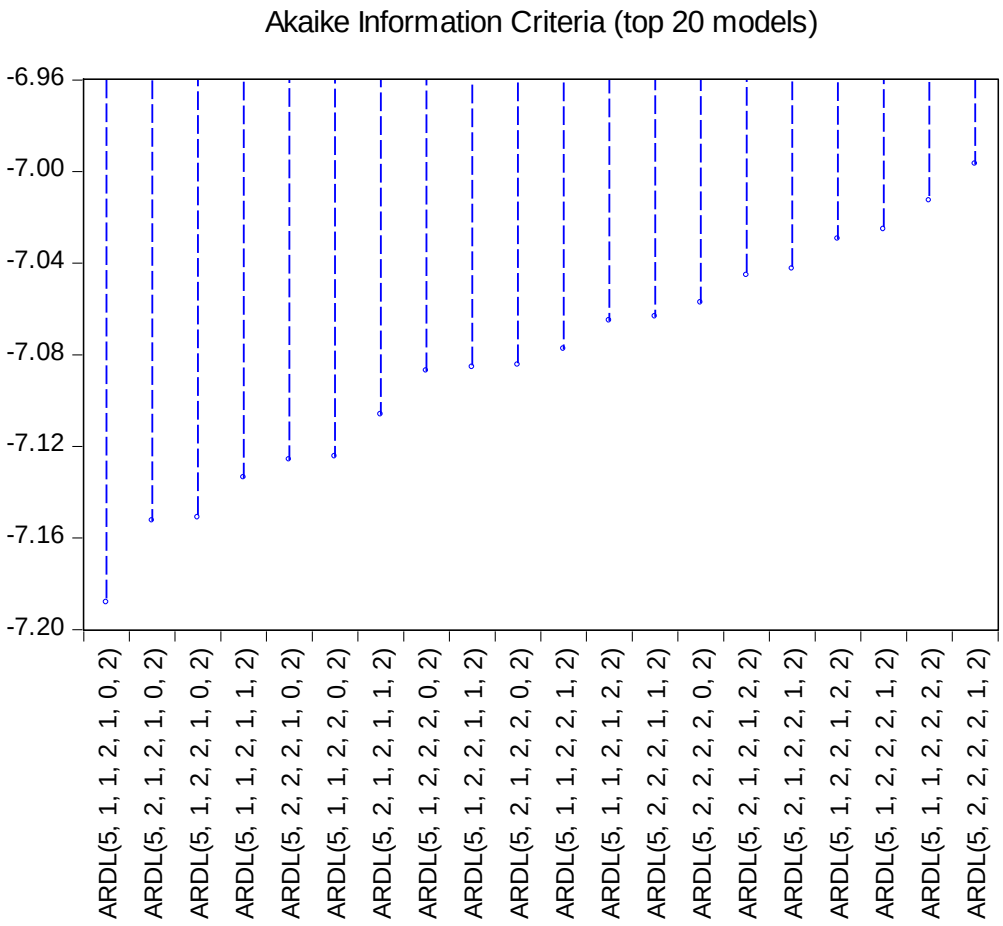
	GDP_PC	EX_RATE	INF_RATE	INT_RATE	PRM_COMR	GCAP_GDP	COMPUTER
1980	411.5179	0.000275	50.07014	11.5	62.97452	5.624008	13.91515
1981	379.7978	0.000275	116.5036	11.5	66.60704	4.572743	15.69471
1982	351.3194	0.000275	22.29557	11.5	NA	3.377636	21.18598
1983	341.0872	0.000883	122.8745	11.5	NA	3.749769	19.7049
1984	358.3968	0.003597	39.66531	15	NA	6.876823	24.78422
1985	354.22	0.005434	10.30544	15.75	NA	9.570089	14.89595
1986	437.0782	0.008916	24.56542	17	NA	9.362076	18.43066
1987	376.4318	0.015365	39.81507	17.58333	NA	10.43405	17.28938
1988	375.1812	0.020224	31.35927	16.5	NA	11.29599	25.85528
1989	368.9624	0.026985	25.22369	NA	NA	13.20901	24.49192
1990	402.5889	0.032616	37.25907	NA	NA	14.444	25.29354
1991	438.6143	0.036763	18.03144	21.32333	65.6092	15.87899	27.99607
1992	414.7673	0.043685	10.05612	16.32333	67.7031	12.8	27.79255
1993	375.3204	0.064871	24.95984	23.62917	NA	22.21017	27.63947
1994	333.4049	0.095568	24.87026	23.14667	NA	23.95773	25.47945
1995	385.7373	0.119914	59.46155	28.73417	NA	20.02141	25.21084
1996	403.5344	0.163547	46.56102	34.4975	NA	21.2	26.70846
1997	391.3557	0.204796	27.88521	35.75917	NA	24.80621	26.01208
1998	414.7685	0.231166	14.62417	32.04917	NA	23.10939	28.28313
1999	417.768	0.266643	12.40867	23.5625	68.71009	21.00053	27.65036
2000	263.1125	0.544919	25.19322	28.60417	71.76749	23.9986	20.70467
2001	273.6597	0.716305	32.90541	30.85417	67.99452	26.59942	19.39088
2002	309.4845	0.792417	14.81624	16.20833	69.29826	19.7	21.72463
2003	373.2816	0.866764	26.67495	14.32333	70.10018	22.93693	21.95372
2004	423.1936	0.899495	12.62457	13.625	68.79762	28.37751	23.80994
2005	498.1724	0.906279	15.11819	10.1625	74.47263	29.00214	33.99827
2006	922.9352	0.916452	10.91517	8.885417	71.15738	21.63567	29.72182
2007	1090.687	0.935248	10.73273	8.895833	77.44185	20.10776	17.45865
2008	1224.402	1.057858	16.52214	11.285	83.69076	21.45232	19.96208
2009	1086.765	1.4088	19.25071	17.06417	85.67312	20.67065	17.47067
2010	1312.608	1.431025	10.70757	12.87833	NA	25.99591	13.90108
2011	1574.979	1.51185	8.726837	8.908333	92.89778	26.44009	29.58067
2012	1629.8	1.9	9.160778	10.05	98.2	31.78475	25.2641
2013	1814.492	2.37	11.60833	12.35	98.4	27.73214	22.07556
2014	1432.228	3.19	15.49317	12.90417	96.5	27.13938	33.95577
2015	1361.114	3.81	17.14507	13.33917	101.1	24.62796	42.39326

***NA= None Available

APPENDIX IX. Ghana interpolated data on GDP Per capita, inflation rate, exchange rate, interest rate, primary school completion rate, computer and communication imports as a % of GDP, and capital formation.

	GDP_PC	EX_RATE	INTEREST	INF_RATE	PRMCOM	COMPUTER	GCAP_GDP
1980	411.5179	0.000275	11.5	50.07014	62.97452	13.91515	5.624008
1981	379.7978	0.000275	11.5	116.5036	66.60704	15.69471	4.572743
1982	351.3194	0.000275	11.5	22.29557	66.50726	21.18598	3.377636
1983	341.0872	0.000883	11.5	122.8745	66.40747	19.7049	3.749769
1984	358.3968	0.003597	15	39.66531	66.30769	24.78422	6.876823
1985	354.22	0.005434	15.75	10.30544	66.2079	14.89595	9.570089
1986	437.0782	0.008916	17	24.56542	66.10812	18.43066	9.362076
1987	376.4318	0.015365	17.58333	39.81507	66.00834	17.28938	10.43405
1988	375.1812	0.020224	16.5	31.35927	65.90855	25.85528	11.29599
1989	368.9624	0.026985	18.10778	25.22369	65.80877	24.49192	13.20901
1990	402.5889	0.032616	19.71555	37.25907	65.70898	25.29354	14.444
1991	438.6143	0.036763	21.32333	18.03144	65.6092	27.99607	15.87899
1992	414.7673	0.043685	16.32333	10.05612	67.7031	27.79255	12.8
1993	375.3204	0.064871	23.62917	24.95984	67.84696	27.63947	22.21017
1994	333.4049	0.095568	23.14667	24.87026	67.99081	25.47945	23.95773
1995	385.7373	0.119914	28.73417	59.46155	68.13467	25.21084	20.02141
1996	403.5344	0.163547	34.4975	46.56102	68.27852	26.70846	21.2
1997	391.3557	0.204796	35.75917	27.88521	68.42238	26.01208	24.80621
1998	414.7685	0.231166	32.04917	14.62417	68.56623	28.28313	23.10939
1999	417.768	0.266643	23.5625	12.40867	68.71009	27.65036	21.00053
2000	263.1125	0.544919	28.60417	25.19322	71.76749	20.70467	23.9986
2001	273.6597	0.716305	30.85417	32.90541	67.99452	19.39088	26.59942
2002	309.4845	0.792417	16.20833	14.81624	69.29826	21.72463	19.7
2003	373.2816	0.866764	14.32333	26.67495	70.10018	21.95372	22.93693
2004	423.1936	0.899495	13.625	12.62457	68.79762	23.80994	28.37751
2005	498.1724	0.906279	10.1625	15.11819	74.47263	33.99827	29.00214
2006	922.9352	0.916452	8.885417	10.91517	71.15738	29.72182	21.63567
2007	1090.687	0.935248	8.895833	10.73273	77.44185	17.45865	20.10776
2008	1224.402	1.057858	11.285	16.52214	83.69076	19.96208	21.45232
2009	1086.765	1.4088	17.06417	19.25071	85.67312	17.47067	20.67065
2010	1312.608	1.431025	12.87833	10.70757	89.28545	13.90108	25.99591
2011	1574.979	1.51185	8.908333	8.726837	92.89778	29.58067	26.44009
2012	1629.8	1.9	10.05	9.160778	98.2	25.2641	31.78475
2013	1814.492	2.37	12.35	11.60833	98.4	22.07556	27.73214
2014	1432.228	3.19	12.90417	15.49317	96.5	33.95577	27.13938
2015	1361.114	3.81	13.33917	17.14507	101.1	42.39326	24.62796

APPENDIX X. Optimum model selection by AIC



APPENDIX. XI Coefficient Variance Decomposition

Coefficient Variance Decomposition
Date: 08/02/17 Time: 12:42
Sample: 1980 2015
Included observations: 29

Eigenvalues	0.329043	0.058397	0.017131	0.006334	0.003362	0.002876	0.000540	0.000328
Condition	1.07E-08	6.02E-08	2.05E-07	5.55E-07	1.05E-06	1.22E-06	6.51E-06	1.07E-05

Variance Decomposition
Proportions

	Associated Eigenvalue							
Variable	1	2	3	4	5	6	7	8
GDP_PC(-1)	0.010117	0.878820	0.073040	0.028873	0.005304	0.002350	0.001242	0.000113
GDP_PC(-2)	0.396340	0.582962	0.000291	0.005499	0.013415	0.000518	0.000869	5.40E-05
GDP_PC(-3)	0.072116	0.324522	0.460037	0.091184	0.025685	0.026348	6.85E-05	9.65E-06
GDP_PC(-4)	0.174053	0.047103	0.647583	0.100589	0.002683	0.022201	0.005435	4.74E-05
GDP_PC(-5)	0.081835	0.007111	0.444258	0.315951	0.019872	0.062399	0.063148	0.003191
EX_RATE	0.008787	0.026800	0.116146	0.007818	0.000308	0.016327	0.105091	0.685173
EX_RATE(-1)	0.363991	0.000122	0.100011	0.003582	0.008524	0.007516	0.097385	0.396851
INF_RATE	0.138225	0.080039	7.95E-06	0.045949	0.152980	0.000747	0.042871	4.50E-05
INF_RATE(-1)	0.059474	0.008497	0.010273	0.135595	0.136063	0.034789	0.175673	0.028339
INTINTERPO	0.066242	0.064114	0.021627	0.062117	0.165198	0.036033	0.095125	0.096208
INTINTERPO(-1)	0.049393	0.073536	0.026673	0.081012	0.002758	0.000315	0.021029	0.089925
INTINTERPO(-2)	0.021995	0.000361	0.014889	0.036000	0.129690	0.018743	0.175330	0.093502
PRMINTERPO	0.508749	0.106179	0.034237	0.064780	0.187581	0.091356	0.006473	0.000195
PRMINTERPO(-1)	0.634079	0.017041	0.011924	0.150810	0.048290	0.134592	0.002352	0.000548
GCAP_GDP	0.036053	0.151713	2.82E-06	0.003823	0.006792	0.002963	0.071264	0.021968
COMPUTER	0.040293	0.168783	0.003405	0.000371	0.020575	1.41E-06	0.140251	0.203224
COMPUTER(-1)	0.158279	0.274930	0.068801	0.000599	0.123882	0.003601	0.009033	0.000354
COMPUTER(-2)	0.424303	0.167631	1.12E-05	0.000345	0.138769	0.024116	0.081401	0.005974
C	0.994281	0.004863	0.000142	1.73E-07	0.000662	4.94E-05	2.08E-07	3.69E-07

Eigenvectors

	Associated Eigenvalue							
Variable	1	2	3	4	5	6	7	8
GDP_PC(-1)	0.029218	0.646403	-0.344059	-0.355752	0.209303	-0.150619	0.252762	-0.097710
GDP_PC(-2)	-0.234641	-0.675490	-0.027850	-0.199197	0.427080	-0.090774	0.271382	-0.086770
GDP_PC(-3)	-0.053603	0.269912	0.593330	0.434415	0.316492	0.346552	0.040793	0.019645
GDP_PC(-4)	-0.076226	-0.094127	-0.644375	0.417650	-0.093628	0.291187	-0.332619	0.039828
GDP_PC(-5)	0.028616	-0.020024	0.292201	-0.405247	-0.139510	-0.267268	-0.620756	0.178982
EX_RATE	-0.002288	-0.009486	-0.036461	0.015556	-0.004241	-0.033364	0.195426	0.640054
EX_RATE(-1)	0.017673	-0.000768	0.040599	-0.012636	-0.026757	0.027163	-0.225739	-0.584508
INF_RATE	-0.003118	0.005631	-0.000104	0.012955	-0.032448	0.002452	-0.042875	-0.001781
INF_RATE(-1)	0.002316	-0.002078	-0.004219	-0.025206	-0.034660	-0.018947	0.098303	0.050643
INTINTERPO	-0.005385	-0.012576	0.013485	-0.037584	0.084135	0.042481	-0.159358	-0.205564
INTINTERPO(-1)	-0.004653	0.013476	-0.014985	0.042948	-0.010878	0.003973	-0.074974	0.198864
INTINTERPO(-2)	0.002259	0.000687	0.008144	-0.020826	-0.054260	-0.022301	0.157475	-0.147505
PRMINTERPO	0.108379	-0.117528	0.123216	-0.278732	-0.651087	0.491231	0.301898	-0.067186
PRMINTERPO(-1)	0.134556	-0.052361	0.080867	0.472955	-0.367375	-0.663078	0.202374	-0.125271
GCAP_GDP	0.003761	0.018313	0.000146	-0.008826	0.016150	-0.011533	0.130574	-0.092990
COMPUTER	-0.003392	-0.016478	-0.004321	-0.002345	-0.023979	0.000214	-0.156264	0.241272
COMPUTER(-1)	0.007832	-0.024501	0.022630	0.003474	-0.068549	-0.012635	-0.046202	0.011726
COMPUTER(-2)	0.016679	0.024884	0.000376	0.003427	-0.094366	-0.042530	0.180401	0.062684
C	0.950780	-0.157844	-0.049852	-0.002855	0.242798	0.071677	-0.010747	0.018357

APPENDIX II. Dynamic OLS (DOLS) Output

Dependent Variable: GDP_PC
Method: Dynamic Least Squares (DOLS)
Date: 08/12/17 Time: 20:46
Sample (adjusted): 1982 2012
Included observations: 31 after adjustments
Cointegrating equation deterministics: C
Fixed leads and lags specification (lead=1, lag=1)
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EX_RATE	0.053076	0.007926	6.696769	0.0005
INF_RATE	0.015028	0.011342	1.324980	0.2334
INTINTERPO	-0.037575	0.014143	-2.656734	0.0377
PRMINTERPO	1.215449	0.041806	29.07326	0.0000
GCAP_GDP	-0.046102	0.042723	-1.079089	0.3220
COMPUTER	0.090296	0.035165	2.567802	0.0425
C	1.454696	0.217558	6.686460	0.0005

R-squared	0.999405	Mean dependent var	6.596024
Adjusted R-squared	0.997024	S.D. dependent var	0.210610
S.E. of regression	0.011490	Sum squared resid	0.000792
Long-run variance	3.65E-05		

APPENDIX III. Robust Least Square (RLS) Output

Dependent Variable: GDP_PC
Method: Robust Least Squares
Date: 08/12/17 Time: 19:08
Sample (adjusted): 1980 2013
Included observations: 34 after adjustments
Method: M-estimation
M settings: weight=Bisquare, tuning=4.685, scale=MAD (median centered)
Huber Type I Standard Errors & Covariance

Variable	Coefficient	Std. Error	z-Statistic	Prob.
EX_RATE	0.052063	0.006104	8.529190	0.0000
INF_RATE	-0.004753	0.008919	-0.532862	0.5941
INTINTERPO	-0.043244	0.015664	-2.760729	0.0058
PRMINTERPO	0.970331	0.057977	16.73640	0.0000
GCAP_GDP	0.007592	0.027464	0.276421	0.7822
COMPUTER	0.059225	0.021190	2.794881	0.0052
C	2.490113	0.301382	8.262324	0.0000

Robust Statistics

R-squared	0.751880	Adjusted R-squared	0.696742
Rw-squared	0.993333	Adjust Rw-squared	0.993333
Akaike info criterion	60.72446	Schwarz criterion	75.86151
Deviance	0.020163	Scale	0.019849
Rn-squared statistic	3454.424	Prob(Rn-squared stat.)	0.000000

Non-robust Statistics

Mean dependent var	6.609030	S.D. dependent var	0.222213
S.E. of regression	0.115264	Sum squared resid	0.358714