MODELING GDP USING VECTOR AUTOREGRESSIVE (VAR) MODELS: AN EMPIRICAL EVIDENCE FROM GHANA.

BY

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THIS THESIS IS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF GHANA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE MASTER OF PHILOSOPHY DEGREE IN STATISTICS

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DECLARATION

Candidate's Declaration

This is to certify that, this thesis is the result of my own research work and that no part of it has been presented for another degree in this University or elsewhere.

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Supervisors' Declaration

We hereby certify that this thesis was prepared from the candidate's own work and supervised in accordance with guidelines on supervision of thesis laid down by the University of Ghana.

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DEDICATION

I dedicate this thesis to my beloved mother and wife; Mrs. Rosemond Amoah and Bernice Adongo.

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I thank the Almighty God who has given me the care, knowledge and the opportunity to pursue education up to this level.

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Finally, to all my friends especially 2015 batch of M. Phil students of Statistics Department, I ask for God's guidance and mercies.

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LIST OF ABBREVIATIONS

GDP	……………………..…	Gross Domestic Product
VAR	…………………………	vector autoregressive
VECM	…………………………	vector error correction model
US	…………………………	United States
ADF	………………………....	Augmented Dickey Fuller
KPSS	…………………………	Kwiatkowski, Phillips, Schmidt and Shin
DF	…………………………	Dickey–Fuller
LM	…………………………	Lagrange Multiplier
FDI	…………………………	Foreign Direct Investments
OECD	………………….........	Organization for Economic Co-operation and Dev.
WDI	…………………………	World Development indicator
AR	…………………...........	Autoregressive
LR	…………………………	Likelihood-ratio
AIC	…………………………	Akaike's information criterion
HQ	…………………………	Hannan-Quin
SC	…………………………...	Schwarz criterion
OLS	…………………………...	Ordinary Least Square

MLE	……………………………..	Maximum Likelihood Estimator
IRF	…………………………...	impulse-response function
FPE	……………………………	Final prediction error
HQIC	…………………………...	Hannan-Quin information criterion
SBIC	…………………………….	Schwarz Bayecian information criterion
CI	…………………………….	Co-integration
ce1	…………………………….	correction error term 1
i.i.d	……………….…...…	Independent and identically distributed random variables

ABSTRACT

This study used the VAR models to model the Growth Domestics Products (GDP) of Ghana with other two selected macroeconomic such as inflation and real exchange rate for the period of 1980 to 2013. Data were taken from the World Bank's World Development Indicators and Bank of Ghana. This study employed co-integration test and vector error correction models (VECM) to examine both long-run and short-run dynamic relationships between the GDP and the macroeconomic variables. The time series properties of the data were, first, analysed using the Augmented Dickey-Fuller (ADF) test. The empirical results derived indicate that all the variables were stationary after their first differencing; i.e. variables are integrated of order one, I(1). The study further established that there is co-integration between macroeconomic variables and GDP in Ghana indicating long run relationship. The VECM (3) model was appropriately identified using AIC information criteria with co-integration relation of exactly one .The above long term relation indicates that Real Exchange Rate have a negative effect on GDP whiles Inflation (CPI) showed a positive effect on GDP. The study further investigated the causal relationship using the Granger Causality analysis, which indicates a uni–directional causal relationship between GDP and Real Exchange rate and bi-directional causal relationship between GDP and Inflation rate at 5%. Hence the findings that inflation has a long-run relationship between GDP growth and influences it positively in Ghana, government should invest in local industries to boost domestic production of tradable which would maintain higher export volumes. This will help reduce Exchange rate and hence impact on inflation, thereby increasing GDP growth rate.

CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

Whenever a country overall output boosts up the country real GDP increases and we call it economic growth .Economic growth of any country reflects its capacity to increase production of goods and services. The simplest definition of economic growth can be stated as the increase in the Gross Domestic Product (GDP) of that country. Nominal GDP is usually adjusted for inflation to reflect real GDP.

GDP also indicates the financial health of a country as a whole-which is actually a hunting ground of researchers in the field of business in general and of economics in particular. The issues of GDP has become the most concerned amongst macro economy variables and data on GDP is regarded as the important index for assessing the national economic development and for judging the operating status of macro economy as a whole (Ning et al. 2010)

Sustainable economic growth is of foremost concern for every economy, mainly for the developing economies which usually face tribulations. The gross domestic product (GDP), which is the crucial evaluation of an economy's economic sketch, also refers to the value of all final goods and services produced within a country or an area in a period of time (a quarter or a year), and is often considered the best standard of measuring national economic conditions (Mankiw & Taylor 2007).

Macro-econometric analysis were analyzed using Multivariate simultaneous equations models when Sims (1980) advocated vector autoregressive (VAR) models as alternatives. At that time longer and more frequently observed macroeconomic time series called for models which described the dynamic structure of the variables. VAR models lend themselves for this purpose. They typically treat all variables as a prior endogenous. Thereby follows Sims' critique that the exogeneity assumptions for some of the variables in simultaneous equations models are ad hoc and often not backed by fully developed theories. Restrictions, including exogeneity of some of the variables, may be imposed on VAR models based on statistical procedures.

However, one severe disadvantage of the VAR model is that it requires stationary time series. In most cases the stationarity requirement leads to differencing and thereby information on any long-run relationship between the variables will be lost. Granger (1981) presented a solution to this problem by introducing the relationship between co-integration and error correction models, which was further extended by Engle & Granger (1987). They showed that although individual time series are non-stationary a linear combination of those series can be stationary without differencing. Such relationships are referred to as co-integration, which means that there exists a long-run equilibrium relationship between the variables.

Error correction models draw upon the co-integrating relationship by allowing long-run components of variables to abide by equilibrium constraints while short-run components have a flexible dynamic specification (Engle & Granger, 1987). According to Engle and Granger, a pure VAR is misspecified if there exists a co-integrating relationship between the variables. In the presence of such relationships they advocate a restricted VAR model, known as the vector error correction model (VECM).

There has always been the view that the economy of Ghana could and should grow faster than it has done. The recent growth record is deemed inadequate for the desired transformation of the economy, Aryeetey and Fosu (2005). Ghana in 1993 set itself the target of becoming an upper middle income country by 2020 under its Vision 2020programme according to Aryeetey and Fosu (2005). To achieve the targeted per capita income by that year, using a simple Harrod-Domar type model, it was reckoned that the economy needed to grow at an average of 8% for the period as indicated in the economic review, 1992 by the then Institute of Economic Affairs.

But the growth rate record of Ghana has been unstable when the post-reformed period is compared to the earlier period. With logically high GDP growth in the 1950s and early 1960s, the economy began to experience a reduction in GDP growth in 1964. According to Aryeetey and Fosu (2005), ‘growth was turbulent during much of the period after mid-1960s and only began to stabilize after 1984. In 1966, 1972, 1975-1976, 1979 and 1983, the growth rate of real GDP was negative for Ghana’. The GDP growth has been negative for a number of years. This is mainly due to political instability between these years, even though some years recorded some positive growth in 1974, 1977 and 1978.

To achieve sustained economic growth, increased production and productivity must be at the centre of an economic recovery strategy. To formulate strategies for achieving sustained increased production and the rapid growth necessary for poverty reduction, relevant information is absolutely necessary. It is therefore important to decompose the structure of Ghana's economy and its growth rate, to gain a better understanding of those factors that have produced differences in growth rates in the various periods.

1.1 Problem statement

Exchange rate and inflation as the most important macroeconomic variables in every economy have received much attention both in literature and the world at large over the years. The exchange rate and inflation affect currency stability and price stability respectively in every economy; it is therefore the aim of every country to maintain currency and price stability. Persistent volatility in the exchange rate makes international trade and investments decisions very difficult as this volatility makes investments too risky. Most international investors are prone to exchange rate risk which distorts the income from the return on those investments. Persistent inflation on the other hand causes a redistribution of income where income from fixed income earners (usually the poor) could be redistributed to flexible income earners (the rich) which then affects the economic growth of the country; hence, the need for Central banks to critically monitor the performance of the exchange rate and inflation in their economies.

Exchange rate management and inflation has passed through several reforms before and after independence in Ghana. The Bank of Ghana has been implementing policies to manage the exchange rate volatility and price stability in order to arrive at a stable currency. Over the years, the local currency keeps on depreciating against its major trading currencies-dollar, euro, and pound. Ghana has experienced consistent increase in inflation, not until 2007 where the policy makers decided to implement the inflation targeting approach that witnessed a slight decrease and stability in the inflation rate. The Cedi depreciated against the US Dollar at about 4.9% and 11.5% in the inter-bank and forex markets respectively while the 2012 inflation stood at about 9.4% (Bank of Ghana quarterly bulletin, 2012 Q2).Exchange rate in Ghana has been experiencing severe depreciation over the decades with persistent increase in the price levels. Studying the impact of the exchange rate on the economy of Ghana especially the inflation is of a great interest to all researchers both in and outside the country.

Agalega et al. (2013) analyzed the Impact of Macroeconomic Variables on Gross Domestic Product of Ghana using multiple linear regression models. Their findings showed that there is a positive relationship between GDP and inflation rate. They failed to address for co-integration between the variables.

Asmah (2013) also analyzed sources of Real Exchange Rate Fluctuations in Ghana; the results show that consumer price increases (nominal shocks) contribute significantly to real effective exchange rate appreciations in Ghana, consumer price index (CPI) Granger Cause real effective exchange rate (REER). But he applied unrestricted VAR model, which can only analyze the short-run relationship between the variables. Hence this makes the author interested in using the restricted VAR/VEC model which will analyze the short-run and long-run relationships between the selected macro-economic variable; inflation, exchange rate and GDP growth of Ghana using yearly data from 1980-2013.

1.2 Objectives of the study

The general objective of this study is to model GDP of Ghana using Vector Autoregressive (VAR) models.

Specific:

1. Examines the cointegration link between the series variables.
2. Explain the long-run and short-run dynamics explicitly by using Vector error correction model.

1.3 Relevance of the Study

This research can be very useful to the economists and researchers who wish to find the lung-run and short-run relationships between this selected macroeconomics on GDP. It can also serve as a reference to subsequent research works in the area of GDP in Ghana.

Also the research can bring awareness, even to the common public as well as to highly learned economists.

1.4 Limitations of the Study

Because of the lack of complete data, variables such as unemployment rate and real interest rates that are expected to affect the GDP are not considered in the study.

1.5 Organization of the Study

This study contains five main chapters but prelude to these chapters are the abstract which summarizes the whole research, the table of contents, list of figures, list of tables, list of abbreviations, dedications and acknowledgement. The references and appendix could also be found after the last chapter. Chapter one of this thesis comprises the background of the study, problem statement, study objectives, significance and limitations of the study. Chapter two is made up of the literature review and chapter three discusses the various methods of the stated Vector Autoregressive models used for the research. Chapter four analyzes and discuses the findings of the study, and finally, chapter five presents the summary, conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section begins with methods for unit root tests, VAR model, Granger causality test, cointegrated and VECM. It further looks at the relationship of the two selected variables with GDP. Finally, the application of VAR in various researches in and outside Ghana is also discussed.

2.1 Unit Root Tests

Unit root tests are applied to check whether the time series is stationary. Many unit root tests are proposed in various literatures. Some of these are ADF (Augmented Dickey Fuller) test, Phillips-Peron test and KPSS (Kwiatkowski et al, 1992).

The Dickey-Fuller test is based on testing the hypothesis that series contains unit root against the series is stationary under the assumption that errors are white noise. The test may be carried out using a conventional *t* statistic. However, the tests do not follow the standard student t distribution so the critical values for the test are obtained by simulation. An extension which will accommodate some forms of serial correlation is the augmented Dickey–Fuller test.

Phillips & Perron (1988) suggested non-parametric test statistics for the null hypothesis of a unit root that explicitly allows for weak dependence and heterogeneity of the error process. The advantage is that these modified tests eliminate the nuisance parameters that are present in the DF statistic if the error process does not satisfy the i.i.d. assumption.

KPSS proposed an LM test for testing trend and/or level stationarity. That is, now under the null hypothesis the series is assumed stationary, whereas in the former tests it was a unit root process. Taking the null hypothesis as a stationary process and the unit root as an alternative is in accordance with a conservative testing strategy. One should always seek tests that place the hypothesis we are interested in as the alternative one. Hence, if we then reject the null hypothesis, we can be confident that the series indeed has a unit root. Therefore, if the results of the tests above indicate a unit root but the result of the KPSS test indicates a stationary process, one should be cautious and the stationarity should be investigated further taking into account the autocorrelation structure of the series.

2.2 VAR Model

The vector autoregression (VAR) model is one of the most successful, flexible, and easy to use models for the analysis of multivariate time series. VAR models in economics were made popular by Sims (1980). It is a natural extension of the univariate autoregressive model.

The VAR model is useful for describing the dynamic behavior of financial time series and for forecasting. The use of Vector Autoregressive Models (VAR) and Vector Error Correction Models (VECM) for analyzing dynamic relationships among financial variables has become common in the literature, Granger (1981), Engle & Granger (1987), MacDonald & Power (1995) and Barnhill, et al. (2000). The popularity of these models has been associated with the realization that relationships among financial variables are so complex that traditional time-series models have failed to fully capture.

Engle & Granger (1987) noted that, for cointegrated systems, the VAR in first differences will be miss-specified and the VAR in levels will ignore important constraints on the coefficient matrices. Although these constraints may be satisfied asymptotically, efficiency gains and improvements in forecasts are likely to result from their imposition. Hence, Engle & Granger (1987) suggested that if a time-series system under study includes integrated variables of order 1 and satisfy the conditions of cointegration relations, then this system will be more appropriately specified as a vector error-correction model (VECM) rather than a VAR.

Subsequently, Ahn & Reinsel (1990) and Johansen (1991) have proposed various algorithms for the estimation of cointegrating vectors in full-order VECM models, which contain all non-zero entries in the coefficient matrices. There are many examples of the use of full order VECM models in the analysis of short-term dynamics and long-term cointegrating relationships [Ahn & Reinsel (1992), Johansen(1992, 1995)].

Problems can arise in relation to the use of full-order VECM; as such models assume nonzero elements in all their coefficient matrices. As the number of elements to be estimated in these possibly over-parameterized models grows with the square of the number of variables, the degrees of freedom are heavily reduced**.**

2.3 Granger Causality Test

Causality can be described as the relationship between cause and effect. Basically, theterm 'causality' suggests a cause and effect relationship between two sets of variables,say, Y and X. Recent advances in graphical models and the logic of causation have given rise to new ways in which scientists analyze cause-effect relationships (Pearl, 2012).

However, in recent times, Granger causality modeling has received considerable attention and use in many areas of research. Since the concept of Granger (non) causality was introduced by Granger (1969), it has become a popular concept in econometrics and many other fields of human endeavor. In line with most of the literatures in econometrics, one variable is said to Granger cause the other if it helps to make a more accurate prediction of the other variable than had we only used the past of the latter as predictor. Granger causality between two variables cannot be interpreted as a real causal relationship but merely shows that one variable can help to predict the other one better.

Given two time series variables X_t andY_t, X_t is said to Granger cause Y_t if Y_t can be better predicted using the histories of both X_t and Y_t than it can by using the history of Y_t alone.

Many researchers in the field of Time Series Econometrics have used Granger causality procedure to study the causal interactions that exists among economic indicators in various countries of the world. Moreover, several intelligent articles have surfaced in literature on the use of Granger causality tests to analyze time series data since its introduction by Granger (1969).

Some of the articles include: Granger (1969), Granger (1980), Granger (1988), Swanson &Granger (1997), Entner et al (2010), Mohammed et al(2010), Chu & Chymour (2008), Arnold et al (2007), Clarke & Mirza (2006), Erdal et al (2008), Pearl(2012) just to mention a few. Others include: Shojaie and Michailidis (2010), Moneta et al (2011),Chen and Hsiao (2010),White et al(2011), Zou et al (2010), Havackova- Schindler et al (2007), Haufe et al (2010),Toda et al (1994) etc.

2.4 Co-integration

Co-integration in a vector time series has a number of implications for work in empirical macroeconomics. One of the purported advantages of recognizing cointegration rank in an integrated vector process is that it will result in improved forecast performance.

Yoo & Engle (1987) illustrate that forecasts taken from cointegrated systems are “tied together” because the co-integrating relations must “hold exactly in the long-run.” They demonstrate in a series of Monte Carlo experiments that incorporating co-integration into the forecasting model can reduce mean squared forecast errors by up to 40% at medium to long forecast horizons. As recently as Stock (1995), the apparent value of incorporating cointegration into the forecasting exercise was noted.

2.5 Vector Error Correction Model (VECM)

Granger defined variables that are individually driven by permanent shocks (integrated), but for which there are weighted sums (linear combinations) that are mean reverting (driven only by transitory shocks), as cointegrated variables. He then demonstrated in the Granger Representation Theorem (Engle & Granger, 1987; Johansen, 1991) that variables, individually driven by permanent shocks, are cointegrated if and only if there exist a Vector Error Correction representation of the data series.

This popular specification has the advantage of containing both long-run levels and short-run first differences of non stationary variables. The Co-integration in a vector time series (Engle & Granger, 1987) has a number of implications for work in empirical macroeconomics. Co-integration transforms the linear combination of two non-stationary time series into a stationary one. In economics co-integration is referred to as a long-run equilibrium relationship. The intuition is that non-stationary time series with a long-run equilibrium relationship cannot drift too far apart from the equilibrium because economic forces will act to restore the equilibrium relationship. Therefore one of the purported advantages of co-integration in an integrated vector process is that it will result in improved forecasting performance in long horizon. In an extremely influential and important paper, Engle & Granger (1987), (henceforth referred to as EG) showed that co-integration implies the existence of an error correction model (ECM) that describes the dynamic behavior of two non-stationary series.

The ECM links the long-run equilibrium relationship implied by co-integration with the short run dynamic adjustment mechanism that describes how the variables react when they move out of long-run equilibrium. This ECM makes the concept of co-integration useful for modeling and inference for macroeconomic time series.

2.6 Relationship between Inflation and GDP

Various research studies have been carried out in order to find the relationship between inflation and country's growth. For instance, works of Mallik & Choudhry (2001) and Bruno & Easterly (1998) are those works which see inflation harmful to the economic growth of a country. Findings of these works verified the results of Dornbush (1993) who had concluded that there are extreme values which affect the relationship between economic growth and inflation. By extreme values he meant either there exist very high rate of inflation or very low rate of inflation.Thus, Bruno & Easterly (1998) examined only cases of separate high-inflation with a critical value of 40 per cent and above. They analyzed and concluded that economic growth of any country decreases gravely during high inflation and then get better immediately when there is decrease in inflation. Inflation does not only matter to individuals but it creates difficulties and problems in the whole sector of the economy of a country.

Lupu (2007) established that there is a positive relationship between inflation and GDP growth in Romania in the short run. This implies that, as inflation increases GDP must also increase in the short run. However, when inflation decreases, GDP should also decrease. Drukker et al (2005) established that, if inflation rate is below 19.16%, increases in inflation do not have a statistically significant effect on growth, but, when inflation is above19.16%; further increases in inflation will decrease long run growth. This affirmation is in line with Lupu (2007) but only that, it establishes a threshold beyond which the assertion of Lupu (2007) will not hold. Mallik & Choudhry (2001) established a long run positive relationship between GDP growth rate and Inflation among four South Asian Countries.

In a study of Smyth (1992, 1994, 1995) it was concluded that an increase of one percent in inflation may cause reduction in growth rate by 0.223%. This relationship is negative but insignificant at low rates of inflation; while inflation at higher rate has a significantly negative effect on economic growth.

Mehmet (2011) explored the association between growth, FDI, trade and inflation in turkey using annual time series data over the period from 1970 to 2008. The results of the Johansen cointegration test revealed that inflation and FDI are positively related to growth.

Mallik & Chowdhury (2001) used co-integration and error correction model to assess the long-run relationship between inflation and growth for India, Bangladesh, Pakistan and Sri Lanka using annual data. They discovered that inflation and growth are positively linked in all the four countries. Khan & Senhadji (2001) contend with Malik & Chowdhury when they analyzed the relationship between inflation and growth separately for developed and developing countries using panel data set from a total of 140 countries for the period 1960 to 1998. The authors located a negative and significant relationship between inflation and growth above a threshold level of 1-3% for developed countries and 11-12% for developing countries which is robust with respect to the method of estimation.

Chih (2009) estimated the causal interrelationships between inflation and economic growth within a simultaneous equations framework using cross sectional data of 140 countries over the 1970-2005 period. The results indicated that inflation is harmful to growth whereas the effect from growth to inflation is beneficial. On the relationship between inflation and growth, the outcome of the study confirms a negative relationship between inflation and growth. The granger causality test used by Chih confirmed a bilateral causal relationship between growth and inflation.

Faria and Carneiro (2001) also engaged a bivariate time series model with annual data over the period 1980 to 1995 to look into the same relationship between inflation and economic growth in the context of Brazil. Their findings confirmed a negative and statistically significant relationship between inflation and growth.

Furthermore,

In addition, Olaiya et al. (2012) used a trivariate vector error correction model and the Johansen & Juselius co-integration approach to study the relationships among inflation, government expenditure and economic growth in Nigeria. They used annual time series data and confirmed a negative co-integration relationship between inflation and growth and unidirectional causality running from economic growth to inflation.

Agalega et al (2013) considered two variables to establish their relationship with GDP of Ghana, they concluded that there exist a positive relationship between GDP and inflation rate given the data for the period under consideration and it therefore means that both GDP and inflation rate behaved or moved in the same direction. As inflation rate increased GDP also increased and vice versa.

2.7 The Relationship between Real Exchange Rate and GDP

There have been certain theories presented propounding a relationship between real exchange rate and country's output in terms of GDP. For instance, Gala (2007), and Bhalla(2007) say that real exchange rate of any country plays a very important role in the process of growth. However, there is no clear evidence of the effect of exchange rate volatility on the economic growth. Work of Levy-Yeyati (2002) supports this argument and concludes that there exists a relationship between exchange rate and country growth but the direction is not clear.

According to Rodrik (1998) in his work “the real exchange rate and economic growth: theory and evidence”, undervaluation (high exchange rate) stimulates the growth of an economy. That is, there is a positive relationship between exchange rate and the GDP growth rate and that this is true particularly for developing countries, suggesting that tradable goods suffer disproportionately from the distortions that keep poor countries from converging. The countries used in his work as evidence were China, India, South Korea, Taiwan, Uganda, and Tanzania.

Chen (2012) researched on “Real exchange rate and economic growth: Evidence from Chinese provincial data (1992-2008)”. His paper studied the role of the real exchange rate on economic growth and in the convergence of growth rates among provinces in China. Using data from 28 Chinese provinces for the period 1992-2008 together with dynamic panel data estimation, he found conditional convergence among coastal provinces and also among inland provinces. The results reported here confirm the positive effect of real exchange rate appreciation on economic growth in the provinces.

Mcpherson et al (1998) researched on “Exchange Rates and Economic Growth in Kenya: An Econometric Analysis”. Their objective was to determine the relationship between exchange rate and economic growth in Kenya based on the data for the period 1970 to 1996. They analysed the possible direct and indirect relationship between the real and nominal exchange rates and GDP growth. They derived these relationships in three ways: within the context of a fully specified (but small) macroeconomic model, as a single-equation instrumental variable estimation, and as a vector auto regression model. The estimation results from the three different settings showed that there was no evidence of a strong direct relationship between changes in the exchange rate and GDP growth.

Tarawalie (2010) researched on "Real exchange rate behavior and economic growth: evidence from Sierra Leone". The main focus of this paper was to examine the impact of the real effective exchange rate on economic growth in Sierra Leone. First, an analytical framework was developed to identify the determinants of the real effective exchange rate. Using quarterly data and employing recent econometric techniques, the relationship between the effective exchange rate and economic growth was then investigated. A bivariate Granger causality test was also employed as part of the methodology to examine the causal relationship between the real exchange rate and economic growth. The empirical results suggested that the real effective exchange rate correlates positively with economic growth, with a statistically significant coefficient. The results also indicated that monetary policy was relatively more effective than fiscal policy in the long run, and evidence of the real effective exchange rate causing economic growth was profound. In addition, the results showed that terms of trade, exchange rate devaluation, investment to GDP ratio and an excessive supply of domestic credit were the main determinants of the real exchange rate in Sierra Leone.

Bakaar (2010) examines the real effect of exchange rate on economic growth of Sierra Leone. He uses quarterly data for the period of 1990-2006 for his analysis to investigate the relation with the help of Granger causality tests. He finds positive correlation between real effective exchange rate and economic growth of Sierra.

There exists positive relation between exchange rate volatility and econmic growth in the long run (Hussain, 2009). Qichun (2010) also explored the relationship between exchange rate and economic growth in China. He views that China adopted fixed exchange rate policy and made rapid economic growth. He further adds that fix exchange rate cause the promotion of long run productivity.

Work of Rodrick (2008) is useful in reaching some conclusion in this regard but this work is not taken by the economists as true representative of the world economy since it holds good only for developing counties and does not sufficiently cover the situations of the developed countries. Finally, it is generally agreed that effect of real exchange rate on national economic growth varies from country to country.

2.8 Application of VAR in various researches in Ghana

Bawumia & Abradu (2003) found out that, in the long-run, inflation in Ghana is positively related to the money supply and the exchange rate, while it is negatively related to real income. Their empirical deductions from the study also showed that inflation adjusts to its equilibrium value fairly rapidly. Their study therefore revealed a complete link between exchange rate and inflation in Ghana.

Studying the relationship between the exchange rate and inflation in Ghana, Bhasin (2004) with a cointegration analysis confirmed the existence of three stable long-run relationships among the domestic price level, nominal exchange rate, bank rate, terms of trade of cocoa, domestic credit and foreign exchange reserves. According to him, the determinants of inflation in the short run are bank rate, foreign exchange reserves, terms of trade of cocoa and government expenditure. The determinants of the rate of depreciation of the local currency in the short run are the domestic price level, terms of trade of cocoa and foreign exchange reserves. The pass-through effect from the domestic price level to the nominal exchange rate is neither complete nor instantaneous.

Adam & Tweneboah (2008) using monthly data from 1991:1 to 2006:4examine both long-run and short-run dynamic relationships between the stock market index and macroeconomic variables. They employ the Johansen's multivariate cointegration test and innovation accounting techniques, and find that stock prices in Ghana respond to interest rate, inflation and exchange rate. Osei (2006) also establishes the presence of cointegration between macro-economic variables and stock returns using the Ghana Stock Exchange (GSE) All-share Index as a proxy for stock performance.

Kuwornu & Owusu - Nantwi (2011) find a significant relationship between stock returns and macroeconomic variables such as inflation, exchange rate and Treasury bill rate. Their findings show that inflation has a positive relationship with stock returns while exchange rate and Treasury bill rate have a negative impact on stock returns. They however find no significant relationship between stock returns and crude oil prices.

Again, Kuwornu (2012) using the Vector Error Correction approach did find that in the long-run stock returns are positively affected by inflation, exchange rate and treasury bill rate and negatively by crude oil prices. But in the short-run, they attribute variations in stock returns to inflation (negative effect), and Treasury bill rate (positive effect).

Quartey (2010) used time series data from Ghana over the period 1970-2006. The Johansen co-integration technique establishes a negative impact of inflation on growth over the period of study, which agrees with Murbuah. However, Quartey did not check for directional causality.

Mireku et al.(2013) examined the dynamic relationships between the stock market index and the macroeconomic factors using cointegration test and vector error correction models (VECM). They established a cointegration between macroeconomic variables and stock prices in Ghana, indicating that interest rate and exchange rate have a negative effect on stock prices with a positive relationship between inflation and stock price.

2.9 Application of VAR in various researches outside Ghana

Ghosh & Ostry (1995) used vector auto-regression analysis to argue that current account in developing countries acts as a buffer to smooth consumption to face the shocks and capital mobility may after all be quite high in this group of countries. Johansen (1995) assessed the channels of macroeconomic impact annd their intensity and suggested that export-oriented Development Financial Institutions are likely to have a positive effect on private investment and growth.

Kónya & Singh (2006) reviewed 30 export-growth time-series studies published between 1978 and 2005. Their study was based on various time-series techniques (unit-root and co-integration tests; single equation, vector autoregressive (VAR) and vector error-correction (VEC) models) and they focused exclusively either on India or on a group of countries that include India. Results of four studies found support for a significant positive correlation between exports and economic growth; eight for the ELG hypothesis; seven for the GDE hypothesis; and two for two-way causality between exports and growth.

Li Yuhong et al. (2010) did co-integration analyses with the data of import, export and economic growth, and the results suggests that growth of import greatly promoted economic growth of China, while that of export performed an opposite one.

Konya (2000) investigated the possibility of Granger causality between the log of real exports and real GDP in 25 OECD countries, between 1960 and 1998. They have applied two complementary testing strategies. First one was depending on the time series properties of the data; causality is tested with Wald tests within finite-order vector autoregressive (VAR) models in levels and/or in first-differences. Their study illustrates how sensitive the Granger causality test results can be to different methods and model specifications. With limitation in mind, they claimed that there is no causality (NC) between exports and growth in the Netherlands, export causes growth (ECG) in Belgium and Iceland, growth causes export (GCE) in Canada and Japan, and there is two-way causality (TWC) in Sweden and in the UK. They also suspected that there is NC in Hungary, France, Greece and Luxembourg, ECG in Australia, Austria, Denmark, Ireland, Spain and Switzerland, GCE in Finland and Korea. However, in the case of Italy, Mexico, New Zealand, Norway, Portugal and the USA the results are too controversial to make a simple choice.

Altaf et al. (2012) determined the significance of macroeconomic variables on Pakistan's economic growth with the application of VAR modeling using annual time series data. Their quantitative evidence showed that real per-capita income growth is caused by money-supply. They concluded that exchange rate policies, government spending and money supply are significant in the regression of Investment. Similarly they found that exports and exchange rate policies affect the growth of real per-capita money supply.

Feasel et al. (2001) who used the impulse response analysis and variance decomposition and suggested that the investment rates and growth rates of exports had significant short run effect on the growth rate of per capita output. They employed VAR analysis on the data of Korea for the period 1956-1994 and found the dynamic relationships among investment rates, output growth and export growth.

Shan (2003) used Vector Auto-Regression technique to examine the impact of financial development on economic growth in china. He concluded that after contribution of labor input, financial development came as the second force in leading economic growth in China.

Teixeira and Fortuna (2003) examined the interaction between human capital, innovation capability and economic growth in the Portuguese economy during the period 1960 to 2001. In their study, the Vector Autoregressive (VAR) and co-integration analyses were employed to estimate the equation specified. They obtained 0.42 long run estimates for human capital elasticity, 0.30 long run estimates for internal knowledge elasticity related with the composite variable that measures the interaction between human capital and innovation capacity. The results of the estimate confirmed that human capital and indigenous innovation efforts were enormously important to the process of Portuguese economic growth during the period 1960 to 2001. Hence with the above literature the author interest is to use co-integration approach with VECM to empirically analyze the long-run and short-run relationships between GDP growth of Ghana with macroeconomic variables; exchange rate, inflation rate. The granger causality test is also used to show direction of causality between these variables.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter deals with a description of the methods employed for this study. It begins with source of data and data collection for the study, variables description, as well as model specification. The Vector Autoregressive (VAR) and vector Error Correction (VEC) model are also discussed.

3.1 Source of Data and Data Collection Procedure

The study employs secondary data. Time series annual data on inflation, real exchange and real GDP growth from Ghana over the study period 1980 to 2013 are used for the study,which gives thirty four (34) data points which is statistically large to be used for the study. Data was obtained from Bank of Ghana and WDI, World Bank.

3.2 Variables Description

The variables of interest in this study are GDP as dependent variable, with inflation rate and real exchange rate as independent variables. Brief descriptions of the variable are given below;

3.2.1 Definition of Variables

Inflation: Is the persistent increase in the level of consumer prices or a persistent decline in the purchasing power of money. In real terms, inflation means your money can not buy as much as what it could have bought yesterday.

High inflation is an indicator that shows that the economy is not control properly and this leads to low growth of the economy.

Real Exchange Rate (*RER*): Real exchange rates play a vital role in foreign trade and economic development. It is apparent that changes in real exchange rates (either depreciation or appreciation) have wider and far reaching economic effects. High economic growth helps to maintain an adequate level of foreign reserves and maintain a sustainable internationally competitive exporting sector that will contribute to job creation and high incomes.

The changes of the real exchange rate generally occur as a result of (a) changes in the nominal exchange rate of the local country against foreign currency and or (b) changes in the domestic or foreign prices. In order to get real effective exchange rate (*REER*), the real exchange rate with the foreign trade is weighed to the most important trading partners.

3.3. Model specification

The models used in this study areVector Autoregressive (VAR) and the Vector Error Correction (VEC). The VAR was used for modeling real GDP growth of Ghana, while the VEC was used to find the long-run and short- run relationships between the variables.

3.4. Augmented Dickey Fuller test (unit root test)

To test for the presence of a unit root in the model, ADF of the form given below is carried out, where *Y* represent the series for the *GDP*.

$$\Delta Y_t = a_o + \alpha Y_{t-1} + \beta_2 \Delta Y_{t-1} + \beta_3 \Delta Y_{t-2} + \ldots\ldots\ldots\ldots + \varepsilon_t \quad [1]$$

The null hypothesis for the test is given below

H_o : α=0, there exists a unit root problem.

Decision rule

• If t-statistic > ADF critical value. We don't reject the null hypothesis. Unit root exists in this case.

• If t-statistic < ADF critical value. We reject the null hypothesis. Unit root doesn't exist in this case.

• If the null hypothesis is rejected, the data of the series is stationary and can be used for modeling without taking any difference of the series.

3.5. VAR time series analysis

The Vector Autoregression (VAR) model, proposed by Sims (1980), is one of the most successful, flexible, and easy to use models for analysis of multivariate time series. It is applied to grasp the mutual influence among multiple time series.

VAR models extend the univariate autoregressive (AR) model to dynamic multivariate time series by allowing for more than one evolving variable. All variables in a VAR model are treated symmetrically in a structural sense; each variable has an equation explaining its evolution based on its own lags and the lags of the other model variables (Walter 2003).

Let Y_t= (y_{1t} +y_{2t}+, … …., y_{nt}) denote an (n x 1) vector of time series variables. A VAR model with p lags can then be expressed as follows:

$$\begin{pmatrix} y_{1t} \\ . \\ . \\ y_{nt} \end{pmatrix} = \begin{pmatrix} \varnothing_1 \\ . \\ . \\ \varnothing_n \end{pmatrix} + \begin{pmatrix} \varnothing^{(1)}{}_{11} & \cdots & \varnothing^{(1)}{}_{1n} \\ \vdots & \ddots & \vdots \\ \varnothing^{(1)}{}_{n1} & \cdots & \varnothing^{(1)}{}_{nn} \end{pmatrix} \begin{pmatrix} y_{1,t-1} \\ . \\ . \\ y_{n,t-1} \end{pmatrix} +\ldots\ldots + \begin{pmatrix} \varnothing^{(p)}{}_{11} & \cdots & \varnothing^{(p)}{}_{1n} \\ \vdots & \ddots & \vdots \\ \varnothing^{(p)}{}_{n1} & \cdots & \varnothing^{(p)}{}_{nn} \end{pmatrix} \begin{pmatrix} y_{1,t-p} \\ . \\ . \\ y_{n,t-p} \end{pmatrix} + \begin{pmatrix} \in_{1t} \\ . \\ . \\ \in_{nt,} \end{pmatrix} \quad [2]$$

In matrix notations

$$y_{t}=\varnothing_0+\varnothing_1 y_{t-1}+\ldots\ldots\ldots+\varnothing_p y_{t-p}+\in_t \text{ Where } \in_t \sim \text{ iid N } (0; \Sigma) \qquad [3]$$

Where $\varnothing_1,....,\varnothing_p$ is a (n x n) coefficient matrix, $\in_t$ is an (n x 1) unobservable zero mean white noise vector process, and $\varnothing_0$ is an (n x 1) vector of constants (intercepts) and Σ is the variance-covariance matrix of the error term .

Consider the Lag operators notation and polynomials.

The lag operator moves the index back one time unit, i.e.

$$Bx_t = x_{t-1}$$

More formally, B is an operator that takes one whole time series $\{x_t\}$ andproduces another; the second time series is the same as the first, but moved backwards one date.

Hence from the definition,

$$B^2 x_t = B x_{t-1} = x_{t-2}$$

$$B^j x_t = x_{t-j}$$

$$B^{-j} x_t = x_{t+j}$$

a(B) $x_t = (a_0 B^0 + a_1 B^1 + a_2 B^2) x_t = a_0 x_t + a_1 x_{t-1} + a_2 x_{t-2}$

using the notation we can rewrite the VAR model as:

$(1 - \varnothing_1 B - \varnothing_2 B^2 - .... - \varnothing_p B^p) y_t = \varnothing_0 + \in_t$

$\Phi(B) y_t = \varnothing_0 + \in_t$ [4]

Where $\Phi(B) = 1 - \varnothing_1 B - \varnothing_2 B^2 - .... - \varnothing_p B^p$ is the characteristics polynomial. Each entry in the k x k matrix is a polynomial in B of order p.

If there is a Cointegration relationship among the variables, the analysis of such process is easily done with a model called Vector Error Correction Model (VECM).

3.5.1 Testing the stationarity of time series

Sim et al., (1990) suggest that non-stationary time series are still feasible in VAR modeling. However in practice, using the non-stationary time series in VAR modeling is problematic with regards to statistical inference since the standard statistical tests used for inference are based on the condition that all of the series used must be stationary. In the VAR modeling, we continue to use the ADF unit-root test to check the stationarity of the time series.

3.5.2 Model identification

It is known that the more the lags there are, the less the degrees of freedom. When we determine the number of lags, we choose the one with the minimum AIC and SC value. If the AIC and SC value are not minimized using the same model, we instead apply a likelihood-ratio (LR) test (Johansen 1995). The LR-statistic can be expressed as follows:

$$LR= -2(\log L_k - \log L_{(k+1)}) \sim \chi^2{}_{(n^2)} \qquad [5]$$

Where k is the lag order, L is the maximized likelihood of the model and nis the number of estimated parameters.

If LR≤ $\chi^2{}_{\alpha}$, we do not reject the null hypothesis that all the elements in the coefficient matrix are zero. Then we can reduce the lag order until the null hypothesis is rejected.

Akaike's information criterion (Akaike (1973, 1974))

$$AIC(m) = \log \det(\hat{\Sigma}_m) + \frac{2}{T} mK^2, \quad [6]$$

The Hannan-Quin criterion (Hannan & Quin (1979), Quin (1980)),

$$HQ(m) = \log \det(\hat{\Sigma}_m) + \frac{2 \log \log T}{T} mK^2, \quad [7]$$

And Schwarz (Schwarz (1978)),

$$SC(m) = \log \det (\hat{\Sigma}_m) + \frac{\log T}{T} mK^2, \quad [8]$$

Where $\hat{\Sigma}_m = T^{-1} \sum_{t=1}^{T} \hat{u}\hat{u}'_t$ is the OLS residuals covariance matrix estimator for a reduce form VAR model of order m, mK^2 is the number of VAR parameters in a model with order m, The VAR order is chosen such that the respective criterion is minimized over the possible orders m = 0,……….,p_{max}. Among these criteria, AIC always suggests the largest order, SC choses the smallest order and HQ is in between (Lukepohl(2005, chapter 4 and 8)). Of course, the criteria may all suggest the same lag order.

3.5.3 The estimation of parameters

Although the structure of the VAR model looks very complex, the estimation of the parameters is not difficult. The most common methods are the Maximum Likelihood Estimator (MLE) and the Ordinary Least Square Estimator (OLS) (Yang & Yuan 1991). In this study, the OLS method is used to estimate the parameters.

3.5.4. Model diagnostics

While we estimate the model parameters, it is also necessary to do model diagnostics, in order to check whether the fitted model is appropriate. Portmanteau and Breusch-Godfrey-LM tests are standard tools for checking residual auto-correlation in VAR models. The Breusch-Godfrey LM test for *h*-th order residual autocorrelation assumes a model

$u_t = B_1 u_{t-1} + \ldots + B_h u_{t-h} + e_t$ [9]

The quantity e_t denotes white noise error term, thus a test of

$H_0 : B_1 = \ldots = B_h = 0$ versus $H_0 : B_i \neq 0$ for at least one i ϵ {1… h} may be used for checking that u_t is white noise.

The LM statistic is

$LM_h = T\,(K - tr(\hat{\Sigma}_R^{-1} \hat{\Sigma}_e)) \approx \chi^2(hK^2)$ [10]

Where $\hat{\Sigma}_R$ *and* $\hat{\Sigma}_e$ assign the residual covariance matrix of the restricted and unrestricted models, respectively and T is the sample size.

3.5.4.1 Normality

This displays the frequency distribution of your series in a histogram. The histogram divides the series range (the distance between the maximum and minimum values) into a number of equal length intervals or bins and displays a count of the number of observations that fall into each bin. Complements of standard descriptive statistics are displayed along with the histogram. All of the statistics are calculated using the observations in the current sample.

Jarque-Bera is a test statistic for testing whether the series is normally distributed. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. The statistic is computed as:

$$\text{Jarque-Bera} = \frac{N-K}{6}\left(S^2 + \frac{(K-3)^2}{6}\right) \qquad [11]$$

Where S is the skewness, K is the kurtosis, and N represents the number of estimated coefficients used to create the series. Under the null hypothesis of a normal distribution, the Jarque-Bera statistic is distributed as x^2 with 2 degrees of freedom. The reported Probability is the probability that a Jarque-Bera statistic exceeds (in absolute value) the observed value under the null hypothesis; a small probability value leads to the rejection of the null hypothesis of a normal distribution.

3.6 Structural Analysis

Traditionaly the interaction between economic variables is studied by considering the effects of changes in one variable of interest. In VAR models changes in the variables are induced by nonzero residuals, that is, by shocks which may have structural interpretation if identifying structural restrictions have been placed accordingly. Hence, to study the relations between the variables the effects of nonzero residuals or shocks are traced through the system. This kind of analysis is known as impulse response analysis.The representation of the VAR system allows us to analyze the impact of one unit (e.g., standard deviation) change in innovations on the system variables. The variance decomposition allows us to analyze the proportion of the unanticipated change of a variable that is attributable to its own innovations and shocks to other variables in the system. The impulse-response function (IRF) allows us to examine the dynamic effects of shocks of selected variables of interest on the GDP growth. These impulse responses can, then, be graphed against the horizon to see the relative importance of real shocks.

3.7 Vector Error Correction Model (VECM)

VECM is a kind of VAR model used with co-integration restrictions. Since the variables included in the VAR model are found to be co-integrated, the next step is to specify and estimate a vector error correction model (VECM) including the error correction term to investigate dynamic behaviour of the model. Once the equilibrium conditions are imposed, the VEC model describes how the examined model is adjusting in each time period towards its long-run equilibrium state. The dynamic specification of the model allows the deletion of the insignificant variables, while the error correction term is retained. The size of the error correction term indicates the speed of adjustment of any disequilibrium towards a long-run equilibrium state (Engle & Granger, 1987).

The Vector Error Correction Model (VECM) is given as;

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k} \Gamma_i \Delta y_{t-1} + \varepsilon_t \qquad [12]$$

Where Π and Γ_i are square matrices whose elements depend on the coefficients of long run model and y_t contains the endogenous variables of the model. The Π is a g x g matrix containing the long-run parameter, Δ is the first difference operator and ε_t is the white noise term. If there are r co-integration vectors then Π can be expressed as a product of two matrices as $\Pi = \gamma\beta'$ where both γ and β are g x r matrices. The matrix β contains the coefficients of long-run relationship and γ contains the speed of adjustment parameters which are also interpreted as the weight with which each co-integration vector appears in a given equation.

If there are '*r*' co-integration relationships, the matrix Π is expressed as product of two matrices each of which is of order g x r i.e. $\Pi = \gamma\beta'$. For example if r = 1, the VECM will be written as (for g = 3 variable system)

$$\begin{pmatrix} \Delta y_{1t} \\ \Delta y_{2t} \\ \Delta y_{3t} \end{pmatrix} = \begin{pmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \end{pmatrix} + \begin{pmatrix} g_{11} & g_{12} & g_{13} \\ g_{21} & g_{22} & g_{23} \\ g_{31} & g_{32} & g_{33} \end{pmatrix} \begin{pmatrix} \Delta y_{1,t-1} \\ \Delta y_{2,t-1} \\ \Delta y_{3,t-1} \end{pmatrix} + \begin{pmatrix} \gamma_{11} \\ \gamma_{12} \\ \gamma_{13} \end{pmatrix} \left(\beta_{11} \beta_{12} \beta_{13} \right) \begin{pmatrix} y_{1,t-1} \\ y_{2,t-1} \\ y_{3,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{pmatrix} \qquad [13]$$

3.8 Co-integration Test

Estimation of non-stationary time series data and analysis of short run dynamics is often done by first eliminating the trend in the variables, usually through the process of differencing till stationarity is achieved.

Two broad approaches for co-integration have been developed. These are Engle & Granger (1987) method and the Johansen approach, based on vector autoregressive model (VAR) (Green, 2003).

3.8.1. The Johansen Approach

The Engle and Granger approach is based on assessing whether single equation estimates of the equilibrium errors appears to be stationary. In the Engle-granger approach to co-integration, two time series, say Y_t and X_t, are non stationary in level but stationary in the first difference (that is Y_t~I(1) and X_t~ I(1)), and there exists a linear combination between these two series that is stationary. It follows that these two series are co-integrated implying they have reasonable long run relationships.

The Johansen procedure does not only determine the number of co-integrating vectors but also provides estimates of these vectors. The Johansen approach is superior due to the following reasons. It does not require a prior distinction between endogenous and exogenous variables; it can deal with I(0) and I(1) variables avoiding much of the pre-testing problem and it can capture a wide range of data generating processes. In addition, it identifies multiple co-integrating vectors (if any) unlike Engle-Granger representation which assumes only one co-integrating vector. There are two types of tests for Johansen co-integration approach called trace test and the maximum eigenvalue test. The test statistics for the trace test and maximum eigenvalue test are shown in equations [14] and [15] respectively.

J_{trace}= -T $\sum_{i=r+1}^{n} \ln(1-\lambda_i)$ [14]

J_{max}= -T ln(1-λ_{r+1}) [15]

Where *T* is the sample size, n is number of endogenous variables and $\lambda_i$is thelargest eigenvalue. The trace test tests the null hypothesis of *r* co-integrating vectors against the alternative hypothesis of *n* co-integrating vectors. The maximum eigenvalue test, on the other hand, tests the null hypothesis of *r*co-integrating vectors against the alternative hypothesis of *r* +1 co-integrating vectors where r =1,2,.....n. Neither of these test statistics follows a chi square distribution in general; asymptotic critical values can be found in Johansen & Juselius (1990). Since the critical values used for the maximum eigenvalue and trace tests are based on a pure unit-root assumption, they will no longer be correct when the variables in the system are near-unit-root processes. Thus, the real question is how sensitive Johansen's procedures are to deviations from the pure-unit root assumption. Although Johansen's methodology is typically used in a setting where all variables in the system are I(1), having stationary variables in the system is theoretically not an issue and Johansen (1995) states that there is little need to pre-test the variables in the system to establish their order of integration. If a single variable is I(0) instead of I(1), this will reveal itself through a co-integrating vector whose space is spanned by the only stationary variable in the model.

3.9 Structural Analysis by Granger Causality

In order to investigate the causal relationship between the variables of the system, the linear Granger causality tests should be applied by using the following strategy.

Compare the unrestricted models;

$$\Delta y_t = a_1 + \sum_{i=1}^{m_1} \beta_{1i} \Delta y_{t-i} + \sum_{j=1}^{m_2} \theta_{1i} \Delta y_{j-i} + e_{1t} \quad [16]$$

$$\Delta x_t = a_2 + \sum_{i=1}^{m_1} \beta_{2i} \Delta x_{t-i} + \sum_{j=1}^{m_2} \theta_{2i} \Delta x_{j-i} + e_{2t} \quad [17]$$

with the restricted models

$$\Delta y_t = a_1 + \sum_{i=1}^{m_1} \beta_{1i} \Delta y_{t-i} + e_{1t} \quad [18]$$

$$\Delta y_t = a_2 + \sum_{i=1}^{m_1} \beta_{2i} \Delta x_{t-i} + e_{1t} \quad [19]$$

where $\Delta x_t$and $\Delta y_t$are the first order forward differences of the variables, α, β, $\theta$are the parameters to be estimated and, e_1,$e_2$are standard random errors. The lag order m are the optimal lag orders chosen by information criteria.The equations described above, are convenient tools for analyzing linear causality relationship between the variables. If θ_1 is statistically significant, and $\theta_2$is not, it can be said that changes in variable y Granger cause changes in variable x or vice versa. If both of them are statistically significant there is a bivariate causal relationship between the variables, if both of them are statistically insignificant neither the changes in variable y nor the changes in variable x have any effect over other variable.

CHAPTER FOUR

RESULTS OF DATA ANALYSIS

4.0 Introduction

This chapter thoroughly explores, analyzes the data of the macreconomic variables for Ghana. The chapter start by giving the descriptive statistics of these selected macroeconomic variables, the time series plots of the variables, the ADF test, the determination of lags, the cointegration test, the VECM analysis, the Granger causality test, the impulse response funtion of each variables and finally the variance decomposition tests to further understand the interactions of the variables. All analysis was done using STATA (version 12.1) and Eviews 8.

4.1 Descriptive Statistics

Table 1: Summary of Descriptive Statistics

	GDP	INFLATION	EXCHANGE
Mean	4.579285	29.70059	366.9997
Median	4.822500	18.81600	124.9650
Maximum	15.00700	142.4180	3579.150
Minimum	-6.924000	5.988000	86.80000
Std. Dev.	3.862955	29.23571	715.1731
Skewness	-0.790376	2.410194	3.373345
Kurtosis	5.874579	8.640214	14.12254
Jarque-Bera Probability	0.000489	0.000000	0.000000

Source: Author's computation from the data,2015

The descriptive statistics as evidenced in Table 1 reveals approximate normality in the distribution of each variable in terms of skewness and kurtosis. The GDP has a smaller standard deviation among all the variables. The coefficient of skewness is low and negatively skewed. Over the period under study, real GDP growth averaged 4.57%. By a developing country standard, this figure is considered moderate. The real Exchange rate was on the average 366.99%. Inflation, on the other hand, averaged 29.70% over this period. The average rate of inflation was very high. This might have accounted for the moderate growth of GDP. The maximum growth rate of GDP was 15.0%, whiles the minimum was -6.92%. The maximum real Exchange rate was 3579.15, whiles the minimum was about 86.80. The maximum inflation rate over the entire period was 142.41% as against the minimum of 5.98%.The J-B statistics also indicate that the distributions of all the variables are normally distributed. These results are, however, based on the null hypothesis of normality and provide no information for the parametric distribution of the series.

For this research work, yearly data covering from 1980-2013 is used for the research with selected variables such as GDP, inflation, and Exchange rate. Figure 1-3 below shows the time series plots of the three variables during the sample period.

In order to build an appropriate model, all series that are used in the analysis must be stationary. Therefore the unit-root structure of the data is checked. Although the graphs below give us a rough idea about the stationarity structure of the series we need more formal tests to check the stationary. Hence the Augmented Dickey-Fuller test is applied in order to test unit-roots. Table 2 exhibits the results from ADF test applied to both levels and differences of the series.

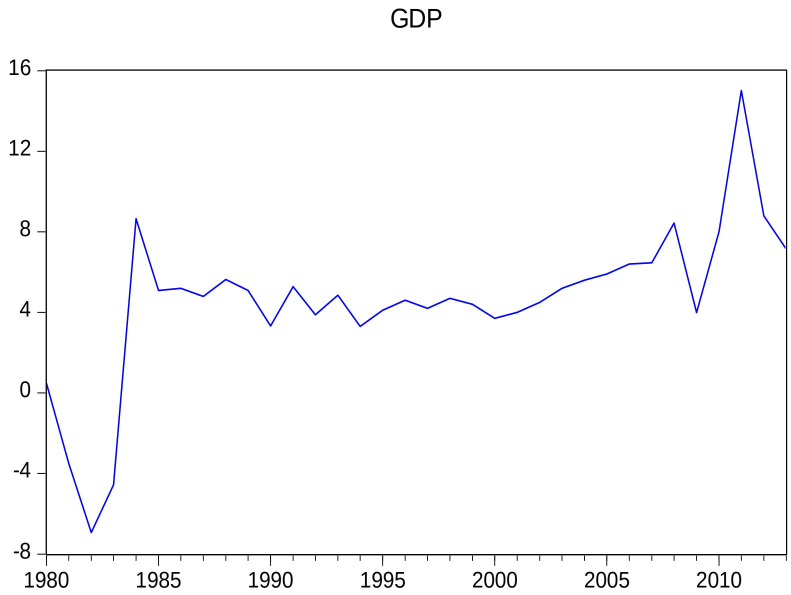

Figure 1: Time Series Plots of the GDP Variable

Source: Bank of Ghana and WDI,World Bank

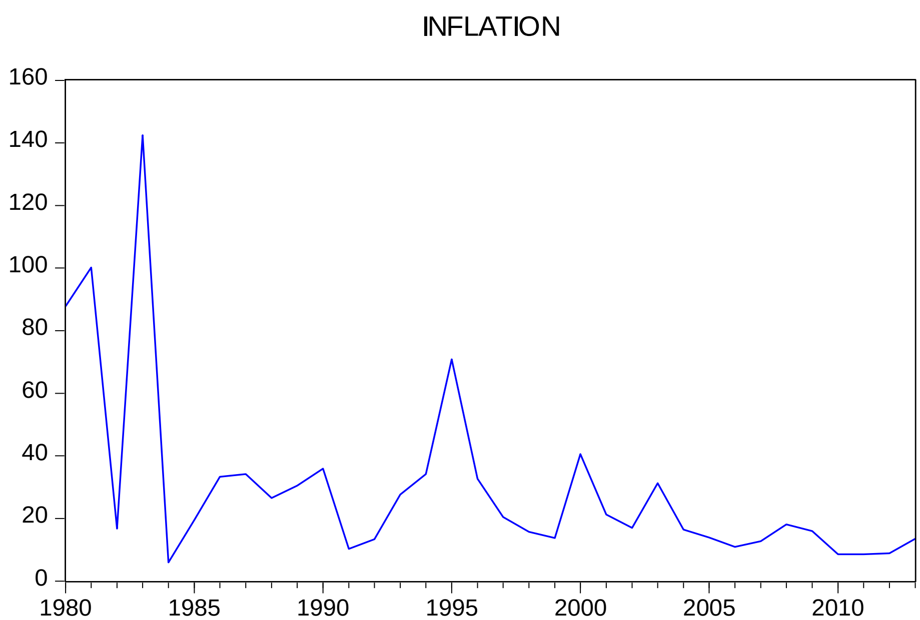

Figure 2: Time Series Plots of the Inflation rate Variable

Source: Bank of Ghana and WDI,World Bank

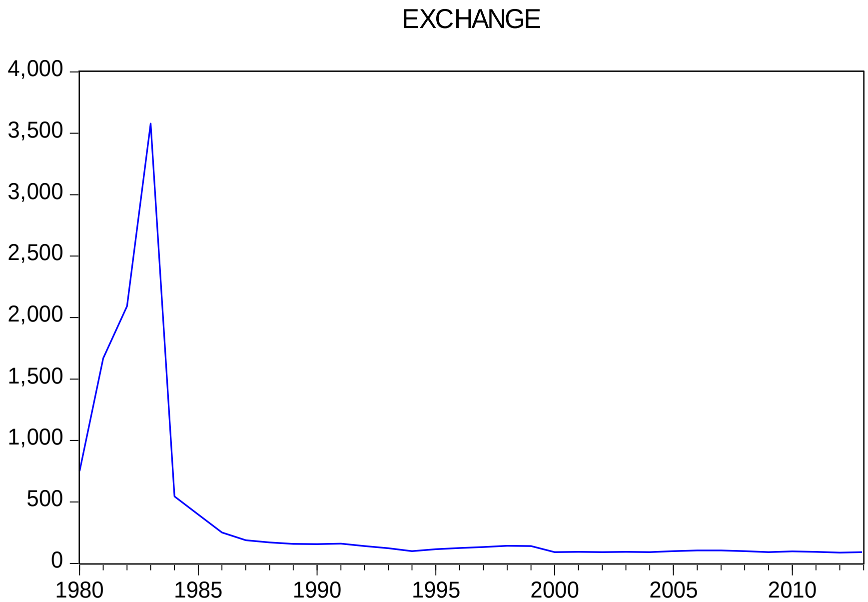

Figure 3: Time Series Plots of the Exchange rate Variable

Source: Bank of Ghana and WDI,World Bank

4.2 Unit Root Test: Tables 2 summarize the results of unit root test. From the results, all the variables are non stationary at levels but stationary in the first difference since the p-values are greater than 0.05 at the levels but the p-values are less than 0.05 in the first difference for the ADF test, leading to non rejection of null hypothesis at these levels but null hypothesis is rejected at first difference. Hence the series are integrated of order one (1). The figure 4-5 also displaces the time series plots for the selected variables in their first difference. It can be confirm that the variables are stationary after the first difference from the various figures

Table 2: The ADF unit root test for identification of order of integration

Levels			First Difference	
Var Trend	t-statistic	prob.	t-statistic	prob.
GDP	-2.778257	0.0723	-5.229822	0.0002
Inflation	-2.187173	0.2146	-7.925575	0.0000
Exchange	-2.187173	0.0887	-7.153836	0.0000

Source: Author's computation from the data,2015

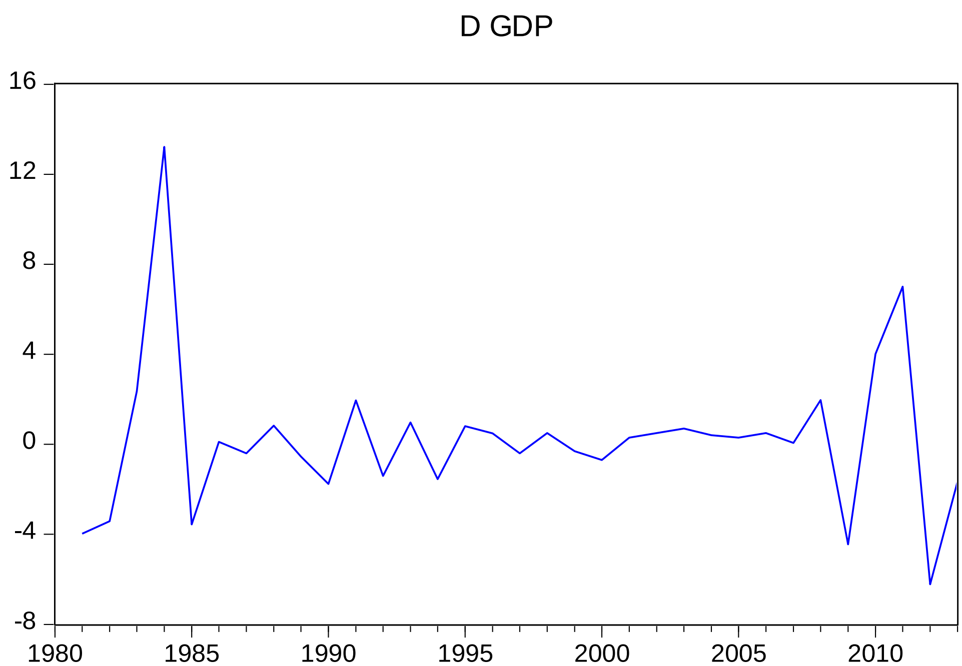

Figure 4: Time Series Plot of GDP Differenced Variable

Source: Bank of Ghana and WDI,World Bank

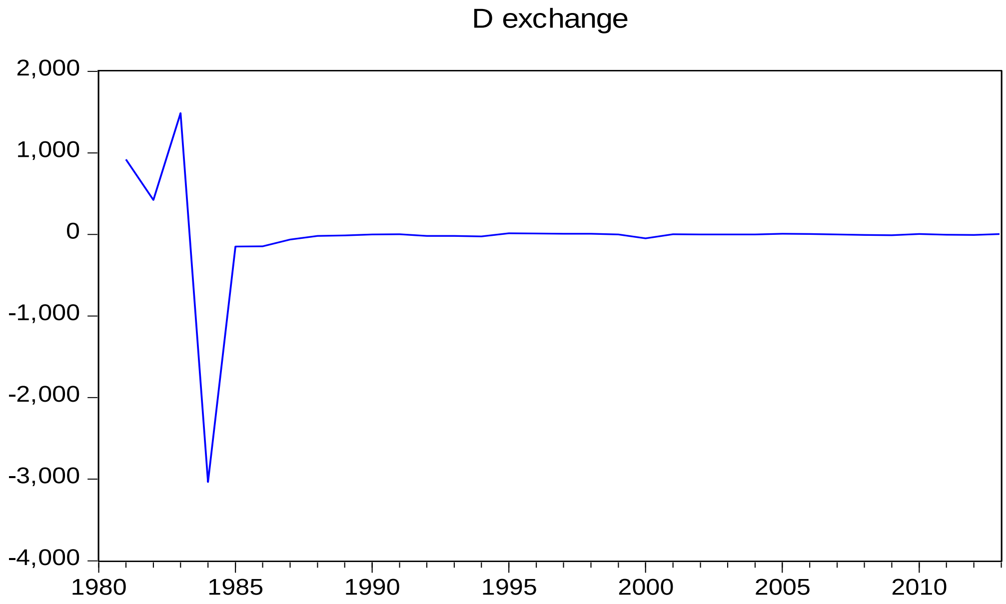

Figure 5: Time Series Plot of Exchange rate Differenced Variable

Source: Bank of Ghana and WDI,World Bank

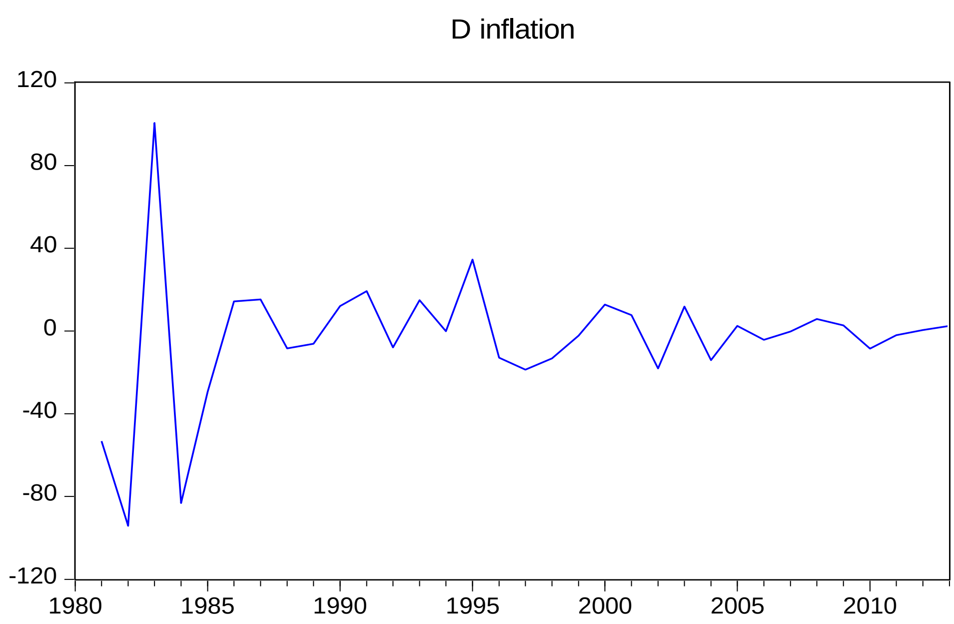

Figure 6: Time Series Plot of inflation Differenced Variable

Source: Bank of Ghana and WDI,World Bank

4.3 VAR model

4.3.1 Determination of Lags

Table 3 reports lag-order selection statistics. The result shows lags order at two by the selection criteria of the AIC; FPE, HQIC, LR, and the SBIC, so the author preceded further tests with lags (2).

Table 3: Lag order selection

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-328.682				1.7e+06	22.8746	22.9189	23.0161
1	-312.373	32.618	9	0.000	1.0e+06	22.3706	22.54478	22.9863
2	-279.153	66.44*	9	0.000	201944*	20.7002*	21.0103*	21.6903*
3	-273.38	11.546	9	0.240	267678	20.9228	21.3658	22.3372
4	-266.448	13.863	9	0.127	347098	21.0654	21.6413	22.9042

Source: Author's computation from the data,2015

4.3.2 VAR Model Checking

The following tests on the residuals are applied to check for the adequacies of our VAR model (i) Godfrey LM test for autocorrelation, (ii) Jarque-Bera test for Normality. The results are summarized in Tables 4 and 5:

Table 4: Results of VAR test for serial correlation

lag	chi2	df	Prob>chi2
1	15.7789	9	0.07165
2	15.9245	9	0.06848
3	4.1701	9	0.89986
4	2.9889	9	0.96473
5	0.8968	9	0.99964

Source: Author's computation from the data,2015

The results of Table 4 shows that the null hypothesis of no serial autocorrelation will be accepted for Godfrey LM test for all lags since their p-values are greater than the significance values of 0.05. Hence we can conclude that there is no serial autocorrelation.

Table 5 Results of VAR test for normality

Equation	chi2	df	Prob>chi2
DGDP	0.459	2	0.79474
Dinflation	1.371	2	0.50388
Dexchange	1.729	2	0.42131
ALL	3.559	6	0.73609

Source: Author's computation from the data,2015

Table 5 shows that in Jarque-Bera test H_0 are rejected for all residuals which indicate that they are all normal. The Eigenvalue stability condition in appendix table 1and figure 1 shows that all the eigenvalues lie inside the unit circle. Hence the VAR model satisfies stability condition.

4.4 Co-integration Test

Co-integration rank (rank of matrix) is estimated using Johansen methodology. Johansen's approach derives two likelihood estimators for the CI rank: a trace test and a maximum Eigen value test. The CI rank (R) can be formally tested with the trace and the maximum Eigen value statistics. The results are presented in Table 6. The trace statistic either rejects the null hypothesis of no co-integration among the variables or does not reject the null hypothesis that there is one co-integration relation between the variables. Start by testingH_0: r = 0. If it rejects, repeat forH_0: r = 1. When a test is not rejected, stop testing there and that value of r is the commonly-used estimate of the number of co-integrating relations. In the trace statistic, H_0 : r = 1 is not rejected at the 5% level (6.9276 < 15.41 and the eigenvalue also does not rejects the null hypothesis when rank (π) = 1. Hence both trace statistic and eigenvalue does not rejects the null hypothesis when the rank is equal to 1. In other words, this trace test and eigenvalue result does not reject the null hypothesis that these three variables are not co-integrated. The final number of co-integrated vectors with three lags is equal to one, i.e. rank (π) =1. Since, the rank is equal to 1 which is more than zero; the series are co-integrating among the variables. The author then proceeds to use VECM model and not VAR model in modeling the selected variables, since the variables are co-integrated.

Table 6: Johansen Test for co-integration rank

Maximum Rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	21	-400.03351	.	43.8809	29.68
1	26	-381.55686	0.69640	6.9276*	15.41
2	29	-378.09308	0.20026	0.0000	3.76
3	30	-378.09306	0.0000		

Source: Author's computation from the data,2015

4.5 Vector Error Correction Model

The Appendix table 7 reports lag-order selection statistics. The result shows lags order at three by the selection criteria of the AIC, HQIC and LR, so the author preceded further tests with lags (3) and co-integration of rank=1.

The presence of co-integration between variables suggests a long term relationship among the variables under consideration. The results of Appendix table 6 suggest that there is long run relationship between GDP, inflation and exchange rate, for one co-integrating vector for Ghana in the period 1980-2013, since the correction error term 1(ce1) is significant and showing negative coefficient value.

GDP = 0.311842 Inflation - 0.0154802 Exchange – 10.42983 (20)

(0.000) (0.000)

The error correction term indicates the rate at which the disequilibrium between the long-run and the short-run estimates are corrected for. The results in VECM estimates show that on annual basis, 0.364% of the disequilibrium between the long-run and short-run estimates are corrected and brought back to equilibrium. This value is highly significant with a p-value of 0.0000 at 5% confidence level and a corresponding standard error of 0.087. In table 4, all the coefficient were significant at 1% level of significance. 1% appreciation of inflation rate is likely to increase GDP growth by 0.312% in the long-run and this estimate is significant. Also a 1% increase in Exchange rate, GDP growth is reduced by 0.015% in the long-run and the coefficient is significant.

Table 7: Vector Error Correction Model

Cointegrating equation			
Equation	parms	chi2	p>chi2
_ce1	2	27.10102	0.0000

Johansen normalization restriction imposed						
Beta	Coef.	Std. Err.	Z	p>ǀzǀ	[95% conf.	Interval]
_cel						
GDP	1	-	-	-	-	-
Inflation	.311842	.0779705	4.00	0.000	.1590227	.4646613
Exchange	-.0154802	.0030094	-5.14	0.000	-.0213785	-.009582
_cons	-10.42983	-	-	-	-	-

Source: Author's computation from the data,2015

4.5.1 VECM Model Checking

The following tests on the residuals are applied to check for the adequacy of our VECM model (i) Godfrey LM test for autocorrelation, (ii) Jarque-Bera test for Normality. The results are summarized in Tables 8 and 9:

Table 8: Results of VECM test for serial correlation

lag	chi2	df	Prob>chi2
1	23.8976	9	0.00447
2	12.5509	9	0.18400
3	25.7618	9	0.00223
4	11.9469	9	0.21632
5	5.2298	9	0.81383
6	9.0685	9	0.43098
7	13.8771	9	0.12677
8	10.8211	9	0.28817

Source: Author's computation from the data,2015

The results of Table 8 shows that the null hypothesis of no serial autocorrelation will be accepted for Godfrey LM test for 6 lags out off the 8 lags since their p-values are greater than the significance values of 0.05 and 2 lags rejects the null hypothesis that there is serial autocorrelation. Hence we can conclude that there is no serial autocorrelation since the majority of the lags accept the null hypothesis.

Table 9 Results of VECM test for normality

Equation	chi2	df	Prob>chi2
D_GDP	5.370	2	0.06821
D_inflation	1.796	2	0.40744
D_exchange	1.448	2	0.48480
ALL	8.614	6	0.19647

Source: Author's computation from the data,2015

Table 9 shows that in Jarque-Bera test the null hypotheses are rejected for all residuals which indicate that they are all normal.

4.6 Granger Causality Analysis

Here, the results for the analysis of causality are presented and the causality between the variables (if any) and the direction of the causality of the systems are determined using Granger Causality test. The results of the test are presented in table 10. The result estimate shows that at 5% most of the variables are Granger-causal for GDP. However, there is unidirectional causality between GDP growth rateand Exchange rate. This finding implies thatGDP granger cause Exchange rate in Ghana. Also there is bidirectional causality between Inflation rate and Exchange rate, which implies that Inflation rate granger cause Exchange rate and visa versa in Ghana. Also there is bidirectional causality between Inflation rate and GDP.

Table 10: Granger Causality Test

Null Hypothesis	F-statistics	Probability	Decision
Inflation does not Granger-cause GDP	4.19711	0.0263	Reject
GDP does not Granger-cause Inflation	9.48715	0.0008	Reject
Exchange rate does not Granger-cause GDP	2.17496	0.1338	Do not reject
GDP does not Granger-cause Exchange rate	6.24427	0.0061	Reject
Exchange rate does not Granger-cause Inflation	4.06237	0.0292	Reject
Inflation does not Granger-cause Exchange rate	22.2754	2.E-06	Reject

Source: Author’s computation from the data,2015

4.7 Impulse Response Function (IRF)

Using this model, which provides information for the long-run relationship of the variables, the author performs Impulse Response Function analysis. The Impulse Response Functions provide information to analyze the dynamic behavior of a variable due to a random shock or innovation in other variables. Specifically, the Impulse Response Functions trace out the effects on current and future values of the endogenous variables of one standard deviation shock to a variable.

The study uses impulse response function as an additional check of the co-integration test's findings. Cholesktype of contemporaneous identifying restrictions are employed to draw a meaningful interpretation. The recursive structure assumes that variables appearing first contemporaneously influence these latter variables but not vice versa. It is important to list the most exogenous looking variables earlier than the most endogenous looking variables. Impulse response functions are shown in Figure 7. A unit shock of inflation rate to GDP creates strong fluctuations. Also an initial response of GDP to a shock in Exchange rate creates slight fluctuations and finally dies off. A shock of Exchange rate to inflation rate creates slight fluctuations and completely becomes positive. In the response of inflation to a shock in GDP creates also strong fluctuations, this confirms the bi-directional causality between these two variables. Similarly, a unit of inflation rate to Exchange rate creates strong fluctuations in this variable and finally dies off. Finally, in the response of Exchange to a shock in GDP creates strong fluctuations, this implies how GDP affects Exchange rate and not the visa versa. The tabular values of the Impulse-Response Functions can be seen in appendix table 5.

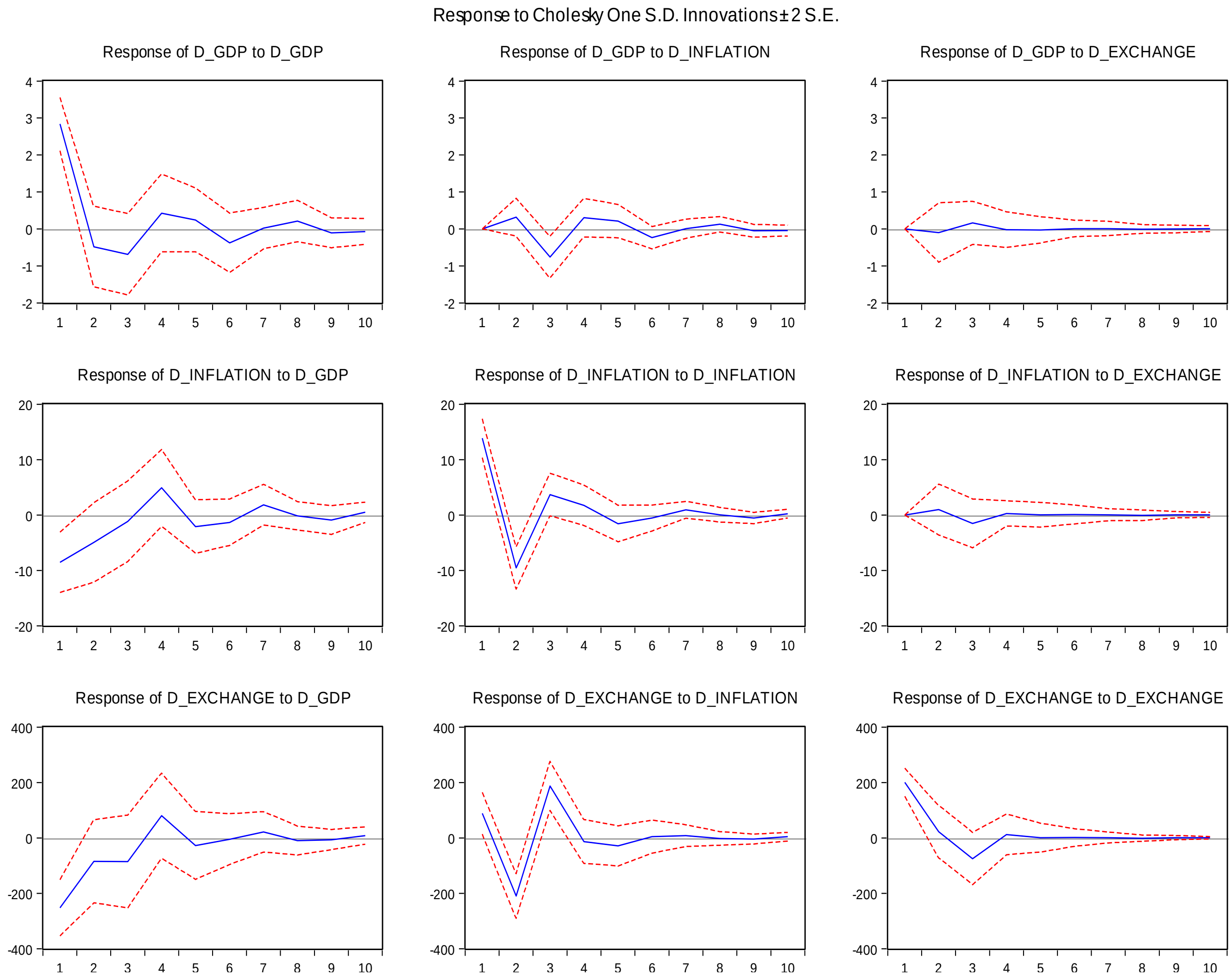

Fig. 7: Impulse-Response Functions

Source: Author's computation from the data,2015

4.8 Variance Decomposition Analysis

Tables 11 to 13 present the variance decomposition results. This analysis is employed as additional evidence presenting more detailed information regarding the variance relations between GDP and selected macroeconomic variables. Variance decomposition results (Table 11) show that by the fourth year period, 91.68 percent variance in GDP is explained by 7.94

percent variance in Inflation rates and by 0.38 percent change in Exchange rate. In the tenth year, 90.79 percent of the variance in GDP is explained by 8.83 percent variance in Inflation rates and 0.38 percent in Exchange rate. This implies that with time, the effect of inflation rates increase whist Exchange rates decreases.

Table 11 Variance decomposition of GDP

Period	S.E	D_GDP	D_INFLATION	D_EXCHANGE
1	2.837016	100.0000	0.000000	0.000000
2	2.896777	98.68491	1.197472	0.117623
3	3.078353	92.40845	7.203191	0.388358
4	3.122711	91.67560	7.941251	0.383145
5	3.139027	91.31080	8.301696	0.387499
6	3.170731	90.91465	8.704865	0.380487
7	3.170819	90.91448	8.704469	0.381056
8	3.180194	90.81753	8.803332	0.379139
9	3.182358	90.80254	8.818768	0.378693
10	3.183512	90.78762	8.833722	0.378654

Source: Author's computation from the data,2015

Table 12 results show that in the fourth period, 70.63 percentage variance in Inflation rate is explained by 28.86 percent variance in GDP and 0.78 percent variance in Exchange rate. In the tenth lag period, 68.90 percent variance in Inflation is explained by 30.34 percent variance in GDP and 0.76 percent of the variance in Exchange rates. We note that variance in the GDP is mostly explained by the Inflation rates followed by Exchange rates

Table 12 Variance decomposition of Inflation rate

Period	S.E	D_GDP	D_INFLATION	D_EXCHANGE
1	16.28171	27.60896	72.39104	0.000000
2	19.55089	25.60094	74.14684	0.252223
3	19.98341	24.83122	74.34828	0.820505
4	20.64749	28.85986	70.35596	0.784180
5	20.81578	29.42993	69.79830	0.771765
6	20.86593	29.69592	69.53523	0.768850
7	20.96733	30.18119	69.05736	0.761454
8	20.96809	30.18517	69.05254	0.762295
9	20.99614	30.30187	68.93763	0.760507
10	21.00306	30.33552	68.90444	0.760046

Source: Author’s computation from the data,2015

Table 13 results show that in the fourth period, 21.29 percent variance in exchange rates is explained by 38.69 percent variance in GDP and 40.01 percent variance in inflation rates. In the tenth lag period, 21.06 percent variance in Exchange rates is explained by 38.93 percent variance in GDP and 40.01 percent of the variance in Inflation rates. We note that variance in the Inflation rates is more explained by the Exchange rates followed by GDP.

Table 13 Variance decomposition of Exchange rate

Period	S.E	D_GDP	D_INFLATION	D_EXCHANGE
1	334.6286	56.90888	7.078530	36.01259
2	404.7889	43.26700	31.82458	24.90841
3	460.5111	36.91555	41.18645	21.89800
4	467.7346	38.69662	40.00762	21.29576
5	469.4447	38.75901	40.10004	21.14095
6	469.4916	38.76258	40.10014	21.13728
7	470.0395	38.87785	40.03382	21.08833
8	470.1517	38.90354	40.01761	21.07882
9	470.2252	38.91324	40.01442	21.07234
10	470.3092	38.92786	40.00732	21.06482

Source: Author’s computation from the data,2015

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents summary,the concluding statements from the study. It further recommends rational measures for policy makers.

5.1 SUMMARY

There are five main objectives of this study; (i) Examines the cointegration link between the series variables, (ii) to determine the long-run equilibrium relationship between all variables, (iii) to examine the causal relationships between all variables.(iv) Explain the impluse response funtion between the series variables and (v) To explain the variance deomposition of the series variables. The time series data cover the period from 1980 to 2013.

Based on the evidence from the Johansen Co-integration test, the study reveals the existence of a long run equilibrium relationship between real GDP growth, inflation rates and real Exchange rates. The Granger Causality test is performed to determine the direction of the relationship between both fundamental variables through VECM. The estimated coefficient of ECT in the real GDP growth equation is statistically significant and has a negative sign, which confirm the existence of a long-run equilibrium relationship between the independent and dependent variables at 10 per cent level of significance. Furthermore, in the short-term relationships, the findings revealed unidirectional causality between GDP growth rate and Exchange rate and bidirectional causality between Inflation rate and Exchange, and also between Inflation rate and GDP.

The Impulse Response Functions provide information to analyze the dynamic behavior of a variable due to a random shock or innovation in other variables. A unit shock of inflation rate to GDP creates strong fluctuations. Also an initial response of GDP to a shock in Exchange rate creates slight fluctuations and finally dies off.Variance decomposition was also employed as additional evidence presenting more detailed information regarding the variance relations between GDP and selected macroeconomic variables. The results implies that with time, the effect of inflation rates increase whist Exchange rates decreases.

5.2 Conclusions

In conclusion, the estimates of the impact of real exchange, and inflation on GDP growth for Ghana suggest that there exists a long run relationship between these variables and GDP growth. Precisely, these findings suggest that the contribution of inflation rate to Ghana economic growth is about 0.311842, with signifiant contribution in the growth model. However, exchange rate has a negative contribution with signifiant contribution in the growth model too.

The Impulse Response Functions results show that a unit shock of inflation rate to GDP creates strong fluctuations. Also an initial response of GDP to a shock in Exchange rate creates slight fluctuations and finally dies off. In the response of inflation to a shock in GDP creates also strong fluctuations, this confirms the bi-directional causality between these two variables. Finally, in the response of Exchange to a shock in GDP creates strong fluctuations, this implies how GDP affects Exchange rate and not the visa versa.

Variance decomposition results also show that by the fourth year period, 91.68 percent variance in GDP is explained by 7.94 percent variance in Inflation rates and by 0.38 percent change in Exchange rate. In the tenth year, 90.79 percent of the variance in GDP is explained by 8.83 percent variance in Inflation rates and 0.38 percent in Exchange rate. This implies that with time, the effect of inflation rates increase whist Exchange rates decreases. While variance in the GDP is mostly explained by the Inflation rates followed by Exchange rates and variance in the Inflation rates is more explained by the Exchange rates followed by GDP.

5.3 Recommendations

The following recommendations were made

a) The findings that inflation has a long-run relationship between GDP growth and influences iti positively in Ghana, government should invest in local industries to boost domestic production of tradable which would maintain higher export volumes. This will help reduce Exchange rate and hence impact on inflation, thereby increasing GDP growth rate.

b) Also raw materials from such products maybe imported on preferential basis to increase the production of essential commodities.

c) It would also be interesting to provide additional evidence from other countries to determine whether the specific results as reported here for Ghana can be generalised to other developing countries.

d) Future research in this area should try to add macroeconomic variables such as unemployment, real interest rates in the model to analyze their impact on GDP growth and considering quarterly data. This is likely to improve upon our results and may even provide more sturdy conclusion

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APPENDIX

Table 1. Eigenvalue stability condition

Eigenvalue	Modulus
-.2154545 + .7149932i	.74675
-.2154545 - .7149932i	.74675
-.3075669 + .2902656i	.422908
-.3075669 - .2902656i	.422908
.1493691 + .3474909i	.378234
.1493691 - .3474909i	.378234

All the eigenvalues lie inside the unit circle.

VAR satisfies stability condition.

Figure 1 Stability graph for VAR model

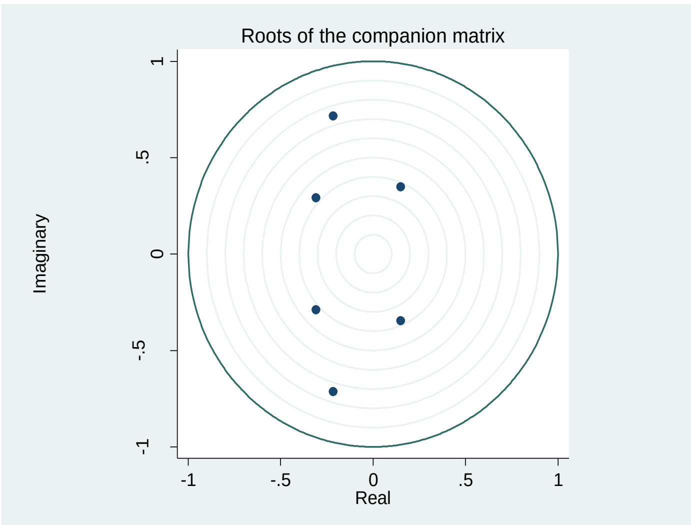

Table 2 VAR model

AIC = 27.04791

HQIC = 27.36457

SBIC = 28.01932

Equation	Parms	RMSE	R-sq	F	P>F
DGDP	7	2.83702	0.4202	3.7439370.0000	
Dinflation	7	16.2817	0.7128	12.82176	0.0000
DExchange	7	334.629	0.7629	16.6225	0.0000

		Coef.	Std. Err.	t	p>ltl	[95% Conf.	Interval]
DGDP							
DGDP							
	L1.	-.1353208	.2010882	-0.67	0.507	-.5503465	.2797048
	L2.	-.313276	.2278275	-1.38	0.182	-.7834888	.1569367
Dinflation							
	L1.	.0260621	.0196277	1.33	0.197	-.0144475	.0665718
	L2.	.0458444	.0236001	-1.94	0.064	-.0945526	.0028638
DExchange							
	L1.	-.004947	.0017563	-0.28	0.781	-.0041195	.00313
	L2.	-.0006773	.0011925	0.57	0.575	-.0017838	.0031384
	_cons	.5197069	.4735662	1.10	0.283	-.4576857	1.497099
D_inflation							
DGDP							
	L1.	-3.492696	1.154051	-3.03	0.006	-5.87454	-1.110852
	L2.	-2.79219	1.307508	-2.14	0.043	-5.490754	-.093626
Dinflation							
	L1.	-.7219777	.1126442	-6.41	0.000	-.9544638	-.4894915

L2.	-.0388118	1.34416	-0.29	0.777	-.3183496	.240726
DExchange						
L1.	.0048896	.0100792	0.49	0.632	-.0159129	.025692
L2.	-.0063083	.0068435	-0.92	0.366	-.0204326	.007816
_cons	1.947774	2.717809	0.720.480		-3.661508	7.557057
DExchange						
DGDP						
L1.	-67.96688	23.71854	-2.87	0.009	-116.9195	-19.01423
L2.	-72.67087	26.87246	-2.70	0.012	-128.1329	-17.20884
DInflation						
L1.	-15.88667	2.31511	-6.86	0.000	-20.66482	-11.10851
L2.	7.992556	2.783653	2.87	0.008	2.247378	13.73773
DExchange						
L1.	.1099938	.2071524	0.53	0.600	-.3175478	.5375354
L2.	-.3415532	.1406509	-.2.43	0.023	-.6318423	-.051264
_cons	-8.823306	55.85758	-0.16	0.876	-124.1076	106.461

Figure 2. Residuals plots from the VAR model

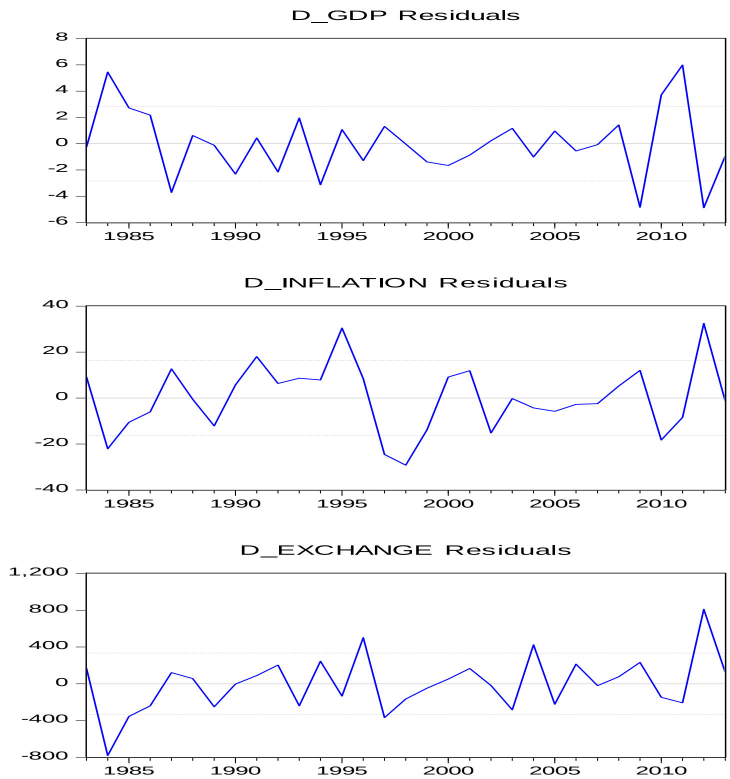

Table 3. Response of D_GDP

Period	D_GDP	D_INFLATION	D_EXCHANGE
1	2.837016	0.000000	0.000000
	(0.36030)	(0.00000)	(0.00000)
2	-0.481982	0.316992	-0.099349
	(0.54522)	(0.25735)	(0.40102)
3	-0.689855	-0.762961	0.164109
	(0.54949)	(0.28322)	(0.29045)
4	0.427461	0.302959	-0.023663
	(0.52735)	(0.26116)	(0.24031)
5	0.240243	0.208877	-0.028644
	(0.43108)	(0.22526)	(0.17746)
6	-0.377935	-0.239039	0.008375
	(0.39978)	(0.14995)	(0.11107)
7	0.022077	0.002920	0.007703
	(0.27970)	(0.13020)	(0.09852)
8	0.210542	0.123213	-0.005751
	(0.27965)	(0.10564)	(0.05961)
9	-0.104810	-0.052682	-0.002636
	(0.20255)	(0.08735)	(0.05076)
10	-0.071809	-0.046510	0.004893
	(0.17344)	(0.07260)	(0.03847)

Table 4. Response of D_INFLATION

Period	D_GDP	D_INFLATION	D_EXCHANGE
1	-8.555098	13.85296	0.000000
	(2.71495)	(1.75933)	(0.00000)
2	-4.966546	-9.566210	0.981882
	(3.59600)	(1.90384)	(2.30372)
3	-1.141881	3.671954	-1.520686
	(3.63694)	(1.92421)	(2.20423)
4	4.886191	1.743782	0.257932
	(3.46684)	(1.82643)	(1.14611)
5	-2.117511	-1.578892	0.030411
	(2.41393)	(1.65063)	(1.11210)
6	-1.331638	-0.560092	0.058650
	(2.10410)	(1.16957)	(0.85719)
7	1.842047	0.921347	0.010042
	(1.83289)	(0.75577)	(0.54778)
8	-0.164386	0.024970	-0.062775
	(1.28241)	(0.65588)	(0.46865)
9	-0.932635	-0.553491	0.032996
	(1.29542)	(0.51103)	(0.28109)
10	0.486362	0.232381	0.013367
	(0.91392)	(0.40023)	(0.22947)

Table 5. Response of D_EXCHANGE

Period	D_GDP	D_INFLATION	D_EXCHANGE
1	-252.4370	89.02963	200.8123
	(50.8363)	(37.7977)	(25.5032)
2	-84.67761	-210.2846	22.08810
	(74.7789)	(40.2914)	(47.3608)
3	-85.97813	187.6124	-75.00492
	(83.9509)	(44.1284)	(47.2367)
4	79.82350	-13.51399	12.27783
	(77.0350)	(39.5213)	(36.7525)
5	-27.52648	-29.06681	0.399184
	(61.2695)	(36.2007)	(26.2627)
6	-4.990906	4.226145	1.095254
	(45.6441)	(29.8288)	(16.0191)
7	21.31215	7.738790	0.807828
	(36.5644)	(19.7287)	(9.75215)
8	-9.893985	-2.533209	-1.108171
	(26.0658)	(12.3460)	(5.75634)
9	-6.947582	-4.541246	0.510819
	(18.1827)	(8.76869)	(3.58896)
10	7.941057	3.985022	0.005858
	(15.5022)	(7.74003)	(2.32854)

Table 6. VECM

AIC – 26.29399

HQIC - 26.68604

SBIC - 27.49669

Equation	Parms	RMSE	R-sq	chi2	p>chi2
D_GDP	8	2.14512	0.6883	50.78318	0.0000
D_inflation	8	16.3808	0.7217	59.64361	0.0000
D_Exchange	8	230.234	0.8936	193.2454	0.0000

	Coef.	Std. Err.	z	p>lzl	[95% Conf.	Interval]
D_GDP						
_ce1						
L1.	-.3640467	.087521	-4.16	0.000	-.5355847	-.1925087
GDP						
LD.	-.1278053	.1698086	-0.75	0.452	-.4606241	.2050135
L2D.	-.3905244	.19671099	-1.99	0.047	-.7760707	-.004978
inflation						
LD.	.0818465	.0206745	3.96	0.000	.0413251	.1223678
L2D.	.0668201	0346458	1.93	0.054	-.0010845	.1347246
Exchange						
LD.	-.0011168	.0014963	-0.75	0.455	-.0040495	.0018159
L2D.	-.0029512	.0013172	-2.24	0.025	-.0055328	-.0003695
_cons	.3198084	.4165143	0.77	0.443	-.4965447	1.136162
D_inflation						
_ce1						
L1.	.8161141	.6683383	1.22	0.222	-.4938049	2.126033

GDP						
LD.	-3.173078	1.296713	-2.45	0.014	-5.714589	-.6315675
L2D.	-1.981208	1.502148	-1.32	0.187	-4.925364	.962947
inflation						
LD.	-22.55327	2.218975	-10.16	0.000	-26.90238	-18.20416
L2D.	-8.631474	3.718497	-2.32	0.020	-15.91959	-1.343353
Exchange						
LD.	.0059802	.0114263	0.52	0.601	-.0164149	.0283753
L2D.	.004693	.0100585	0.47	0.641	-.0150213	.0244074
_cons	-.61294563.180637		-0.19	0.847	-6.846879	5.620988
D_Exchange						
_ce1						
L1.	49.99613	9.393533	5.32	0.000	31.58514	68.40711
GDP						
LD.	-76.35108	18.22538	-4.19	0.000	-112.0722	-40.63
L2D.	-56.06533	21.11277	-2.66	0.008	-97.4456	-14.68506
Inflation						
LD.	-22.55327	2.218975	-10.16	0.000	-26.90238	-18.20416
L2D.	-8.631474	3.718497	-2.32	0.020	-15.91959	-1.343353
Exchange						
LD.	.1147625	.160597	0.71	0.475	-.2000017	.4295268
L2D.	.2084635	.1413731	1.47	0.140	-.0686226	.4855497
_cons	.0123341	44.70403	0.00	1.000	-87.60596	87.63063

Table 7 Lag order selection for VECM

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-431.303				3.0e+08	28.0195	28.0648	28.1583
1	-404.093	54.42	9	0.000	9.2e+07	26.8447	27.0256	27.3998*
2	-389.53	29.126	9	0.001	6.5e+07	26.4858	26.8025	27.4572
3	-378.093	22.874*	9	0.006	5.9e+07	26.3286*	26.7809*	27.7163

Figure 3. Stability graph for VECM

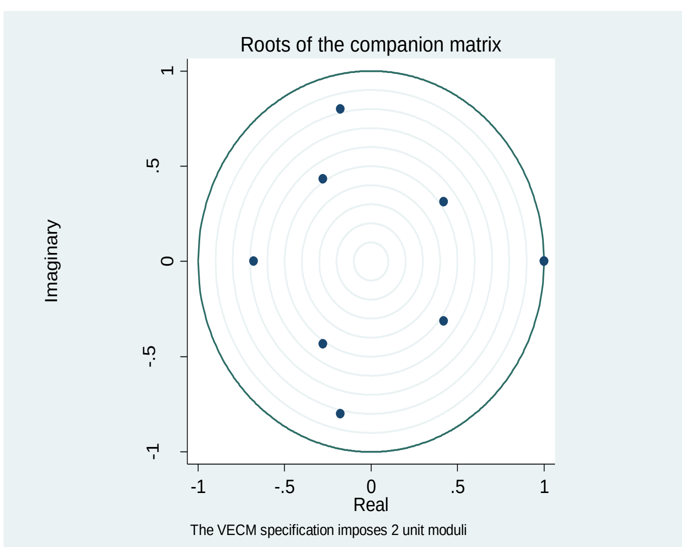

Figure 4. Residuals plots from the VECM

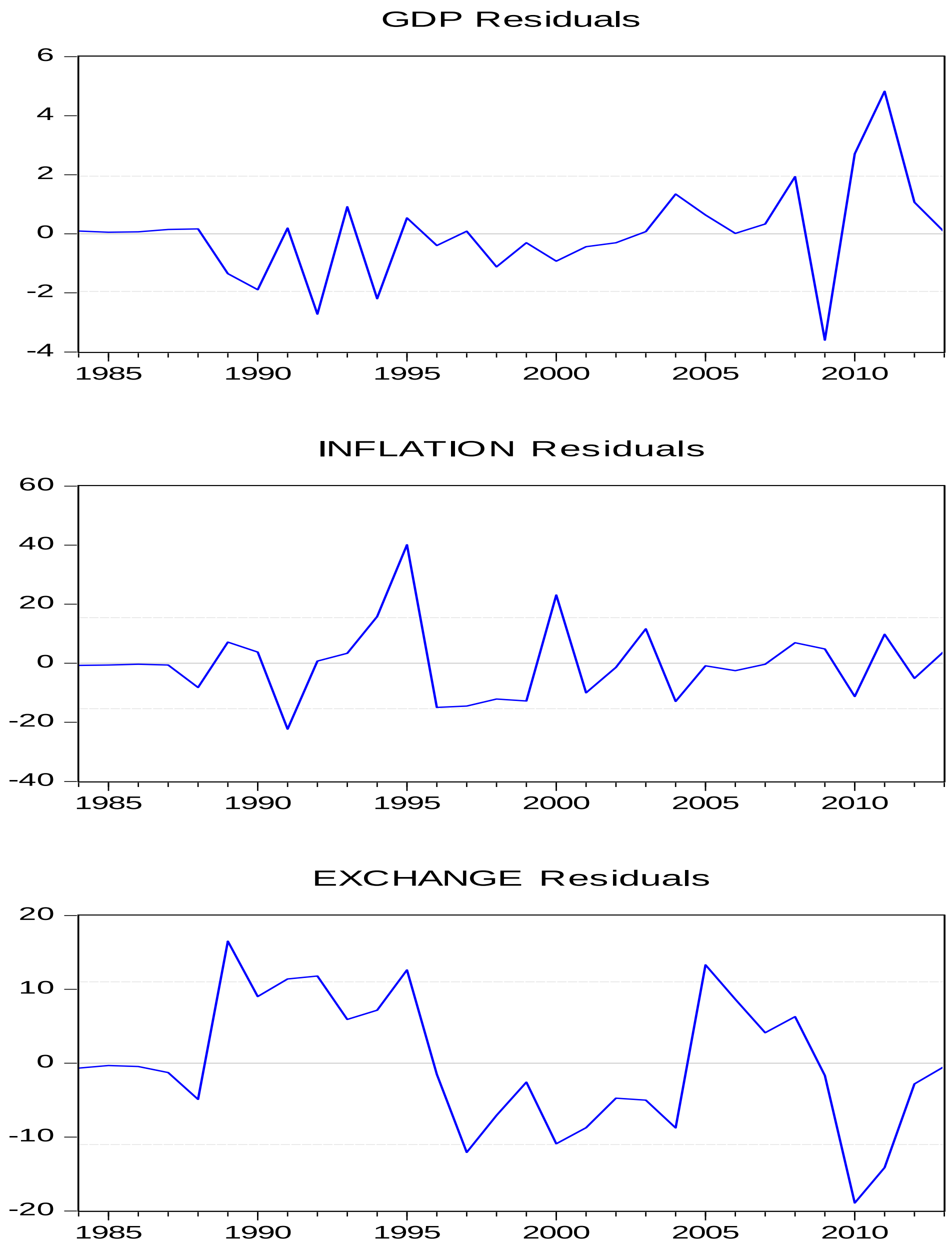

Table 8. Data used for the analyses

YEARS	REAL GDP GROWTH	INFLATION RATES	REAL EXCHANGE RATES
1980	0.4717	87.839	750.5800
1981	-3.5030	100.222	1669.4000
1982	-6.9240	16.787	2092.3900
1983	-4.5640	142.418	3579.1500
1984	8.6480	5.988	546.0100
1985	5.0920	19.499	397.6000
1986	5.1990	33.335	251.5200
1987	4.7950	34.180	188.3000
1988	5.6280	26.556	169.7700
1989	5.0860	30.458	158.5700
1990	3.3290	35.902	157.5100
1991	5.2820	10.259	160.7900
1992	3.8790	13.332	141.8400
1993	4.8500	27.656	123.9300
1994	3.3000	34.178	100.3900
1995	4.1120	70.819	115.9611
1996	4.6020	32.663	126.0000
1997	4.1960	20.465	133.3000
1998	4.7000	15.749	142.2600
1999	4.4000	13.795	140.5000
2000	3.7000	40.540	91.9400
2001	4.0000	21.288	92.9600
2002	4.5000	16.995	92.5600
2003	5.2000	31.274	92.7900
2004	5.6000	16.441	91.4900
2005	5.9000	13.908	100.0000
2006	6.4000	10.923	105.2700
2007	6.4600	12.748	104.5600
2008	8.4310	18.133	99.5200
2009	3.9910	15.973	91.5700
2010	8.0070	8.579	97.6500
2011	15.0070	8.579	92.7700
2012	8.7890	8.839	86.8000
2013	7.1320	13.500	92.3400