ANALYSING THE EFFECTS OF MACROECONOMIC VARIABLES ON INFLATION IN GHANA USING DISTRIBUTED LAG MODELS.

BY

AMEN AGBENORHEVI
(10215306)

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL ACTUARIAL SCIENCE DEGREE

JUNE, 2016
DECLARATION

Candidate’s Declaration

This is to certify that, this thesis is the result of my own research, under the guidance of my supervisors, except for references to others people’s work which have been duly acknowledged and that no part of it has been presented for another degree in this university or elsewhere.

I bear responsibility for the views expressed in this study as well as all errors.

SIGNATURE: ........................................... DATE: ............................................

AMEN AGBENORHEVI

(10215306)

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.

SIGNATURE: ........................................... DATE: ............................................

DR EZEKIEL N. N. NORTEY

(Principal Supervisor)

SIGNATURE: ........................................... DATE: ............................................

DR ANANI LOTSI

(Co-Supervisor)
ABSTRACT

The study examines the relation between inflation and some key macroeconomic variables such as money supply, interest rate, exchange rate, and GDP in Ghana. These macroeconomic variables are obtained from the Bank of Ghana spanning through January 1990 to December 2014. Data obtained were on monthly basis. However, it is only the GDP which was an annual data but had been transformed into monthly data. We use the Augmented Dickey-Fuller (ADF) technique; the Granger Causality Test Technique, the Autoregressive Distributed Lag (ARDL) Cointegration Technique, and the Error Correction Model (ECM) of the ARDL model are used to test for the existence of the short and long run relationship between inflation and the other variables. Unit root test is performed using the ADF test, the ARDL model is used in establishing the long-run relation between inflation and money supply, interest rate, exchange rate and GDP while the ECM is used to establish the relation between the variables and the level of significance used throughout the study is 5%. From the study, it is established that there exists a significant long-run and short-run relationship between inflation rate and money supply; this confirms the monetarist theory which says ‘inflation is everywhere a monetary problem’, interest rate, exchange rate and GDP. The Granger-causality test used lag two (2). The test results show there is a unidirectional causal relation running from inflation rate to money supply, a unidirectional causality from interest rate to inflation. The results also suggest a non-directional causality between exchange rate and inflation rate and a bidirectional causality between GDP and inflation rate.
DEDICATION

The Lord Almighty I dedicated this work to not forgetting my wife and Daughter, my late parents, brothers and sisters Agbenorhevi Godis, Emmanuel Mensaklo, Ali Bernard, Ami Afla, and Winnifred Nyawuto.
ACKNOWLEDGEMENT

I extend my profound gratitude to the Almighty God for His Loving-kindness bestowed upon me in the course of my study at the University.

My appreciation goes to my supervisors, Dr. E. N. N Nortey and Dr. Anani Lotsi for their rich suggestions and critiques which have propel me to this level in the field of academia. I salute all the lecturers and other auxiliary workers of the Department of Statistics.

My final gratitude profoundly goes to my brothers and sisters Ali Bernard, Agbenorhevi Godis, Menasklo Emmanuel, Afla Ami and Nyawuto Winnifred for their selfless financial contribution towards this work.
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LIST OF ABREVIATIONS

USD………………………………. United States Dollar

ARDL………………………………. Autoregressive Distributed Lag

ECM………………………………. Error Correction Model

ECT……………………………….. Error Correction Term

VECM………………………………. Vector Error Correction Model

VAR……………………………… Vector Autoregressive

OLS………………………………. Ordinary Least Square

GDP……………………………….. Gross Domestic product

M…………………………………… Money Supply

R………………………………………. Interest Rate

E………………………………………. Exchange Rate

I …………………………………….. Inflation Rate

GARCH …………………………… Generalized Autoregressive Conditional Heteroscedasticity

ADF …………………………………. Augmented Dickey-Fuller

AIC ………………………………….. Akaike Information Criteria

SBC …………………………………. Schwartz Bayesian Criteria

CUSUM …………………………… Cumulative Sum of Recursive Residuals

XI
CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Over the years, Ghana has experienced unfavourable exchange rate trends coupled with relatively high rate of inflation. This situation has not changed in recent times as the country continues to battle with the rapid depreciating of its currency. The problem of how to reduce inflation and to arrest the depreciation of the Ghana Cedi (GhS) has been a central issue among policymakers since the 1980s.

The politicians and policy analysts alike have been at each other’s throat on this issue in recent times, and it has become more of a political issue than of an economic issue in Ghana. Oppositions blame the occurrence of the phenomenon on the ruling National Democratic Congress (NDC) Government, the ruling NDC Government also blames the opposition for over exaggeration of the phenomenon. The basic argument surrounding this controversy has been to explain the interconnection between or among these major macroeconomic indicators.

The so-called over politicisation of this major economic problem may dampen investor confidence in the Ghanaian economy.

According to Ghana Statistical Service, Ghana experienced steady single digit inflation for about twenty-four months which spanned from 2010 to 2012 recorded as 8.58% in December 2010, 8.54% in December, 2011, and 8.84% in December, 2012 and here after increased to 13.5% in December, 2013, 17% in December, 2014, and 17.1% in December, 2014.

Ghana has been battling with the problem of inflation few years after independence. The country recorded single digit inflation during the early five years which could be best described as a
relative stable economy. The economy began to experience macroeconomic volatility with inflation reaching a high level which was described unprecedented and this unfavourable economic condition prevailed between 1970s and the early days of 1980s. The economy experienced for the first time after independence an inflation rate which was over 100% in July 1977 and it was the same for March 1983. The unstable nature of the economy had however pushed Ghana to enter into agreement with the Bretton Woods institution for a form of support to stabilise the economy especially to work out the necessary equations so as to bring inflation down to its accommodating level but all the effort put in could not salvage the situation. Ghana was not able to free itself from the jaws of unfavourable rates of inflation and took Ghana over 35 years to experience an unfavourable rate of inflation but inflation rate was hovering on average above 25%.

According to Sowa (1994), many economic reforms and programmes were initiated to fight macroeconomic instability of which inflation is the central of all but no solution was found within the period of ten years. Catoa and Terrones (2003), among other macroeconomic indicators inflation is very key therefore the need conduct study on Ghana’s inflation experience. They specifically built econometric model to achieve their objective. They concluded in their findings that for every economy to be stabilised inflation must be given the needed attention it deserves hence, the importance of inflation as a macroeconomic indicator cannot be over emphasised. In another development, Atta et al, (1996) asserted that an economy could only do well having a firm grip on inflation if the factors that affect inflation are studied very well and one must also know the mechanism through which these factors work and the emphasis more tilted to fiscal and monetary policies. A number of economic policies and reforms were carried out. These programmes and reforms were under the auspices of the Banks and Fund however; a lot of macroeconomic policies were carried out, a period that this paper covers. In the 1990s, few
studies were done in respect of inflation in Ghana and this was in the early part of 1990 and towards the mid-1990s. Sowa (1996) Sowa et al. (1991) Chhibber et al. (1991), were the people who did creditably well in conducting studies into this area. In recent times most of the studies on inflation in Ghana have assumed multi-country efforts with a much broader dimension. In Ghana few studies were carried out on inflation in the early years of the country’s independence. However, it was difficult to put the situation under control due the external shocks the economy had been battling with. One of the major contributions of the study is in the use of a broad and up-to-date data set for the period 1960-2003. In recent times a lot of contributions have made to the body of knowledge in time series forecast by the use of cogent econometrics models which are capable of distinguishing between long and short-run influences on inflation.

Studies into inflation as a major economic concern had revealed that there were wide range of causes that had led to inflationary pressures and that there is no single specific theory propound that is capable of explaining pressures from inflation in any economy because the causes of inflation may come from the presence of vibrant labour unions, the developmental needs of the economy and the manner of approach to these needs, and the nature of the structure the economy is practicing. Therefore, what best fit in approaching inflationary pressures may not be the same for the other economy. Inflation raises government expenditure and revenue hence, causing an upward adjustment in government’s fiscal decision especially when government’s budget is index to inflation and the simultaneous effect leads to an increase in government revenue. The imbalances in government budget have been the main source of macroeconomic instability. As stated by (CEPA, 2001), Ghana failure to strictly go by the conditionality set out for Poverty Reduction and Growth Facility (PRGF) had worsened the state of the affairs in the economy in 1999 and 2000 fiscal year as money supposed to be disbursed in the form of aid was unduly delayed. It is a common practice of the Bank of Ghana to bounce government cheques.
The main purpose of the study is to analyse the effect of the macroeconomic variables on inflation in Ghana for the period 2000-2014.

Figure 1: The graphical display of the year-on-year inflation in Ghana for the period 2000-2014.

The graph clearly shows the performance of the economy from January 1990 to December 2014 with respect to inflation rate. From the graph, Ghana recorded high rate between 1990 and 1993. The highest rate recorded was between 1994 to 1996. There was a bit of volatility from 1998 to 2002 afterwards, Ghana experience a stable moderate inflation rate.
1.2 Problem Statement

The past and present governments seek to stabilize the major macroeconomic variables thereby, making the business environment more attractive to both domestic and foreign private investors to invest in Ghana. Kuffour-led administration saw the need for greater private participation as the “engine of growth” which resulted in the spring up of many private banks both domestic and foreign, as well as other financial establishments such as the microfinance companies, private hospitals, and all categories of educational institutions. The housing sector also received its fair share not forgetting the transport sector in general. The sudden economic boom was as a result of a bit stable macroeconomic environment experienced under the Kuffour-led administration.

Here comes Mills – Mahama-led administration with the firm belief that the economy could only grow if the macroeconomic environment is stable. This led to the unprecedented 24 months single digit inflation experienced between the years of 2010 and 2012. Now the present macroeconomic environment is nothing to write home about under the same administration with the popular mantra “home grown policies”. The major macroeconomic indicators such as inflation and exchange rates are worsening each passing moment and therefore, the need to investigate the effect of other macroeconomic variables on inflation in Ghana since high inflation rate poses threat to economic security and stability.

Gyebi et al. (2013) stated that for a monetary policy to survive, inflation must be well catered for even though the maintenance macroeconomic stability in totality is also paramount, but checks on inflation is very important because the hardest hit by the negatives from inflation is the poor since the poor is hedged against the negativities of inflation.
1.3 Objectives of the study

1.3.1 Main objectives

The project seeks to;

- Identify the relationship between inflation and other macroeconomic variables.
- Examine the degree of the relationship that exists between inflation and other macroeconomic variables.

1.3.2 Specific objectives

Specifically the project seeks to;

- Establish the short and long run relationship between inflation and other macroeconomic variables using cointegration techniques; Autoregressive distributed Lag model (ARDL) and error correction model (ECM).
- Determine the causality between inflation and each of the macroeconomic variable using Granger Causality test.

1.4 Research Questions

The study seeks to find answers the following questions:

- What is the effect of other macroeconomic variables on inflation?
- Which of the macroeconomic variables affect inflation?
- Which of the macroeconomic variable does inflation affect?
- Does short-run relationship exists between inflation and other macroeconomic variables?
- Does long-run relationship exists between inflation and other macroeconomic variables?
1.5 Significance of the study

The study throws light on the importance of the interaction of the macroeconomic variables in determining the path of inflation in Ghana. Modeling the pattern of inflation in Ghana is important in determining the flow of investment in general and foreign investment in particular since unreasonable inflation rate prevailing in any economy dampens investor confidence in the economy hence, a fall in direct foreign investment resulting in unemployment.

The beauty of this project is the use of appropriate statistical tools in the analysis of data to present with high degree of accuracy the findings from this work, and this will inform potential investors in making decisions regarding the macroeconomic performance in general and inflation in particular in Ghana. The local investors and government alike will also be guided by the detailed diagnosis done on the macroeconomic variables.

Finally, the project may put to rest the debate in regard to the disconnect between inflation and other macroeconomic variables as purported by Dr. Mahamudu Bawumia, in the upcoming 2016 general elections during a lecture on the topic “Restoring the value of the Cedi”.

1.6 Data collection and source

The data sets to be used in the study are secondary. The data on the following variables: money supply, interest rate, inflation and exchange rates Gross Domestic Product (GDP) were all obtained from the research department of Bank of Ghana for the period 1990-2014.

1.7 Overview of the study

The rest of the thesis is organized into four chapters. Chapter two comprises of reviews of related literature on the topic, chapter three looks at the methodology that was adopted in analyzing the
data. Chapter four comprises of the analysis and the discussion of the results while chapter five includes summary of findings, conclusion, limitations and recommendations of the study.
2.1 Introduction

This chapter of the study covers a review of studies that investigate the short and long-term relationship that exists between inflation, on the one hand, and some macroeconomic variables such as money supply, exchange rate, Government Expenditure and Gross Domestic Product (GDP), on the other hand. Researchers across the globe have done lots of work on similar topics involving the use of different econometric and statistical methodologies. Below are some reviewed articles that are relevant to this study.

2.1 Evidence from the world

A study by Khai (2011) established the relations between macroeconomic variables namely oil price with inflation, exchange rate, unemployment rate and money supply were studied. A unit root test was conducted and the Augmented Dickey Fuller (ADF) technique was used. By this, it was established that all the variables (time series data), both dependent and independent, are unstable at the level but become stable at the first difference. Johansen-Juselius cointegration test, Granger Causality test and Vector Error Correction Model (VECM) were used to establish the relationships between oil price with inflation, exchange rate, unemployment rate and money supply. Confirmation of VECM equation validity was performed on VECM by using diagnostic test. The outcomes from the test suggest that, oil price and money supply happen to have positive relationship with inflation in the long run and the short run. On the contrary, exchange rate and unemployment rate happen to have negative relationship with inflation in the long run and the short run. In this study, empirical evidence supports the macroeconomic theory of inflation in Malaysia. The results from this study show that government must appropriately implement fiscal
and monetary policies to help control and to also reduce the dangers of inflation, considering the macroeconomic determinants.

The relevant factors that have impacted on the general rise in price of goods and services in Tanzania have been researched into by Laryea et al. (2001). They have established that the factors that cause inflation include cost-push, demand-pull and structural factors. The data obtained for the study was on quarterly basis spanning from 1992 to 1998. Tanzania experienced the raw inflation figure in the year 1994; the increase in inflation was as high as 33% and was due to a 32.5% annual growth rate in supply of money. By and by, Tanzania put up measures to control inflation. Among the measures was a tight monetary policy by the Central Bank. As a result, the growth rate in supply of money decreased from 32.5% in the year 1994 to approximately 7.7% in the year 1998. The policy implemented by the Central Bank had impacted positively on the inflation rate within the same period and there was a drop in inflation rate from 33.1% in the year 1994 to approximately 12.8% in the year 1998. The study established that there is a direct relationship between money supply and inflation rate through the application of Ordinary Least Square (OLS). The test results also confirmed that money supply has significant effect on the general level of prices for goods and services in the economy of Tanzania. This result supports the stand of the monetary economist that inflation everywhere is a monetary issue since we have established that in the long run the elasticity of inflation to money supply is 0.77. The Restricted Error-Correction Model has revealed the importance of money supply as a factor which has a great impact on inflation in the short run in Tanzania. The results also display a short-run elasticity of inflation as 0.33.
Franz et al. (2004) explained the causes of frequent but general rise in prices of goods and services in South Africa. South Africa wanted to reduce inflation to a level that will be favourable as far as trading with its partners are of importance matter and this, for South Africa, is achievable through an introduction of new monetary regime known as inflation targeting. The study comes up with a model that can relate labour market and the foreign exchange market conditions and that of domestic price change to the South African money market. We clearly show that the issue of general price change in South Africa is a question of structure. There is a direct relationship between broad money supply, labour costs and domestic inflation. An appreciation of the rand or a rise in the nominal effective exchange rate will lower domestic inflation in South Africa. The effect of rising labour cost to inflation in the long run is very significant. The increase in the nominal interest rate in the short run on inflation is negligible but will lead to a fall in inflation rate in the long run. On the other hand, domestic inflation will be affected in the long run when the supply of broad money is increased. It looks as if purchasing functional equality exists between South Africa and its major trading partners. The paramount source of variation in the forecast of domestic inflation errors is own shocks. Instaurations from labour costs with a given nominal effective exchange rate are also important sources. The largely structural nature of inflation in South Africa, coupled with the reality that the Central Bank has no or limited control over the main determining factors which make it difficult to achieve the stated objective of the regime (inflation targeting regime).

A study was conducted by DaCosta et al. (2008) to analyse the relation between inflation rate and what exactly determines it in some selected Caribbean countries by analyzing annual-based time series data from 1970 to 2006. The Dynamic Ordinary Least Squares (DOLS) procedure can be used to determine the long-run relationship between each determinant and inflation while
that of the short-run relationship can be determined by applying Error Correction Model (ECM). Results from the DOLS procedure show a 3.8% decrease in inflation rate in Jamaica, given a rise in unemployment rate to about 10%. In the case of Trinidad and Tobago, inflation rate went up by 0.28 while the unemployment rate dropped by 10%. Results from the ECM test show that Jamaica will experience a 1.12% increase in inflation on the basis that unemployment will decrease by 10%. Accordingly, Trinidad and Tobago will experience a decrease in inflation by 0.34% margin if the employment rate goes up by 10%.

Furuoka et al. (2007) investigated the relationship between inflation rate and unemployment rate in Malaysia which spans through 1973 to 2004. The results based on the Johansen cointegration test show that between inflation rate and unemployment rate there exists a negative relationship in the long-run. A test based on VECM was carried out to determine the causality relationship between inflation rate and unemployment rate using the Granger-Causality technique. The outcome of the t-test reveals that unemployment rate and inflation rate have a long-run relationship based on the Granger Causality. This stems from the fact that the error correction term (ECT) is statistically significant because it is negative. In the same vein, there is a short-run Granger Causality between inflation rate and unemployment rate and this is based on the results from the Wald Test outcomes in Granger-Causality Test. The author draws the conclusion that in Malaysia there is a long-run and short-run cointegration and causality relationship between inflation rate and unemployment rate. These empirical results prove that Philips Curve, which gives the trade-off relationship between unemployment and inflation, does exist in Malaysia.

Cheng et al. (2002) conducted a study to identify the major variables that have significant effect on inflation of Malaysia. Data is obtained on Quarterly base from Q1 1973 until Q2 1997. It was
shown that money supply has a significant positive effect on inflation based on the results of the impulse response functions.

Adekunle et al. (2006) investigated the determinants of inflation in Nigeria between 1981 and 2003. Inflationary trends have, over the years, stared the Nigerian economy in the face to the extent that the long-term solution, through various government policies, aim at bringing improved living standards of the Nigerian citizenry proved futile. And this has necessitated the commencement of research into the multidimensional and dynamic variables that affect inflation with the view to making appropriate recommendations to curbing it. The outcome from the research shows that all the dependent variables (fiscal deficits, money supply, interest and exchange rates) significantly and directly affected inflation rate in Nigeria during the period under review. The dependent variables accounted for 72% of the variation in inflation during the period with the error terms capturing 28% of the variation. This research contributes to the idea that the causes of inflation in Nigeria are multi-dimensional and dynamic, requiring full knowledge at any point in time to be able to proffer solutions to the inflationary trends in the country, and thereby engendering high productivity and increased living standards of the citizenry.

Armesh et al. (2010) conducted a study to assert and analyse the main determinants that affect general price rise in goods and services in Iran. Time series data on annul basis were obtained and used. Ordinary Least Squares (OLS), a simple econometric procedure was used to analyse the relationship between the inflation rate and its factors. The outcomes generated from the OLS estimation show that there is a direct relationship between inflation and money supply. The long-run coefficient of the dependent variable is positive as expected and it was significant at 5% level
of significance. The findings from the study show that money supply has a long-run direct effect on inflation in Iran.

Abidemi et al. (2010) conducted a study into “the relationship between inflation in Nigeria and its determinants from 1970 to 2007”. Based on the results from Augmented Engle-Granger (AEG) cointegration test, it shows that money supply growth rate has a long-run positive relationship with inflation. Results estimated from Error Correction Model (ECM) show that there exists a positive relationship between money supply and inflation, and money supply growth rate has a positive impact on inflation rate in the short run.

Ginting et al (2009) conducted a research into the causes of inflation in Cambodia from 2003 – 2008 and came out with the findings that there exists a long-run relationship between money supply and inflation. Before year 2007, the result shows the coefficient for money supply as 0.07 meaning that inflation rate will rise by a margin of 0.7% if money supply increases approximately by 10%. The rapid economic growth experienced after 2007 influenced the coefficient of money supply from 0.07 to 0.155. This means that a 10% rise in money supply will cause inflation to rise by 1.55%. However, the test results also illustrate that money supply has a short-run positive effect on inflation. The findings from the study show that money supply has a long-run direct effect on inflation in Cambodia.

A study by Khan et al. (2007), using Ordinary Least Square (OLS), indicates that exchange rate has a significant impact on inflation in Pakistan. The import price level for goods and services will rise on condition that exchange rate depreciates and this will automatically lead to an
inflationary phenomenon in the economy. Pakistan experienced general rise in price of goods and services in 1990s due its currency depreciation.

Lim et al. (1997) conducted a study on inflation using quarterly data from the year 1970 to 1995. It clearly demonstrated by the findings that exchange rate has a negative relationship with inflation in the long-run. The results of a test carried out using Johansen Cointegration Procedure, by interpretation, mean exchange rate depreciation will cause inflation rate to increase. Another test conducted on the variables by the use of instrument variables (IV) and Ordinary Least Squares (OLS) shows that exchange rate has an effect on inflation in the short run.

Tafti, 2012 researched into the major factors that influence inflation in the economy of Iran. Results available show that 10% liquidity growth in the long run causes a 2.7% growth in inflation rate of retail sale and 3.2% in wholesale. On the other hand, a 10 percent increase in product growth rate leads to a decrease of 1.7 percent in inflation rate of retail sale and 2.4 percent reduction in wholesale. Also, he shows that conducting a suitable policy can fill about 66 percent from the actual inflation rate gap and equilibrium rate of inflation by the Error Correction Model. Finally, he concludes that inflation is not a monetary phenomenon in Iran.

Malian et al. (2009) analyzed the determinants of inflation differentials and price levels across the Euro area countries. Dynamic panel estimations for the period 1999-2006 reveal that inflation differentials are fundamentally established by cyclical positions and inflation persistence. The persistence in inflation differentials appears to be partly explained by administered prices and to some extent by product market regulations. In a cointegration framework, we find that the price level of each Euro area country is governed by the levels of GDP per capita.
Dharmandra et al. (1994) investigated major determinants of the inflation rate in the United States. For this investigation, we use a vector autoregressive model that includes major variables interacting with the price level in the macro economy. Our results suggest that changes in the money supply, the wage rate, the budget deficit and energy prices are important determinants of the inflation rate in the United States. Further, the relative contribution of these factors to the variance of the forecast error of the price level is consistent with a more dominant impact for monetary changes on the inflation rate. This presents a channel through which Fed officials can counter successfully demand and supply shocks that have potential inflationary effects on the United States economy.

Abbasi (2004) investigated a long-run relationship between inflation rate and monetary policies in the case of Iran. The study employed the Engle Granger, Julius Johansen and Autoregressive Distributed Lag (ARDL) methods by utilizing data for the period 1960 to 2001. The result shows that 10 percent of money growth leads to 3 percent increase in the general price level. Also, they have not accepted hypotheses of inflation as a monetary phenomenon and believe that GDP, import price index and exchange rate are as important factors influencing inflation in Iranian economy.

Gottschalk et al. (2008) in their paper on analysing determinants of inflation, they argue that when there are data limitations, as it was in the case of Sierra Leone, they used the structural vector auto regression approach to help forecast inflation and found out that domestic inflation increases with higher oil prices, higher money supply and leads to nominal wage depreciation.

The factors that determine inflation are studied using the Unrestricted Error Correction Model (UECM) approach proposed by Pesaran et al. (2001). General Autoregressive Distributed-lag
(ARDL) model is used to estimate short and long run effects jointly. This approach is described by Pesaran et al. (2001) as the ARDL approach to cointegration modeling. This approach has two main advantages over the other common procedures to cointegration analysis, mainly the Engle and Granger two-step approach and the Johansen maximum likelihood framework. The first advantage stems from the fact that the other methods focused on the estimation of long-run relationships among I(1) variables, which inevitably involves a certain degree of pre-testing and thus introduces a further degree of uncertainty into the analysis of relationships between levels (Cavanagh et al., 1995; Pesaran et al., 1996; Pesaran et al., 2001). Moreover, their widespread use has led to the common misconception that long-run relationships exist only in the context of cointegration among integrated variables (Greenidge, 2006; Loayza 2006). With the UECM, cointegration analysis can be conducted irrespective of whether the explanatory variables are I(0), I(1) or a mixture of both. The second advantage is that this technique improves upon the other methods since it is better at handling a small sample and dynamic sources of bias. Pesaran and Shin (1998), Pesaran et al. (2001) and Haug (2002) show that the OLS estimators of the short run parameters in the UECM are square root of $T$-consistent and the long-run coefficients are super consistent in small sizes.

In analysing inflation in Uganda, Kabundi (2012) used the error correction model to analyse the dynamics of inflation and found out that in the short run and long run, external and domestic factors contribute to inflation causation with the agricultural sector being affected by the demand and supply of its commodities.

Devarajan et al. (2013) observed that inflation works against the poor, especially in the developing countries, who have to cut on their spending when they come face to face with
inflation. This would lead to cutting down on how much is spent on vital items like education and healthcare, which in his opinion makes inflation the worst tax to the poor. Inflation is a serious concern for the common people. Campbell et al. (2001) discovered that there may be a difference between how common people and economists perceive inflation. Non-economists perception of inflation is that it may lower the people’s standard of living. Easterly & Fischer (2001) found out that inflation affects the poor more than it does the rich.

At international level, such studies include Chhibber et al. (1998) who employed a highly disaggregated econometric model for Zimbabwe. They found out that monetary growth, foreign prices, exchange and interest rates, unit labour cost and real output are the key determinants of inflation in that country. In a study for the African Economic Research Consortium (AERC), Kilindo (1997) investigated the links between fiscal operations, money supply and inflation in Tanzanian. The findings reveal a strong relationship among the three. He then recommends the adoption of a restrictive monetary policy in which the supply of money must be constrained to grow steadily at the rate of growth of real output.

Olorunfemi et al. (2012) estimated and tested the relationship between inflation and money supply in Nigeria, using Vector Autoregressive (VAR) model. The paper also evaluated the key determinants of inflation such as money supply, real exchange rate, real interest rate, oil revenue and government expenditure, all within the period 1970-2008. The study reveals a unidirectional causality from money supply to inflation, from exchange rate to inflation, as well as from interest rate to inflation. Their results provided supportive evidence of a positive link between money supply and inflation rate. The result for the VAR model shows that own shock raised malfunction in the first two years that came down to negative and slightly rose to flatten out. The
shock in money supply had no early effect on inflation rate but later had a slight positive effect on inflation.

In the same vein, Hassan (2004) examined the relationship between money growth and inflation in Nigeria using cointegration and causality analysis. The study used annual time series data from 1970 to 2012, Johansen cointegration approach, Vector Error Correction Model (VECM) and Granger causality test were used to identify a long-run relationship, the short run dynamic and the causal relationship among the variables respectively. The empirical results confirm that in the long-run, money supply growth has a significant and positive relationship with inflation while lagged value of money supply growth has a negative and insignificant relationship with inflation in the short run. Moreover, the causality test result reveals that money supply growth has unidirectional causal relationship with inflation. The causal relationship runs from money supply growth to inflation. However, interest rates and import have a positive and significant relationship with inflation but exchange rates and GDP have a negative and significant relationship with inflation in the long run. In the short run, lagged GDP variable has a significant and positive relationship with inflation, lagged import variable and lagged interest rate variable have a significant and negative relationship with inflation, while the lag of exchange rate variable has insignificant and negative relationship with inflation in the short run. Moreover, the causality test result reveals that exchange rate, interest rates and GDP variable have unidirectional, bidirectional and no causal relationship with inflation respectively. The study concludes that for maintaining price stability and minimum rate of inflation, Nigeria needs to reduce money supply growth, improve GDP, reduce interest rate and
impose strong import restriction measures as well as exchange rate depreciation along with import substitution strategy.

Likukela (2007) in this paper, employs various econometric techniques to analyze the determinants of inflation in Namibia, focusing particularly on the relationships that exist between the Namibian price, as the dependent variable, and the real Gross Domestics Product, Broad money supply, interest rate, and the South African Price index as well as the United States price index, being the explanatory variables and probable determinants of inflation rate in Namibia. Quarterly data from 1993 to 2003 were used to estimate inflation equations for Namibia, South Africa and the United States, and it was found out that in the short run, domestic prices are influenced by the level of economic growth and foreign prices, particularly in South Africa.

Ge (2012) studied the major effects on China’s inflation 1994-2009 using GETS Modeling. In his study, he tried to establish the relationship or the correlation between inflation, money supply, output gap, the exchange rate and crude oil prices in China. He carried out the study at the China has transited from a planned economy to a market-based economy. The empirical results suggest that, one, in the long-run there exists a positive correlation between inflation and money supply. The magnitude of money supply coefficient in the short-run and the long-run is small and this result agrees with the empirical economic theory that inflation is not always a monetary phenomenon. A rise in the production cost translates into an increase in money supply in China within the study period and has also contributed to the magnitude of the coefficient of the money supply. In addition, he established that there is positive correlation between output gap and inflation in the long-run. In the short-term, the correlation between output gap and
inflation is negative but this result does not support empirical economy theory. Also, in the long-term, there exists a negative correlation between real exchange rate and inflation. But in the short-run real exchange rate appreciation is not able to stop inflation but rather causes inflation. He concluded that international crude oil price does not have any effect on inflation for the period under study.

Katrin et al. (2007) conducted a study on the determinants of inflation in Japan. They used Band Spectrum Regression (BSR) technique to model the data. One of the findings is that money growth positively correlates with inflation in Japan and that there exists unidirectional causality from money growth to inflation, meaning that money growth relates information about future inflations that are not explained in the model. Also, there is positive correlation between output and inflation in the long-run. In the short-term, the correlation between output and inflation is also positive, a result that supports empirical economy theory. The causality that exists between output and inflation is from output to inflation. Though money growth has the potency to predict future inflation rates, this does not in any way an advice to Bank of Japan to target money growth since the relationship over time change the long and variable lags.

Nagayasu (2010) used panel regional data from 1999 to 2005 to test for the relationship between price, money and output using panel cointegration method. He first confirmed the existence of long-term relationship between price, money and output. He explained that there is the a relationship between inflation and money growth, inflation and product growth inflation exchange rate and credits. It is revealed that the Chinese monetary authority targets money growth by using credits and exchange rate as tools.
A study of the factors influencing inflationary pressure in the Libyan economy was carried out by Agil et al. (2013). Time series data from 1980 to 2011 was used to investigate the study topic. ARDL approach cointegration was employed to establish the short run and the long run relationship between the variables. Exchange rate, output gap factors money supply, real income, expected inflation and imported inflation are the time series variables for the study. The study result confirms that in the short-run and the long-run, money supply, imported inflation, and real income significantly impacted inflation most in Libya. In the same vein, output gap, inflation expectation and exchange rate have also impacted inflation but are the effective factors. The p-value of (-0.46) that corresponds to the error correction coefficient suggests a moderate speed of adjustment to equilibrium. This means (-0.46) is significant and further demonstrate tendency of inflation rate returning to the long-run equilibrium after the shocks in the short run.

2.2 Evidence from Ghana

Nortey et al. (2015) investigated the volatility and conditional relationship among inflation rates, exchange rates and interest rates. They also constructed a multivariate GARCH, DCC and BEKK models using data on Ghana from January 1990 to December 2013. The study reveals that the cumulative depreciation of the Cedi to the US dollar from 1990 to 2013 is 7,010.2% and the yearly weighted depreciation of the Cedi to the US dollar for the period is 20.4%. There is evidence that, the fact that the inflation rate is stable does not mean that exchange rates and interest rates are expected to be stable. Rather, when the Cedi performs well on the forex market, inflation rates and interest rates react positively and become stable in the long run.

Appiah (2000) established the notable causal factors of inflation in Ghana. From the regression results, the key determinants of demand in Ghana are the growth of money supply and the rate at
which gross domestic product (GDP) grows in both the short term and the long term, and this is mainly determined by money supply. The Monetarist theory of inflation in the long term is corroborated by the coefficient for money supply from the estimated long-run inflation function. Based on the result forecasted, any attempt by policy makers at reducing the impacts money supply has on inflation depends largely on the central bank’s independence. The independence of this institution is useful in checking the bank’s discretionary monetary practices like financing of government debt by the printing of currency. In addition, the success of inflation targeting policy being practised by countries like the United Kingdom and Sweden which place great value on the autonomy of the central bank emphasizes my point made with regard to the autonomy of the Bank of Ghana. The central objective of this study was to demonstrate the major determining factors of inflation in Ghana. From the regression estimates, it is clear that the rate of growth of real GDP and the growth of money supply are the major determining factors of inflation in Ghana- both in the short term and the long term, and money supply is the key factor. The coefficient for liquidity supply from the estimated long term inflation model corroborates the Monetarist concept of inflation in the long run. Based on the result forecasted, the Bank of Ghana’s autonomy is very necessary if policy makers intend to minimize the impacts liquidity supply has on inflation. The discretionary monetary practices like financing of government debt by the central bank through the printing of currency can be checked by the independence of the Bank.

Osei et al. (2005) used annual data from 1970-2002 in their study of the major determinants that accounted for inflation in Ghana. From 1973 - 1982, military expenditure led to a huge balance of payment deficits in Ghana. In dealing with this problem of deficits, the government of Ghana implemented an expansionary monetary policy. As a result, the money supply appreciated
significantly and this resulted in a rise in the general price level in the country. In 1983, Ghana experienced an increase of 123% in inflation rate. It was found out that the coefficient for money supply has a positive sign which is also statistically significant. This conclusion was drawn from findings that had been obtained from using ordinary least squares econometric method which estimated the long-run inflationary function. Their conclusion is that if the money supply increases, inflation rate in Ghana will increase by 15.72% in the long run. Their study thus lends credence to the monetarist theory of inflation.

Boafo et al. (2013) attempted to find out the macroeconomic factors that accounted for inflation in Ghana from 1990 to 2009. To this end, the time series model selection was influenced by the various diagnostic, evaluation and selection criteria. The result from this study is that the model has adequate predictive powers and the findings compare favourably with those of other studies. Real output and money supply constitute the strongest forces putting pressure on the price level and thereby increasing the exchange rate depreciation, and the implementation of ERP helped reduce the level of inflation in the country. This proves that the ERP accomplished its basic objective which is to reduce the inflationary trend in Ghana. These were established by the research findings.

According to Sowa (1996), inflation seems to be the major headache in Ghana for which no remedy has been found under the economic recovery programme. Possibly, either a wrong diagnosis has been made of the problem, or that certain factors within the economy are preventing inflation from staying within target levels.
Using an Error-Correction Model (ECM), the paper estimates an inflation equation for Ghana. The convenience of this model is in the fact that all the data series exhibit an autoregressive scheme of order one. This means that they are I(1) series. In such an instance, the Granger-Engle Theorem shows that the ECM provides the most efficient model. Further, the ECM unveils some of the short-run dynamics which are missing in other estimation techniques. The results of the econometric regression showed that inflation in Ghana, in either the long run or the short run, is influenced more by output volatility than by monetary factors.

Sowa et al. (1991) explained that even though the periods before and after the reform were part of the objectives of the study, Ghana’s inflationary experience for the period 1963-1989 did not compare these periods. Though regressors like money, output, exchange rate and price expectation were in their inflation equation, their function failed to capture the short term dynamics of the inflation process. Their conclusion is that inflation in Ghana is the result of both real and monetary shock. In accounting for inflation in the ERP period they also recognize the influence of supply-side factors. Their conclusion is that monetary pressures are far outweighed by output pressures on the economy.

Ahiakpor (2014) examined the factors that influence inflation in Ghana over the sample period of 1965-2012, using the Bayesian Model Selection (BMS) techniques to address issues of model uncertainty. Using data from the world development indicators, the study found real output growth, population growth rate, broad money, exchange rate, lending rate and budget deficit as some of the key factors contributing to Ghana’s inflation.
Osei (2014) investigated the determinants of inflation dynamics in Ghana. The findings of the study indicate that the primary determinants of inflation in Ghana are exchange rate, domestic food prices, inflation persistence, reflecting price expectation and the petroleum prices. Domestic inflation is slightly affected by the other determining factors of inflation considered in this study. These factors are money supply and the world food prices. Anchoring inflation expectations and managing exchange rate misalignment are major policy strategies employed by the Central Bank in their bid to attain and maintain price stability in Ghana, in addition to moderating the negative impacts of other inflation determinants. This is the recommendation of the study.

Dodzi et al. (2014) studied the demand for broad money and its long term stability in Ghana. The approach adopted was multivariate time series. The study employed Johansen's cointegration approach to establish that the variables are cointegrated since all the variables are integrated of I(1). Therefore, to find the determining factors of broad money, the vector error correction model was used. In addition, to verify the long-term stability of the demand equation, CUMSUM and CUMSUMSQ plots were used. The verdict is that nominal foreign interest rate and expected inflation are long-term determining factors of demand for money whilst real income and nominal exchange rate are short-term factors. In the period under review, it was also discovered that the long run broad money demand equation was stable.

Andinuur (2013) explored linkages between inflation, foreign direct investment and economic growth in Ghana using annual time series data covering the period 1980 to 2011. The study employs the cointegration approach by Pesaran, Shin and Smith (2001) and the Granger causality testing procedure suggested by Toda and Yamomanto (1995) to empirically examine the relationships and directional relationships between the variables. The study finds that GDP
growth relates positively and negatively with foreign direct investment and inflation respectively both in the long run and short run. The relationship between inflation and foreign direct investment is positive. Furthermore, bidirectional causality was established between GDP growth and FDI, while unidirectional causal links were found from GDP and FDI to inflation. There was no directional causal relationship inflation to GDP and FDI. Finally, a unidirectional causality was discovered running from GDP to inflation.

2.3 Conclusion

The various studies above clearly show that results differ from country to country since they have different economic conditions. Conspicuously, the main determinant of inflation in most countries is money supply.
CHAPTER THREE
METHODOLOGY

3.1 Introduction
The methodology used for achieving the research objectives and questions of this study is described in this chapter. The study is fundamentally focused on analysing the relationship between inflation and the individual macroeconomic variables. This chapter is concerned with the description of the data set and the statistical models; the Autoregressive distributed Lag (ARDL), the Error Correction parametisation of the ARDL Model and Granger Causality technique are the tools that will be used to establish the relationship between inflation and the following: money supply, interest rate, exchange rate and GDP.

3.2 Data Collection and Source
The data set used in the study is secondary. The data on the following variables: money supply, interest rate, inflation and exchange rates and Gross Domestic Product (GDP) are all obtained from the research department of Bank of Ghana for the period 2000-2014.

3.3 Description and transformation of data
We use the actual values obtained from the research department of Bank of Ghana. Before applying the statistical models, each data set was checked for stationary (that is if the mean and variance are constant over time). We check this stationarity by using the Augmented Dickey Fuller (ADF) test. Any data set that is not stationary is differenced using the formula $\Delta Y_t = Y_t - Y_{t-1}$. Every non-stationary data set was differenced until it became stationary.
3.4 Transformation of GDP-Quarterly Data into GDP-Monthly Data

The GDP ($Y_t$) data obtained is on a quarterly basis and to make it fit for the analysis, we did a simple extrapolation. The quarterly data was divided by three (3) which transformed it into a monthly data.

i.e. $Y_m = \frac{Y_q}{3}$, where $Y_m$ is a monthly GDP and $Y_q$ is a quarterly GDP.

3.5 Unit root test for stationarity

Usually, macroeconomic time series variables are found to be non-fixed. A time series data is fixed if its mean and variance are unchanging over time, while the values of the covariance between two time periods depend only on the gap between the periods and not the actual time at which this covariance is considered. If one or both of these conditions are not satisfied, then the process is said to be non-stationary, Charemza and Deadman (1992). The stationarity test of a time series data was carried out using the Augmented Dickey-Fuller Test (ADF), Phillips-Perron test or the KPSS test which could be applied as a perfect substitute to ADF and Phillips and Perron test. Many studies conducted attested to the fact that time series variables are non-stationary or integrated of order 1 (that is, their first difference is fixed). We consider the following time series variables in our studies; money supply, interest rate, inflation and exchange rates Gross Domestic Product (GDP). To apply the ARDL methodology, a unit root test is first performed on the time series variable in the study to establish whether they are stationary or not. For this study, the Augmented Dickey-Fuller (ADF) unit root test was used for this purpose. In the application of the ADF test, three regression forms are generated:
\[ \Delta Y_t = \mu_i Y_{i-1} + \sum_{i=1}^{m} \lambda_i \Delta Y_{t-i} + \varepsilon_t \]  \hspace{1cm} (3.1)

\[ \Delta Y_t = \mu_o + \mu_t Y_{t-1} + \sum_{i=1}^{m} \lambda_i \Delta Y_{t-i} + \varepsilon_t \]  \hspace{1cm} (3.2)

\[ \Delta Y_t = \mu_o + \mu_t Y_{t-1} + \mu_2 t + \sum_{i=1}^{m} \lambda_i \Delta Y_{t-i} + \varepsilon_t \]  \hspace{1cm} (3.3)

Where \( \varepsilon_t \) is white noise error. The lagged terms in the model are to ensure that errors are uncorrelated. The ADF test is based on the hypothesis below:

\[ H_0: Y_t \text{ is not I(0) or } Y_t \text{ is non-stationary} \]

\[ H_1: Y_t \text{ is I(0) or } Y_t \text{ is stationary} \]

The critical value of the ADF test is read from Fuller’s table. We fail to reject the null hypothesis \( (H_0) \) if the test statistic is less than the critical value, and we conclude that the series is non-stationary or not integrated of order zero. In drawing the conclusion of the test conducted, we can compare the probability (that is p-value) of the test to the level of significance. If a variable is integrated of order zero if the variable attains stationarity without differencing, and it is integrated of order one if the variable attains stationarity after first difference.

### 3.6 Cointegration

The linear combination of variables that displays stationarity are said to be cointegrated. If the variables under consideration are found to have unit roots (non-stationarity), and are of the same order, then the cointegration relationship between the variables in the long run can be studied.
either by the Engle-Granger (1987), the Johansen-Juselius (1992) procedure or the ARDL approach. However, the Engle-Granger and Johansen-Juselius procedure can only be used if the variables are integrated of the same order while the ARDL can be used if the variables are integrated of unequal order or same order. However, in this study, the ARDL methodology was used since the order of integration of variables were different.

### 3.7 Cointegration (The ARDL approach)

Lag selection is vital in the ARDL model estimation. In selecting the best lag-length, we use the Final Prediction Error (FPE) criterion, Akaike Information Criterion (AIC) or Schwarz Bayesian criterion (SBC) given that the errors in their nature are white noise. Time series \( (H_t) \) is called white noise if \( (H_t) \) is a sequence of identically distributed and independent random variables with constant mean and variance. Determination of the appropriate lag length precedes, the specification and estimation of ARDL model.

### 3.8 ARDL model the simple case

The ARDL model is given by:

\[
y_t = \mu_o + \mu_1 y_{t-1} + \lambda_o x_t + \lambda_4 x_{t-1} + \epsilon_t
\]

(3.4)

Where it is assumed that \( \epsilon_t \sim iid(0, \sigma^2) \) and \( |\mu_t| < 1 \). The coefficients are interpreted as the long run effects. ARDL (1,1) means that both the dependent and independent variable have a lag of one. In long-run equilibrium, we expect that \( y_t = y_{t-1} \) and \( x_t = x_{t-1} \) so we can write equation (3.4) as:

\[
y_t = \mu_o + \mu_1 y_t + \lambda_o x_t + \lambda_4 x \leftrightarrow (1 - \mu_t) y_t = \mu_o + (\lambda_o + \lambda_4)x
\]

(3.5)
Thus the long-run response to $y$ of a change in $x$ is given by

$$k = \frac{\lambda_o + \lambda_1}{1 - \mu_1}$$  \hspace{1cm} (3.6)$$

Now in establishing the connection between the ARDL model and the error correction model (ECM), subtract $y_{t-1}$ from both sides of equation (3.4) and then add and subtract $\lambda_o x_{t-1}$ on the right-hand side to get

$$y_t - y_{t-1} = \mu_o + (\mu_1 - 1)y_{t-1} + \lambda_o (x_t - x_{t-1}) + (\lambda_o + \lambda_1)x_{t-1} + \varepsilon_t$$ \hspace{1cm} (3.7)$$

And substituting

$$\lambda_o + \lambda_1 = k(1 - \mu_1)$$ from equation (3.6) and $\Delta y = y_t - y_{t-1}$ and $\Delta x = x_t - x_{t-1}$ into equation $\Delta y_t$ we get

$$\Delta y_t = \mu_o + (\mu_1 - 1)(y_{t-1} - kx_{t-1}) + \lambda_o \Delta x_{t-1} + \varepsilon_t$$ \hspace{1cm} (3.8)$$

Thus equation (3.4) is the ECM that is implied by the ARDL (1,1) model. There are other transformations that have been considered in estimating the error correction model.

**3.9 Generalization of the ARDL model**

An ARDL $(m,n)$ model with $p$ exogenous variables, which can also be written as ARDL$(m,n;p)$, is given by:

$$y_t = \mu_o + \sum_{i=1}^{m} \mu_i y_{t-1} + \sum_{j=1}^{p} \sum_{i=0}^{n} \lambda_{ij} x_{jt-1} + \varepsilon_t$$ \hspace{1cm} (3.9)$$

Where $\varepsilon_t \sim i.i.d(0, \sigma^2)$. We might also write this, using the lag operator $L^n z_t = z_{t-n}$, as
\[ \mu(L)y_t = \mu_o + \sum_{j=1}^{p} \lambda_j(L)x_{ij} + \epsilon_t \] \hspace{1cm} \text{where } \mu(L) = 1 - \sum_{i=1}^{m} \mu_i L^i \text{ and } \lambda_j(L) = \sum_{j=1}^{n} \lambda_{ji} L^j \tag{3.10}

However, in the case of only one and two independent variable (i.e ARDL(m,n;1) and ARDL(m,n;2)) as in the case of this project, equation (3.9) can be written as:

\[ y_t = \mu_o + \mu_1 y_{t-1} + \ldots + \mu_m y_{t-m} + \lambda_{01}x_{1t} + \lambda_{11}x_{1t-1} + \ldots + \lambda_{n1}x_{1t-n} + \epsilon_t \tag{3.11} \]

\[ y_t = \mu_o + \mu_1 y_{t-1} + \ldots + \mu_m y_{t-m} + \lambda_{01}x_{1t} + \lambda_{11}x_{1t-1} + \ldots + \lambda_{n2}x_{1t-n} + \epsilon_t \tag{3.12} \]

It is possible that one can use other techniques to transformation this equation and because they do not add or remove any linearly independent columns from the data matrix, or similar projections of the dependent variable on to the data. In the same vein, with joint stationarity in long-run equilibrium we expect \( y_t = y_{t-1} \) and \( x_t = x_{t-1} \). so we can write the equation (3.9) as

\[ y_t = \mu_o + \sum_{i=1}^{m} \mu_i y_{t-1} + \sum_{j=1}^{p} \sum_{i=0}^{n} \lambda_{ji} x_{jt} \tag{3.13} \]

\[ (1 - \sum_{i=1}^{m} \mu_i) = \mu_o + \sum_{j=1}^{p} \sum_{i=0}^{n} \lambda_{ji} x_{jt} + \epsilon_t \tag{3.14} \]

Thus the long-run response to \( y \) of a change in \( x \) is given by

\[ k = \frac{\sum_{j=1}^{p} \sum_{i=0}^{n} \lambda_{ji}}{1 - \sum_{i=1}^{m} \mu_i} = \frac{\sum_{j=1}^{p} \lambda_j(1)}{\mu(1)} \tag{3.15} \]
Where $\mu(1)$ and $\lambda(1)$ represent the substitution of unity for the lag operator $L$ in the lag polynomials.

3.10 The error correction parametrization of the generalized ARDL model

Error correction models in time series econometrics provides a way of capturing adjustments in a dependent variable which depend on the extent to which an explanatory variable deviates from an equilibrium relationship with the dependent variable. It measures the speed at which a dependent variable $Y$ returns to equilibrium after a change in an independent variable $X$. We can derive a generalized error correction model (ECM), corresponding to the $ARDL(m, n; p)$ model with $p$ exogenous variables $x_1, x_2, ..., x_p$ by steps similar to those used in the specific cases above.

The result, which allows us to specify directly a general dynamic regression model in the form of an ECM, is (for $r \leq m$):

$$
\Delta y_t = \mu_0 + \sum_{i=1}^{r} \eta_i \left( y_{t-1} - \sum_{j=1}^{p} x_{j,t-1} \right) + \sum_{j=1}^{p} \lambda_{j0} \Delta x_{jt} + \sum_{j=1}^{p} \sum_{i=1}^{r} \xi_{ji} x_{j,t-i} + \sum_{i=1}^{n} \sum_{r+1}^{m} \lambda_{ji} x_{i,t-i} + \sum_{i=1}^{m} \mu_i y_{i,t-i} + \epsilon_t \quad (3.16)
$$

With

$$
\eta_i = \mu_i - 1, \quad \eta_i = \mu_i, \quad i = 2, ..., r \quad r = \min(m, n)
$$

$$
\xi_{ji} = \mu_i - 1 + \lambda_{ji}, \quad \xi_{ji} = \mu_i + \lambda_{ji}, \quad i = 2, ..., r
$$

and $x_{j,t-i} = (x_{j,t} - x_{j,t-i})$

3.11 ARDL Model specification as applied to the variables under study

Three ARDL models will be specified and estimated all variables under study. Thus, inflation on the rest of the variables: money supply, interest rate, exchange rate and Gross Domestic Product (GDP).
\[ I = \kappa_o + \sum_{i=1}^{m} \mu_i I_{t-i} + \sum_{i=1}^{n} \lambda_i M_{t-i} + \sum_{i=1}^{r} \gamma_i R_{t-i} + \sum_{i=1}^{w} \phi_i E_{t-i} + \sum_{i=1}^{z} \psi_i GDP_{t-i} + \mathcal{Q}_t \]  

(3.17)

Where \( I \) = Inflation Rate

\( M \) = Money Supply

\( R \) = Interest Rate

\( E \) = Exchange Rate

\( GDP \) = Gross Domestic Product

\( m, n, r, w, z \) are lag length of inflation rate, money supply, interest rate, exchange rate and (GDP) respectively.

\( \mathcal{Q}_t \) the white noise error term and \( \kappa_o \) the drift component.

In investigating the long run relationships between inflation rate and money supply; inflation rate and interest rate; inflation rate and exchange rate; and inflation rate and gross domestic product, the bound testing procedure under Pesaran et al. (2001) is used. F-test is used as the test procedure. The test hypothesis is a test of no cointegration among the variables against the existence or presence of cointegration among the variables. The hypotheses are similarly stated as:
\( H_0 : \mu_1 = \mu_2 = 0 \)
\( H_1 : \mu_1 \neq \mu_2 \neq 0 \)

\( H_0 : \varphi_1 = \varphi_2 = 0 \)
\( H_1 : \varphi_1 \neq \varphi_2 \neq 0 \)

\( H_0 : \alpha_1 = \alpha_2 = 0 \)
\( H_1 : \alpha_1 \neq \alpha_2 \neq 0 \)

\( H_0 : \gamma_1 = \gamma_2 = 0 \)
\( H_1 : \gamma_1 \neq \gamma_2 \neq 0 \)

The paired equations above are to respectively test whether inflation rate and money supply; inflation rate and interest rate; inflation rate and exchange rate; and inflation rate and gross domestic product are in their paired nature co-integrated.

The ARDL bound testing procedure is based on a Wald-test (F-statistic). The wald statistics is distributed under the null hypothesis of no cointegration among the variables. Pesaran et al. (2001) provided two critical values (lower and upper bounds) for testing cointegration relationship between variables. According to the values provided by Pesaran, the lower critical value assumes that all the variables are I(0) meaning that there is no cointegration relationship between the variables under study. However, the upper bound assumes that all the variables are I(1) implying that there is a cointegration relationship between the variables. If the computed F-statistics from the test is greater than the upper critical value, \( H_o \) is rejected (meaning the variables are cointegrated). However, if the F-statistic is below the lower bound critical value, \( H_o \) cannot be rejected (meaning there is no cointegration among the variables). Also, if the computed F-statistics falls between the lower and upper bound values of the critical values then the results are inconclusive.
After establishing the existence of cointegration relationship, the estimates of the long run coefficients between the variables are computed. After the parameters of the short run, parameters can then be estimated using the error correction model. The most appropriate models are selected based on the Schwarz Bayesian Criteria in relation to the lags of each variable. The error correction model was used to help capture the speed of adjustment to equilibrium among the variables affecting GSE market returns.

3.12 ECM specification as applied to the variables under study

Equation (3.9) is the ECM specification for inflation rate, money supply, interest rate, exchange rate, and gross domestic product.

\[
I = \kappa + \sum_{i=1}^{m} \mu_i I_{t-i} + \sum_{i=1}^{n} \lambda_i M_{t-i} + \sum_{i=1}^{r} \gamma_i R_{t-i} + \sum_{i=1}^{w} \phi_i E_{t-i} + \sum_{i=1}^{z} \psi_i GDP_{t-i} + ECM_{t-i} + \vartheta
\]  

(3.18)

3.13 Model Selection Criteria

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

The Akaike Information Criterion (AIC) was introduced by Hirotogu Akaike in 1973. It was the first model selection criterion to gain widespread acceptance. The AIC was an extension to the maximum principle and consequently the maximum likelihood principle which is applied to estimate the parameters of the model once the structure of the model has been specified. The AIC is defined as;

\[ \text{AIC} = 2(N) - 2(\text{loglikelihood}) \]

where \( N \) is the number of parameters in the model. Given a family of competing models of various structures, the maximum likelihood estimation is used to fit the model and the AIC is computed based on each model fitted. The selection of the most appropriate model is then made by considering the model with the minimum AIC. The first term of the AIC equation above measures the model goodness of fit whereas the second term is called the penalty function. It is called the penalty function because it penalizes a competing model by the number of parameters it contains.

3.15 Schwarz Bayesian Information Criterion

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

\[ \text{BIC} = k \ln(N) - 2(\text{loglikelihood}) \]

Where \( N \) denotes the number of parameters in the model, \( n \) is the length of the time series or the sample size. Again, the maximum likelihood estimation is used to fit the model and the BIC is computed for each of the models in a family of competing models and the fitted model with the minimum BIC is considered to be the most appropriate model.
3.16 Model diagnostic checks

The model diagnostic checks are performed to determine the adequacy or goodness of fit of a chosen model. The model diagnostic checks are performed on residuals. According to the ARDL model, the residuals are assumed to be independently and identically distributed with fluctuating variance and serially uncorrelated errors.

3.17 Diagnostic tests for the ARDL model

To ascertain how good the ARDL model is, we conducted stability and diagnostic tests. The diagnostic tests conducted were the serial correlation test of residuals, normality and heteroscedasticity associated with the residuals. The stability test conducted was the cumulative sum of recursive residuals (CUSUM) to determine if there were significant breaks with the sampled period.

3.18 Lagrange multiplier (LM) test for Serial correlation

The LM statistic is useful in identifying serial correlation, not only of the first order, but of higher orders as well. In carrying out the test we first estimate the regression model (in this case the ARDL model) by ordinary least squares and compute its estimates residuals \( e_t \). After we regress the errors \( e_t \) against the independent variable \( x_{i1}, ..., x_{ik} \). The test statistic is

\[
LM = (n-1)R_{e}^2
\]

Where \( R_{e}^2 \) is the R-square from the regression model. We reject the null hypothesis of no serial correlation \( (\rho = 0) \) in favour of the alternative that \( (\rho \neq 0) \) if \( (n-1) R_{e}^2 > \chi^2_{1,(1-\alpha)} \) If the test shows that there is serial correlation in the residuals, then we would expect \( e_t \) to be related to \( e_{t-1} \).
3.19 Testing for Heteroscedasticity

To test the null hypothesis of homoscedasticity against the null hypothesis of heteroscedasticity we apply the Breusch-Pagan Test. The test either uses the F-statistic which is dependent on the goodness of fit measure from the entire model or the Lagrange multiplier statistic which is an easier approach. Therefore, the test statistic for the Breusch-Pagan test for heteroscedasticity based on the Lagrange Multiplier is given by:

\[ LM = nR_e^2 \]

The LM statistic is distributed as where \( \chi_k^2 \), \( k \) is the number of regressors.
3.21 The concept of Granger causality (The pairwise relation between Inflation and the following variables: Money Supply, Interest rate, Exchange rate, GDP)

A time-series data approach to causality was proposed by Granger (1969). According to Granger, \( x \) is a cause of \( y \) if it is useful in predicting \( y \). “Useful” in this context is explained to mean that \( x \) has contributed to effectively to predicting \( y \) in relation to a forecast, considering only past values of \( y \).

**Definition:** “Assuming to have an information set \( \Omega_t \) with the form \((x_t, \ldots, x_{t-j}, y_t, \ldots, y_{t-i})\), we say that \( x \) is *Granger causal* for \( y \) wrt. \( \Omega_t \), if the variance of the optimal linear predictor of \( y_{t+h} \), based on \( \Omega_t \), has smaller variance than the optimal linear predictor of \( y_{t+h} \) based only on lagged values of \( y_t \), for any \( h \). Thus, \( x \) *Granger-causes* \( y \) if and only if \( \sigma_1^2(y_{t+h} : y_{t-j}, x_{t-i}) < \sigma_2^2(y_{t+h} : y_{t-j}) \), with \( j \) and \( i = 1, 2, 3, \ldots, n \) and \( \sigma^2 \) representing the variance of the forecast error.”

There three different ways Granger-causality test can be applied but this work looks at one and that is the, the simple Granger-causality test were two variables are considered at a time given there lags. Others are one, multivariate Granger-causality test which considers more than two variables and the last one is the Granger-causality which is tested in a VAR framework which is an extension of the multivariate model to test for simultaneity of all included variables.

Now considering the simple case the following equations can be specified according to Mahdavi and Sohrabian (1989) for the relations between: Inflation and Money supply, Inflation and Exchange rate, Inflation and Interest rate, and Inflation and GDP.
3.21.1 The Relation between Inflation (I) and Money supply (M)

\[ I_t = \alpha + \sum_{i=1}^{m} \beta_i (I)_{t-i} + \sum_{j=1}^{n} r_j (M)_{j-1} + \mu_t \]  
(3.27)

\[ M_t = \theta + \sum_{i=1}^{p} \phi_i (M)_{i-1} + \sum_{j=1}^{q} \varphi_j (I)_{j-1} + \eta_t \]  
(3.28)

3.21.2 The Relation between Inflation (I) and Exchange rate (E)

\[ I_t = \delta + \sum_{i=1}^{x} \chi_i (I)_{t-i} + \sum_{j=1}^{y} \gamma_j (E)_{j-1} + \zeta_t \]  
(3.29)

\[ E_t = \delta + \sum_{i=1}^{a} \sigma_i (E)_{i-1} + \sum_{j=1}^{b} \upsilon_j (I)_{j-1} + \xi_t \]  
(3.30)

3.21.3 The Relation between Inflation (I) and Interest rate (R)

\[ I_t = \gamma + \sum_{i=1}^{o} \mu_i (I)_{t-i} + \sum_{j=1}^{p} \delta_j (R)_{j-1} + \Psi_t \]  
(3.31)

\[ R_t = \nu + \sum_{i=1}^{e} \rho_i (R)_{i-1} + \sum_{j=1}^{h} \kappa_j (I)_{j-1} + \xi_t \]  
(3.32)

3.21.4 The Relation between Inflation (I) and GDP

\[ I_t = h + \sum_{i=1}^{q} \Lambda_i (I)_{t-i} + \sum_{j=1}^{r} \kappa_j (GDP)_{j-1} + \varphi_t \]  
(3.33)

\[ GDP_t = \Omega + \sum_{i=1}^{s} \lambda_i (I)_{i-1} + \sum_{j=1}^{f} \gamma_j (GDP)_{j-1} + \Xi_t \]  
(3.34)
3.22 Hypotheses Test for a Simple Granger-Causality Testing

Three different hypotheses can be formulated between each pair of variables based on the estimated OLS coefficients for the equations above.

(1) Unidirectional Granger-causality: One variable Granger-cause the other but not vice versa.

\[
\begin{align*}
\sum_{j=1}^{n} \lambda_j &\neq 0 \text{ and } \\
\sum_{j=1}^{m} \omega_j &\neq 0
\end{align*}
\]

(2) Bidirectional (or feedback) causality: One variable Granger-cause the other and vice versa.

\[
\begin{align*}
\sum_{j=1}^{n} \lambda_j &\neq 0 \text{ and } \\
\sum_{j=1}^{m} \omega_j &\neq 0
\end{align*}
\]

(3) Non-directional Granger-causality: In this case there is no Granger-causality in any direction.

\[
\begin{align*}
\sum_{j=1}^{n} \lambda_j &\neq 0 \text{ and } \\
\sum_{j=1}^{m} \omega_j &\neq 0
\end{align*}
\]

The Granger-causality testing procedure is based on a Wald-test (F-statistic). The wald statistics is distributed under the null hypothesis of no causality between variables. One critical value for testing causality between variables is computed. However, the null hypotheses is rejected if the F-statistics is greater the critical at 5% level of significance otherwise, the null is uphold.
CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter presents the analysis and the discussion of the results obtained from the study. The data used for the study consist of monthly inflation rates, money supply, exchange rate (US dollar rate), interest rate, Gross Domestic Product (GDP). The chapter begins with a diagnostic analysis of the stationarity of the three variables (returns, inflation and exchange rate) in the study. This is then followed by the Autoregressive distributed lag (ARDL), Error correction model (ECM) methodology which was used in determining the short and long run relationships between the variables and the causality check is carried out the Engel Granger Causality technique. The various graphs were drawn by the help of Ms Excel; MICROFIT 5.0 was used for the ARDL methodology.
4.2 Preliminary analysis

The preliminary analysis seeks to test the stationarity status of the variables used in this work, and this is done by time series plots.

Figure 4.1: Time series plot of nominal interest rate (Monthly data) in Ghana (2000-2014)

Figure 4.2: Time series plot of nominal GDP (Monthly data) in Ghana (2000-2014)
Figure 4.3: Time series plot of the monthly inflation rate in Ghana (2000-2014)

Inflation (year-on-year)

Year


Figure 4.4: Time series plot of the monthly money supply in Ghana (2000-2014)

Money supply

Year

Figures 4.1 – 4.5 display the time series plots of money supply, GDP, inflation rate, interest rate, and exchange rate on the monthly for the period January 2000 to December 2014. The figures show that the five variables used to plot the time series do not have constant means stable variances except money supply. To confirm the presence of this non-stationarity, the Augmented Dickey-Fuller (ADF) test was performed. The p-value of the tests were more than 0.05 except for interest rate whose p-value was 0.263, hence we fail reject the null hypothesis of unit root (non-stationarity) at 5% level of significance. We conclude that, apart from interest rate which was stationary over the period, the rest of the variables are non-stationary over the period January 2000 to December 2014. The following table 4.1 shows the result of the Augmented Dickey-Fuller (ADF) test.
Table 4.1: Augmented Dickey-Fuller Unit Root Test for Money supply, Interest rate, Inflation rate, Exchange rate (Dollar rate), and GDP (all are monthly variables) in Ghana (2000-2014).

Null Hypothesis: Interest rate has a unit root

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rate</td>
<td>Constant</td>
<td>-4.129215</td>
<td>-2.878723</td>
<td>0.0063*</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-4.550897</td>
<td>-3.436957</td>
<td>0.0018*</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>-2.965066</td>
<td>-1.942745</td>
<td>0.0097*</td>
</tr>
</tbody>
</table>

Null Hypothesis: Exchange rate has a unit root

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange rate</td>
<td>Constant</td>
<td>-0.451076</td>
<td>-3.877636</td>
<td>0.8963</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-2.252660</td>
<td>-5.435269</td>
<td>0.4572</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>0.243964</td>
<td>-2.942624</td>
<td>0.7559</td>
</tr>
</tbody>
</table>

Null Hypothesis: Gross Domestic Product has a unit root

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>Constant</td>
<td>-0.967332</td>
<td>-2.878723</td>
<td>0.7642</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-2.075187</td>
<td>-4.436957</td>
<td>0.5554</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>2.161027</td>
<td>-1.942745</td>
<td>0.9928</td>
</tr>
</tbody>
</table>
Null Hypothesis: Inflation rate has a unit root

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>Constant</td>
<td>-0.705324</td>
<td>-2.878723</td>
<td>0.8414</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-2.421404</td>
<td>-5.436957</td>
<td>0.3672</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>2.456334</td>
<td>-3.942745</td>
<td>0.9967</td>
</tr>
</tbody>
</table>

Null Hypothesis: Money Supply has a unit root

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money Supply</td>
<td>Constant</td>
<td>-1.992281</td>
<td>-2.877636</td>
<td>0.2901</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-1.723552</td>
<td>-3.435269</td>
<td>0.7369</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>-0.435544</td>
<td>-1.942624</td>
<td>0.5245</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

We cannot apply the technique of Autoregressive distributed lag model (ARDL) and Error correction model (ECM) to a non-stationary (i.e. the data is not integrated of order zero (I(0))). We need to transform these variables by a suitable transformation technique, which in our case is the ordinary differencing transformation. All the variables involved in the study were differenced once in order to attain stationarity, and were displaced in Figures (4.6, 4.7, 4.8 and 4.9) and table 4.2. The plots show that the mean and variance of the first difference of the variables appear to be constant over time. This is confirmed by the ADF test of stationarity. Since the p-values from Table 4.2 are each less than 0.05 we conclude that the variables are stationary. Hence this shows
that after first difference, all the variables became stationary. This means that the variables are integrated of order one I(1).

**Figure 4.6:** Time series plot of the first difference of monthly GDP in Ghana (2000-2014)

**Figure 4.7:** Time series plot of the first difference of monthly inflation rate in Ghana (2000-2014)
Figure 4.8: Time series plot of the first difference of monthly money supply in Ghana (2000-2014)

Figure 4.9: Time series plot of monthly Exchange rate after the first difference (2000-2014)
Table 4.2 Augmented Dickey-Fuller Unit Root Test for Interest rate, Inflation rate, Exchange rate (Dollar rate), and GDP (all are monthly variables) in Ghana (2000-2014) after first difference.

Null Hypothesis: D(Exchange rate) has a unit root

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(Exchange rate)</td>
<td>Constant</td>
<td>-5.796190</td>
<td>-2.877636</td>
<td>0.0000*</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-5.765957</td>
<td>-3.435269</td>
<td>0.0000*</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>-5.141940</td>
<td>-1.942624</td>
<td>0.0000*</td>
</tr>
</tbody>
</table>

Null Hypothesis: D(Gross Domestic Product) has a unit root

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(GDP)</td>
<td>Constant</td>
<td>-3.424296</td>
<td>-2.878723</td>
<td>0.0094*</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-3.673193</td>
<td>-3.436957</td>
<td>0.0162*</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>2.161027</td>
<td>-1.942745</td>
<td>0.0035*</td>
</tr>
</tbody>
</table>
Null Hypothesis: D(Inflation rate) has a unit root

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(Inflation rate)</td>
<td>Constant</td>
<td>-13.09422</td>
<td>-2.877636</td>
<td>0.0000*</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-13.05758</td>
<td>-3.435269</td>
<td>0.0000*</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>-13.13078</td>
<td>-1.942624</td>
<td>0.0000*</td>
</tr>
</tbody>
</table>

Null Hypothesis: D(Money Supply) has a unit root

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model type</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(Money Supply)</td>
<td>Constant</td>
<td>-10.31258</td>
<td>-2.877636</td>
<td>0.0000*</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-10.35839</td>
<td>-3.435269</td>
<td>0.0000*</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>-10.33993</td>
<td>-1.942624</td>
<td>0.0000*</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

4.3 The Autoregressive Distributed Lag Model (ARDL)

We have already established that GDP, inflation rate, money Supply, and exchange rate are integrated of order one I(1) and according to Pesaran et al., (2001), variables that are integrated of order one I(1), order zero I(0) or the mixed of order zero I(0) and order one I(1) are best fit for the ARDL approach. To measure the effect of all other variables on inflation which is the dependent variable, a ARDL model was built to measure the effect money supply, GDP, interest rate, and exchange rate on inflation.
4.4 ARDL model for Inflation Rate against Money Supply, Interest rate, Exchange rate, and GDP.

Table 4.3 displays the estimates of the ADRL model describing the pair relationship between inflation rate and the followings: money supply GDP, interest rate, and exchange rate. We study both the short and long run relationships and effects.

<table>
<thead>
<tr>
<th>Number of regressors</th>
<th>Computed F-statistic</th>
<th>5% critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound Value</td>
</tr>
<tr>
<td>K = 4</td>
<td>9.647</td>
<td>4.94</td>
</tr>
</tbody>
</table>

The F – statistics was calculated field data whilst values for the critical bound were extracted from Pesaran et al table, (2001).

Table 4.3 displays the result of the ARDL bound test for cointegration for Inflation rate, Money supply, Interest rate, Exchange rate, and GDP, Inflation being the dependent variable. The null hypothesis of no cointegration is rejected since the F–statistics calculated which is 9.647 is above the upper bounds critical value of 5.73 at 5% level of significance this according to (pesaran et al, 2001). This implies there exist a long-run relationship between the variables.

The estimates for the ARDL long-run coefficient and that of the Error Correction Model (ECM) are computed in the Tables; 4.4 and 4.5 respectively. ARDL (1,0,0,0,0) means that the dependent variable (Inflation rate) has a lag of one whiles each independent variable (exchange rate, Interest rate, Money supply, and GDP) has a lag of zero.
Table 4.4: Estimated Long Run coefficients: ARDL (1,0,0,0,0) selected by Schwarz Bayesian Criterion.

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money Supply</td>
<td>0.9642</td>
<td>0.8868</td>
<td>1.0873</td>
<td>0.007*</td>
</tr>
<tr>
<td>Exchange Rate</td>
<td>0.0524</td>
<td>0.0117</td>
<td>4.4671</td>
<td>0.000*</td>
</tr>
<tr>
<td>Interest Rate</td>
<td>-0.2106</td>
<td>0.0700</td>
<td>-3.0043</td>
<td>0.012*</td>
</tr>
<tr>
<td>GDP</td>
<td>-0.5405</td>
<td>0.2617</td>
<td>-2.0651</td>
<td>0.000*</td>
</tr>
<tr>
<td>Constant</td>
<td>0.1134</td>
<td>0.0225</td>
<td>5.0453</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

The results displayed in Table 4.4 show the long run relationship of Inflation rate which is the dependent variable in relation to the other variables (independent variables) which are Money supply, Exchange rate, Interest rate, and GDP. The p-value of each of the variable used in the computation is less than 0.05. This means Money supply and Interest rate have a negative significant effect on Inflation rate. On the contrary, Exchange rate and GDP have a positive significant effect on Inflation rate. The coefficient of money supply is estimated to be 0.9642 which an injection of GHc1.00 into the economy will cause rise in inflation by 0.9642% on the average holding all other independent variables constant and vice versa. Again, a 1% appreciation of the dollar against Ghana cedis will lead an average increase in inflation rate by 0.0524% all things being equal. The inverse relation between inflation rate and interest rate makes that a 1% in interest rate will on the average cause a decline in inflation rate 0.2106% holding other variables constant, and finally a 1% growth in the economy will lead to an average decline in inflation rate by a percentage margin of 0.5405 consideration all other things being equal.
This means that Money supply, Exchange rate, Interest rate, and GDP have an aggregate significant long run effect on inflation rate.

Table 4.5: Error correction representation of the selected ARDL model: ARDL (1,0,0,0,0) selected by Schwarz Bayesian Criterion.

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>Prob</th>
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<tr>
<td>Money Supply</td>
<td>0.5642</td>
<td>0.3204</td>
<td>1.7700</td>
<td>0.00*</td>
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<td>d(Exchange Rate)</td>
<td>-0.0102</td>
<td>0.0040</td>
<td>-2.5641</td>
<td>0.010*</td>
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<tr>
<td>d(Interest Rate)</td>
<td>-0.0940</td>
<td>0.0504</td>
<td>1.8650</td>
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<tr>
<td>d(GDP)</td>
<td>-0.0408</td>
<td>0.0133</td>
<td>3.0601</td>
<td>0.701</td>
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<tr>
<td>ECM(-1)</td>
<td>-0.0321</td>
<td>0.0104</td>
<td>3.0875</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Source: Computations based on the researchers own calculation from field data

In table 4.5 above, the results show that Money supply and Exchange rate have a significant effect on Inflation rate in the short-run. On the other hand, Interest rate and GDP has no short-run significant effect on Inflation rate. The p-value of (0.008) that corresponds to the error correction coefficient suggests a moderate speed of adjustment to equilibrium.

4.5 Diagnostic tests for Inflation rate against Money supply, Exchange rate, Interest rate, and GDP model.

The model fits well since the estimated R-square value of the ARDL model is 0.7023 (70.23%). The result from the test for heteroscedasticity by the use of Langrange Multiplier test distributed as chi-square has a value of 0.10233 as against a p-value of 0.618. In the same vein, Langrange Multiplier test for serial correlation was ran and the value is 0.08343 against a p-value of 0.512. Also, the chi-square value from a Shapiro Wilks test for normality is 0.76 against a p-value of 0.543 which satisfied the assumption of normality of error test.
We conclude that the diagnostic tests for heteroscedasticity, serially uncorrelated errors, and normality are satisfied at 5% level of significance.

The estimates from the recursive errors suggest stability of the regression coefficients over the sampled periods. This is evident based on the Cumulative Sum (CUSUM) plot from the recursive residuals.

**Figure 4.10: CUSUM test for stability.**
4.6 The concept of Granger causality (The pairwise relation between Inflation and the following variables: Money Supply, Interest rate, Exchange rate and GDP)

It has been established that there is a long-run relationship between inflation rate, money supply, exchange rate, interest rate and GDP. Now we would want to determine the direction of causality between these variables which also means to ascertain the responsiveness of these macroeconomic variables to each other contemporaneously.

Table 4.6: a pairwise Granger-causality test
Sample: 180
Lags: 2

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Obs</th>
<th>F-Statistics</th>
<th>P-value</th>
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<tbody>
<tr>
<td>Money supply does not Granger-Cause Inflation rate</td>
<td>178</td>
<td>8.97481</td>
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<td>Inflation rate does not Granger-Cause Money supply</td>
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<td>Interest rate does not Granger-Cause Inflation rate</td>
<td>178</td>
<td>9.35104</td>
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<td>GDP does not Granger-Cause Inflation rate</td>
<td>178</td>
<td>3.87211</td>
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<td>Inflation rate does not Granger-Cause GDP</td>
<td>3.37158</td>
<td>0.0037'</td>
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</table>

Source: Calculations based on the researchers own calculation from field data

The Granger causality test reported in table 4.6 uses two (2) lags. The test results show that there is a unidirectional causal relation running from inflation rate to money supply at 5% level of
significance, rejecting the null hypothesis that states that “Money supply does not Granger-Cause Inflation rate” since the p-value of (0.0002) is less that 5% level of significance. In the same vein, we fail to reject the null hypothesis that states “Inflation rate does not Granger Cause Money supply”, a confirmation of a unidirectional relation from money supply to Inflation rate. This agrees with the monetary economics theorists that propound that inflation everywhere is a monetary issue. Also, we reject the null hypothesis that states that “Interest rate does not Granger-Cause Inflation rate” at 5% level of significance since the p-value of (0.0001) is less than 5% significant value, which means that interest rate Granger-causes inflation rate. On the other hand, we fail to reject a null hypothesis which states that “Inflation rate does not Granger-Cause Interest rate” since the p-value of (0.6950) is greater than 5%. By interpretation, it means that there is a unidirectional causality from interest rate to inflation rate, hence increasing product costs by increasing interest rate raises product’s prices and consequently inflation a position confirmed by Berument (1999).

In another development we fail to reject the null hypothesis that exchange rate does not Granger-Cause inflation rate since the p-value of (0.1377) is greater than 5% significant value and we fail to reject the null hypothesis that inflation rate does not Granger Cause exchange rate given the p-value of (0.96021) which is greater than 5% level of significance. This result also suggests a non-directional causality between exchange rate and inflation rate and vice versa. The outcome supports the literature by Flood and Rose (1995) who concluded that there is no causality between exchange and inflation. Finally, there exists a bidirectional causality between GDP and inflation rate. The null hypotheses; “GDP does not Granger Cause Inflation rate” and “Inflation rate does not Granger Cause GDP” are both rejected based on the fact that the p-values of (0.0012) and (0.0037) respectively are less than 5% level of significance. The test conducted by
Vikesh Gokal and Subrina Hanif (2004) on the topic “Relationship between inflation and growth” revealed a weak negative relationship between inflation and growth, given the change in output gap bears a significant bearing. The causality between the two variables run one-way from GDP growth to inflation and this finding contradicts in one way our claim based on the field data that there is a bidirectional causality between inflation and GDP.
CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The chapter focuses mainly on a summary of all findings from the study, conclusions and recommendations to guide others in future works. The study seeks to examine the relation between inflation and some key macroeconomic variables as follows: money supply, interest rate, exchange rate and GDP in Ghana. These macroeconomic variables are obtained from the Bank of Ghana spanning through January 1990 to December 2014. Monthly data are obtained except GDP which is also transformed to a monthly data. We use the Augmented Dickey-Fuller (ADF) technique, the Granger Causality Test Technique, the Autoregressive Distributed Lag (ARDL) Cointegration Technique, and the Error Correction Model (ECM) of the ARDL model. Unit root test is performed using the ADF test, the p-value of the tests are more than 0.05 except for interest rate whose p-value is 0.263, which that means apart from interest which is stationary over the period, the rest of the variables are non-stationary over the period January 2000 to December 2014. The rest of the variables have also attained stationarity after their first difference. The ARDL model is used in establishing the long-run relation between inflation rate and money supply, interest rate, exchange rate and GDP.

Money supply and interest rate have a negative significant effect on inflation rate. On the contrary, exchange rate and GDP have a positive significant effect on inflation rate. The coefficient of money supply is estimated to be 0.9642 which means an injection of GHc1.00 into the economy will cause a rise in inflation by 0.9642% on the average holding all other independent variables constant and vice versa. Again, a 1% appreciation of the dollar against the Ghana cedi will lead to an average increase in inflation rate by 0.0524% all things being equal.
The inverse relation between inflation rate and interest rate means a 1% increase in interest rate will on the average cause a decline in inflation rate 0.2106% holding other variables constant, and finally a 1% growth in the economy will lead to an average decline in inflation rate by a percentage margin of 0.5405, all other things being equal. ECM is used in establishing the relation between the variables in the short-run and the results reveal that money supply and Exchange rate have a significant effect on inflation rate in the short-run. On the other hand, interest rate and GDP have no short-run significant effect on inflation rate. The p-value of (0.008) that corresponds to the error correction coefficient suggests a moderate speed of adjustment to equilibrium.

The Granger-causality test uses two (2) lags. The test results show there is a unidirectional causal relation running from inflation rate to money supply and a unidirectional causality from interest rate to inflation. The results also suggest a non-directional causality between exchange rate and inflation rate and a bidirectional causality between GDP and inflation rate. The level of significance used throughout the study is 5%.

5.2 Conclusions

This section tries to evaluate the set objectives outlined to be achieved. The ARDL model is used to establish the long-run relation between inflation rate and money supply, interest rate, exchange rate, and GDP. ECM is used to establish the relation between the variables in the short-run and the results reveal that money supply and Exchange rate have a significant effect on inflation rate in the short-run. On the other hand, interest rate and GDP have no short-run significant effect on inflation rate.
The Granger-causality test uses two (2) lags. The test results show there is a unidirectional causal relation running from inflation rate to money supply and a unidirectional causality from interest rate to inflation. The results also suggest a non-directional causality between exchange rate and inflation rate and a bidirectional causality between GDP and inflation rate.

5.3 Limitations of the study

- The limitation to this project stems from the extrapolation of the quarterly data into monthly data which does not reflect the reality on the ground.

5.4 Recommendations

The following recommendations are proposed based on the findings from the research work.

1. Government must focus all its efforts on macroeconomic stability because volatility in any one of the key macroeconomic variables influences another variable especially inflation which determines cost of goods and services in the economy, in the short-run and the long-run.

2. Bank of Ghana and government must work closely together since inflation does not only stem from money supply.
REFERENCES


Gottschalk. (2008). Determinants of inflation when there are data limitations in the case of Sierra Leone. *Internet*.


## APPENDICES

### Appendix A

#### Data

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>GH₵/US$</th>
<th>GH₵/GBP</th>
<th>Inflation (YOY)</th>
<th>M2 (GHC'M)</th>
<th>M2+ (GHC'M)</th>
<th>Monetary Policy Rate</th>
<th>Inter-Bank Rate</th>
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