THE RELATIONSHIP BETWEEN INFLATION AND ECONOMIC GROWTH IN ETHIOPIA

by

ABIS GETACHEW MAKURIA

submitted in accordance with the requirements

for the degree of

Master of Commerce

in the subject

ECONOMICS

at the

UNIVERSITY OF SOUTH AFRICA

Supervisor: **DR. SENIA NHAMO**

November 2013

Declaration and Copyright

I declare that **The Relationship between Inflation and Economic Growth in Ethiopia**
is my own work and that all the sources that I have used or quoted have been indicated
and acknowledged by means of complete references.

…………………………………………………

Signature: A.G. Makuria

Acknowledgements

I wish to thank my supervisor Dr. Senia Nhamo for her constructive advice and encouragement over the course of this dissertation.

I wish also to thank the UNISA student funding (USF) for the financial assistance of this dissertation.

ABIS G. MAKURIA

November 2013

Abbreviations and Acronyms

ADF – Augmented Dickey Fuller test

AIC – Akaike Information Criteria

ARDL – Autoregressive Distributive Lag

ARCH – Autoregressive Conditional Heteroscedasticity

ASEAN – Association of South East Asian Nations

BOP – Balance of Payment

CE – Co-integrating Equation

CIS – Commonwealth of Independent States

CLRM – Classical Linear Regression Model

CPI – Consumer Price Index

CLS – Conditional Least Square

CSA – Central Statistics Agency

CUSUM – Cumulative Sum

DW – Durbin Watson

ECM – Error Correction Model

ECT – Error Correction Term

EIA – Ethiopian Investment Agency

GDP – Gross Domestic Product

GTP – Growth and Transformation Plan

HP – Hodrick-Prescott

HQ – Hannan-Quinn

IFS – International Finance Statistics

IMF – International Monetary Fund

IID – Independently and Identically Distributed

LM – Lagrange Multiplier

LR – Likelihood Ratio

MA – Moving Average

MDGs – Millennium Development Goals

MoFED – Ministry of Finance and Economic Development

NBE – National Bank of Ethiopia

OECD – Organization for Economic Co-operation and Development

OLS – Ordinary Least Square

PASDEP – Plan for Accelerated and Sustained Development to End Poverty

PP – Phillips Perron

PWT – Penn World Table

QTM – Quantity Theory of Money

REER – Real Effective Exchange Rate

RESET – Regression Specification Error Test

RGDP – Real Gross Domestic Product

RSS – Residual Sum of Square

SAP – Structural Adjustment Program

SDPRP – Sustainable Development and Poverty Reduction Program

SIC – Schwarz Information Criteria

SSA – Sub-Saharan Africa

TAR – Threshold Autoregressive

TIR – Trade Intensity Ratio

VAR – Vector Autoregressive

VARFIMA – Vector Autoregressive Fractionally Integrated Moving Average

VECM – Vector Error Correction Model

WDI – World Development Index

WEO – World Economic Outlook

Abstract

The main purpose of this study is to empirically assess the relationship between inflation and economic growth in Ethiopia using quarterly dataset from 1992Q1 to 2010Q4. In doing so, an interesting policy issue arises. What is the threshold level of inflation for the Ethiopian economy? Based on the Engle-Granger and Johansen co-integration tests it is found out that there is a positive long-run relationship between inflation and economic growth. The error correction models show that in cases of short-run disequilibrium, the inflation model adjusts itself to its long-run path correcting roughly 40% of the imbalance in each quarter. In addition, based on the conditional least square technique, the estimated threshold model suggests 10% as the optimal level of inflation that facilitates growth. An inflation level higher or lower than the threshold level of inflation affects the economic growth negatively and hence fiscal and monetary policy coordination is vital to keep inflation at the threshold.

Keywords: Inflation, Economic Growth, Ethiopia, Threshold, Co-integration, Vector Auto regression (VAR), Ordinary Least Square (OLS), Error Correction Model.

Table of Contents

Chapter One

Introduction

1.1 Background

The relationship between inflation and economic growth is one of the most popular macroeconomic issues among central bankers, policy makers and macroeconomists (Barro 1995: 166). There exists a large debate in the relationship between these two macroeconomic variables both theoretically and empirically. The differences in the relationships are highly dependent on the economic condition of the world. During the rise of the Keynesian economics, after the Great Depression, countries have been effective in implementing Keynesian policies. Increasing aggregate demand increased not only production but it has also increased the general price level. Since the 1970's inflation was not considered as a threat to the economy but rather it was considered to have a positive effect on growth. This is shown in the empirical study of Phillips (1958) which was quickly adopted by Keynesians in 1950's. According to Phillips Curve, inflation has a positive reaction to economic growth and is negatively related to unemployment. However, this world economic condition survived only until the 1970's (Snowdon and Vane 2005: 134 – 40).

In the 1970's, it came out that countries with high rates of inflation started to exhibit lower rates of economic growth. Due to this reason the view that inflation is positively related to growth was substituted by the fact that high level of inflation is negatively related to growth (Friedman 1976: 270-73). The latter view is well known as the monetarist view of macro-economics. The conflicting views in the relationship between inflation and growth are not only in the theoretical

literature but also exist in empirical findings based on the macroeconomic and development condition of the countries under study. Among the numerous empirical studies the findings of Khan and Senhadji (2001) reveals that the economy of developing countries can accommodate higher inflation than that of developed ones.

In Ethiopia, formal macroeconomic regulation policies were implemented since the late 1950's. Since then the macroeconomic policies of the country had different objectives. At present, like other developed and developing economies, the main objective of the Ethiopian macro-economic policy is to achieve rapid economic growth together with low and stable inflation (Erchafo 2001: 3).

According to MoFED (2000) for the first decade of the post socialist regime (i.e. post 1991) inflation in Ethiopia was generally stable. This can be mainly attributed to the good agricultural sector performance and the tight fiscal and monetary policies. The former is given higher importance because agricultural items, mainly food, comprises almost 60 percent of the consumer market basket in which food items can highly affect the consumer price index (CPI) of the country.

The data for the first decade of the post 1991 period reveals that inflation remains low and stable (i.e. below 5%) except during the times of crop failure. In the years 1994, 1998 and 2004 there were poor harvests in major cereal crops and hence the level of inflation reached 20.7%, 13.4% and 15.1%, respectively. The tight fiscal and monetary policy is one of the reasons for the low and stable inflation for this period. However, as indicated in Geda (2005) this may not show policy effectiveness but unnecessary sacrifice of employment, public expenditure and economic growth.

The annual report of MoFED (2005) points out that in the second decade of the post socialist regime the level of inflation started to increase at an alarming rate which has never been equalled in the price history of the country. As mentioned in Geda and Tafere (2008), before the year 2002/03, inflation has not been a serious issue among Ethiopian economic researchers and macroeconomic policy makers. When they explain the recent inflation, they point out that the rise of inflation is not due to crop failure but it is largely attributed to less conservative fiscal and monetary policies. Moreover, these authors explain the loose policies of government due to its ambitious infrastructural projects that led to a budget deficit and hence the way of financing the deficit has led to higher inflation.

In the year 2007/08, general inflation has reached 25.3% and in 2008/09 it was 36.4%. Regarding food price in 2007/08 it was 34.9% whereas in 2008/09 it increased to 44.3% (NBE 2009). This gigantic macroeconomic shock was however coupled with higher rate of economic growth. At this point it is important to discuss the growth history of the country.

For the most part, the modern history of Ethiopia (i.e. since 1855) reflects both internal and external conflicts (Pankhurst 1963b). Internally, the main sources of conflict can be attributed to religion, land, nationalism and ethnicity. Externally, the country was never colonized and protected its independence for years from Italians, Egyptians, Dervishes and British. These continuous wars and conflicts gave an institutional heritage of conflict which is mainly considered as a cause for major constraints of economic growth in the country.

After the fall of the socialist regime in May 1991, the Structural Adjustment Policies (SAPs) of market liberalization prescribed by international financial organizations was adopted. For the last decade of the 20th century (1991 – 2000), the economic growth of the country was quite

remarkable. During this period, the average real gross domestic product (GDP) was growing at an average rate of 3.7% and the per capita GDP grew at an average rate of 0.7% per annum. The reason for this notable growth can be credited to the liberalization reforms and the favourable weather conditions (Geda and Tafere 2008: 2 – 7).

In the first decade of the 21st century, i.e., in the second decade of the post socialist regime especially from 2003/04, Ethiopia has exhibited a sustained double digit GDP growth that has made it the fifth largest economy in Africa (Minney 2010:67). The governments' key development plan from 2001 – 2005, i.e., Sustainable Development and Poverty Reduction Program (SDPRP) and Plan for Accelerated and Sustained Development to End Poverty (PASDEP) extending from 2006 – 2010 have highly focused on improving living standards of the rural poor who comprise 80% of the population that depend heavily on favourable weather condition.

The inflation and economic growth trends in Ethiopia can easily be understood in the time series graphical illustration of the two variables.

Figure 1.1 Graphical Representation of the Inflation Trend
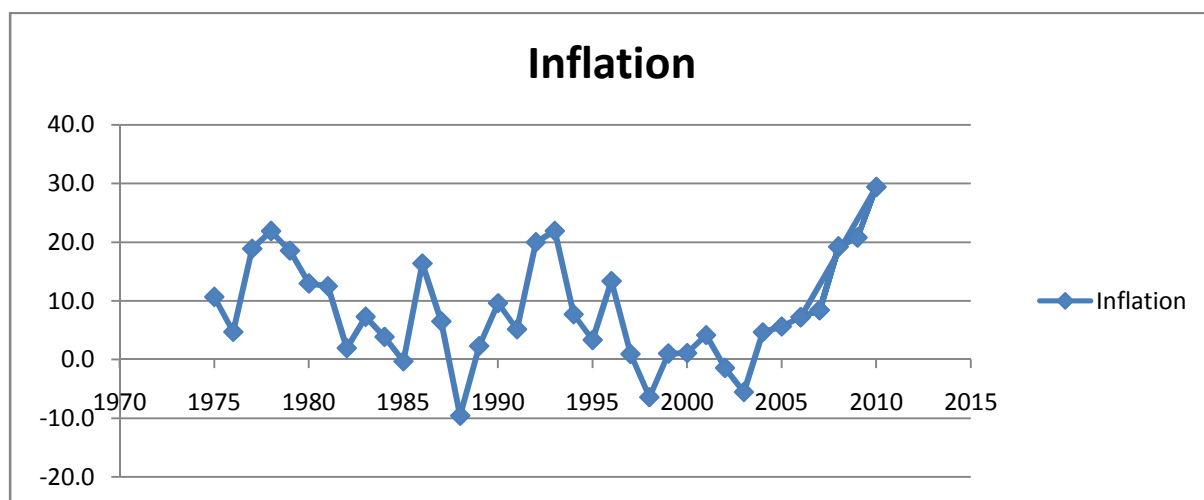
Figure 2.1: Graphical Representation of the RGDP Trend
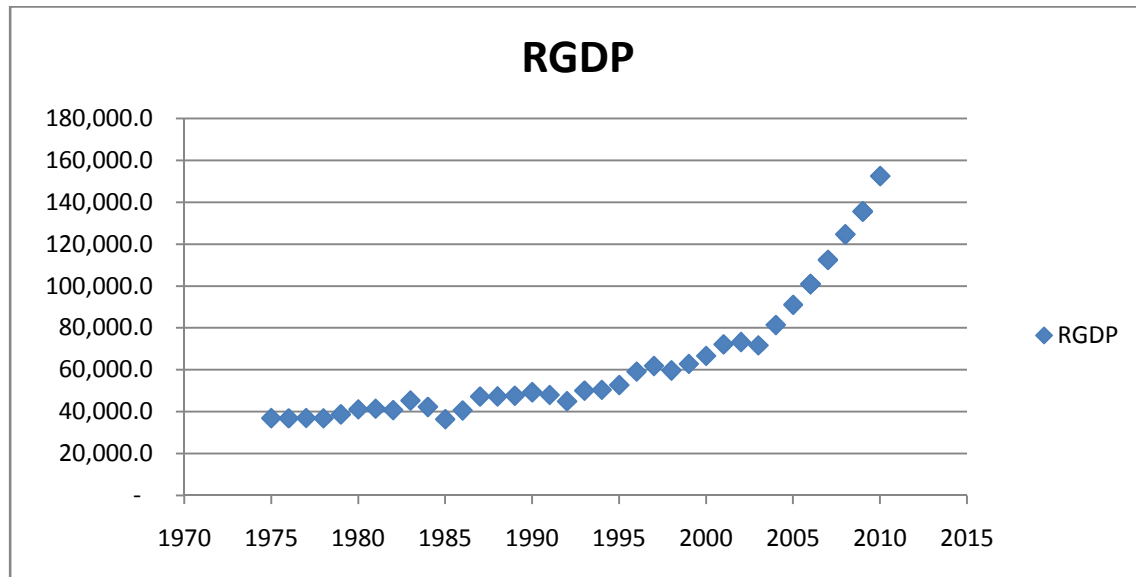
Based on annual data from 1970 to 2010, the trend of inflation and real GDP growth is shown in Figure 1. According to these figures, the real GDP growth trend shows slower growth till the year 2002/03. Then after the growth of the real GDP was continual and fast growth. On the other hand, the rate of inflation moves up and down until 2002/03. However, starting from the year 2002/03 it has been growing at an increasing rate as shown in the figure.

1.2 Statement of the Problem

The impact of inflation on economic growth is one of the most central points of macro-economic issues that need to be resolved. Though there are numerous studies carried out, the relationship between inflation and economic growth is not well defined. As mentioned above, this is mainly due to macro-economic and development conditions of the world, region or country under study. Regardless of this, recently, there exists a high level of consensus among

researchers and economists that positive and lower level of inflation is positively related to economic growth while high and unstable level of inflation has negative impact on the growth of an economy. Due to this reason economists and policy makers largely aim for low and stable level of inflation with rapid rate of economic growth (Bruno and Easterly 1996: 141)

Maintaining price stability became the leading objective of monetary policy of central banks in many countries. This policy got extensive support after the high inflation period experienced in the 1970's in various industrial economies. At present, a number of countries adopted inflation targeting monetary policy giving priority to price stability. This implies that high inflation is certainly a problem that causes the economy not to operate at its optimal level (Palensuela, Mendez and Garcia 2003: 5-8).

As described by Smal (1998) inflation causes harm to the economy through the uncertainty it creates. Economic decisions such as investing, borrowing, buying and selling are highly determined by the current price and expected future price. High and unstable inflation causes uncertainty about future prices. Due to this reason, economic decisions are affected negatively harming the welfare in the economy.

Smal (1998) also has mentioned the negative effects of inflation on the well being of individuals in the economy in the form of redistribution costs. The redistribution cost occurs through economic agents such as lenders, borrowers, fixed income earners and government by reducing the purchasing power of money. Economic agents cannot totally stop holding hard cash for transaction purposes and as a saving deposit. As inflation rises, a large amount of money buys fewer goods and services and hence the purchasing power of money declines. This reduces the welfare of firms and individuals that hold money.

On the other hand, the well-being of lenders and borrowers is affected through a high inflation rate. Lenders are compensated for the lost purchasing power of their principal loan by the nominal interest rate, where it is determined by the level of the anticipated inflation. If the anticipated inflation is less than the actual inflation, then lenders real return declines causing redistribution of income from lenders to borrowers. If the anticipated inflation is higher than the actual inflation, then the well-being of borrowers declines. In most cases anticipated inflation is different from the actual one and hence nominal interest rate favours either the lender or the borrower (Smal 1998: 35 – 8).

Inflation also increases the average weighted tax rate of individuals. Without any increment of the purchasing power, an increase in wage pushes wage earners to enter into high tax brackets. In such cases the redistribution of income goes from wage earners to government (Smal 1998:37-9).

Inflation does not only have negative impacts on welfare in the economy but it also negatively affects the long run growth rate of the economy, through the distortion caused in the labour market, capital market, saving, investment and international competitiveness. A high and volatile inflation rate which is difficult to anticipate, leads workers and employers to engage in short term contracts which again leads to unproductive frequent renegotiations. A high rate of inflation also reduces the international competitiveness of the country through depreciation of the currency which negatively affects the traded goods sector and raises the current account deficit. On the other hand, inflation also affects saving negatively since it lowers its real return and savers are sensitive to the changes to the after tax interest rate. The lower saving reduces the supply of loanable funds and hence investment will be negatively affected. Mainly due to these welfare and economic costs of inflation, a large number of countries tackle inflation as the major objective of their monetary policy (Smal 1998: 41 -3).

The stable macro-economic history of Ethiopia, especially the single digit inflation (apart from the periods of drought) did not encourage policy makers and researchers to consider inflation as a problem. Due to this reason, the impact of inflation on the growth of the economy and the relationship between the two macro-economic variables is not studied well even though it is thoroughly discussed in international literature. This state of affair motivates this study using the quarterly disaggregated data of post socialist regime in Ethiopia.

In addition to this, the stable macro-economic condition in Ethiopia could not be observed since the year 2003/4. Since then a high and sustained increase in the general price level became the common feature of the macro-economic state of the country. For instance, in the year 2007/08 the 12 months moving average of the overall inflation was 25.3% while the 12 months moving average of inflation rate for the year 2008/9 was 36.4%. This roaring inflation however is joined by the double digit growth that astounded international economic observers. The average GDP growth of the country for the same time period where there was high inflation, say 2007/08, real GDP growth was 11.2% and in the year 2008/9 it was 11%. This recent high growth high inflation scenario in the country is the other reason that drives the current study to formally observe the relationship between the two variables (MoFED 2011: 4 - 12).

As mentioned above, there is a huge disagreement on the relationship between inflation and growth both on theoretical and empirical basis. The existing empirical divergence is mainly in the sign and significance of the linear relationship between inflation and growth. Regardless of this divergence, recent research findings agree on the non-linear relationship that positive, low and stable inflation is positively related to growth while high and unstable inflation has depressing effect on the growth of the economy. Still the level of inflation that turns to be

discouraging to growth is indecisive and depends on the development condition of the specific country.

Since inflation has not been considered as a problem in Ethiopia, there was no clear target level of inflation. Nonetheless, from the year 2010 onwards following the five year development plan of the Growth and transformation Plan (GTP), the monetary policy aims to keep inflation at 6%. This is because of the belief that a level of inflation higher than 6% is considered to be destructive to the economy (MoFED 2010: 15 – 16). However, this topic does not seem to be discussed intensively in this regard and hence such a gap inspires this study to provide policy implication regarding the target of inflation that the central bank should focus on.

In conclusion, this study tries to fill the knowledge gap on four aspects. First it eliminates the problem data mixing among different regimes. Other studies mix the data of the pure communist regime where there was no private investment in the economy with the current market oriented economy. An outcome with such mix of data may lead to wrong conclusion and hence wrong policy implication. This problem is eliminated in this study by just focusing on the period after the post socialist regime. Second, the conflicting views on the relationship between inflation and growth not only in global literature but also in Ethiopia have motivated this paper and contributing to the knowledge in this area. Third, is the inclusion and exclusion of variables in both growth and inflation models given the characteristic of the Ethiopian economy. Fourth, the methodology used in this study includes both single equation and VAR system of long-run modelling.

1.3 Objective of the Study

The main objective of this study is to empirically evaluate the relationship between inflation and economic growth in Ethiopia. Given this, the study has the following specific objectives:

1. To examine the long run relationship between inflation and economic growth in Ethiopia

2. To observe the short run relationship and the short-run dynamics in which inflation adjusts to the equilibrium point

3. To estimate the threshold level of inflation for the Ethiopian Economy

Many empirical studies such as Barro (1995) and Ahmed and Mortaza (2005) found out that inflation and growth are negatively related. Due to this reason, this study hypothesizes that there exists a negative relationship between inflation and economic growth. However, the positive relationship cannot be rejected since a number of empirical findings such as (Ozdemir 2010) exist. These conflicting views on the relationship between inflation and economic growth motivate this study.

The study period covers from 1992 – 2010 on quarterly bases with 76 observations. The year 1992 is selected because it marks the beginning of the market oriented economy in the country after 17 years of the socialist regime. During the socialist period there was no private sector in the economy but a command based monetary policy with static and fixed exchange rate regime. The emergence of the private financial institutions, foreign direct investment, "market based" sort of monetary policy in the country and the implementation of managed floating exchange rate system in 1992 has influenced the two macroeconomic variables, inflation and economic growth, to be determined from other sources such as real effective exchange rate and private investment,

respectively. On the other hand, the year 2010 is selected as the latest period in which relevant variables such as GDP can be obtained on quarterly basis.

1.4 Significance of the Study

This topic is relevant and timely given that the Ethiopian economy is exhibiting double digit economic growth coupled with a high rate of inflation that has never been witnessed in its history. The double digit growth is driven by the ambitious five year development plans to reduce poverty as the government focuses on achieving the Millennium development Goals (MDGs) by the year 2015. The five year development plans namely Sustainable Development and Poverty Reduction Program (SDPRP), Plan for Accelerated and Sustained Development to End Poverty (PASDEP) and the current Growth and Transformation Plan (GTP) are very ambitious in reducing poverty and achieving rapid economic growth. These development plans largely deal with heavy infrastructural projects such as hydro-electric power dams, road and railway construction, building schools and health institutions in different parts of the country. These large physical and social investments require a large amount of money to be injected in the economy causing a high rate of inflation (Geda and Tafere 2008: 5). However, this relationship between inflation and growth should be studied using advanced and well structured methods.

In addition to this, there are conflicting theoretical and empirical findings in the relationship between inflation and growth. Such state of affairs makes this study important to find out the behaviour of the relationship between the two macroeconomic variables. Since Ethiopia had stable macroeconomic performance prior to the year 2002/3 the relationship between the two variables in the country has not been studied well. Few studies that are carried out in the Ethiopian context such as (Teshome 2011) and Asaminew (2010) do not have a model that

explains the macro-economic condition of the country. They also do not have in-depth analysis and they used a mix of data of different macro-economic systems of different regimes. In this regard, this study fills the gap by analyzing the relationship between inflation and economic growth with deep methodological analysis that will be discussed in the next section. The study also tries to use a model that can well explain the macro-economic condition of the country both in growth and inflation models. Furthermore, the problem of mixing data of different regimes is removed in this study by focusing only on the post socialist Ethiopia. Though it is possible to identify the regime change using dummy variable, this study focuses on the post socialist Ethiopia with quarterly disaggregated data.

Last but not least, the importance of the study is to provide policy guidance for the monetary policy makers with regard to the threshold level of inflation. As mentioned earlier, there exists a wide range of consensus that stable and low inflation is positively related to growth while high rate of inflation affects the growth of the economy negatively. However, the question still remains on how low should inflation be so that economic growth will not be affected negatively. This threshold point differs based on the development position of each country under study. Identifying this threshold point of inflation for the Ethiopian economy provides possible policy recommendation for monetary policy makers of the country.

1.5 Methods and Data

In order to address the objectives of the study, two econometric models are employed. The two models that are used are the inflation model and the growth model. The inflation model is used to see the long-run and the short-run relationship between the two relevant variables. On the other

hand, the growth equation is used in identifying the maximum level of inflation at which the growth of the economy can be optimized.

One of the objectives of time series analysis in econometrics is identifying relationships among variables. Co-integration modelling is mostly used for long-term forecasting and long-run relationships. The word co-integration itself implies long-term equilibrium (Lin and Tsay 1996: 519 – 20).

Hence, in order to see the long-run relationship between inflation and growth in Ethiopia, the co-integration test is used. In the co-integration test both the Engle-Granger (1987) and the Johansen (1991) methods are employed.

In the analysis to capture the short-run relationship and short-run dynamics, the error correction model (ECM) and the vector error correction model (VECM) that are derived from the Engle-Granger (1987) and the Johansen (1991) models of co-integration are employed, respectively. These models show whether the short-run reaction goes to the long-run equilibrium path or not in the cases of shock. From these models it is also possible to see the short-run relationship between the two variables in the study, inflation and growth.

In addressing the last research objective, i.e., identifying the threshold point of inflation, a technique known as the conditional least square (CLS) is used. This method is widely used in different studies such as Khan and Senhadji (2001), Mubarik (2005) and Bick (2010). In this technique, the growth equation is estimated for different values of the threshold points assigned. Among these values the one that minimizes the residual sum of squares (RSS) and the one that maximizes the R^2 is taken as the threshold point. All these methodological techniques are well explained in the third chapter.

In the econometric models mentioned above, the data for relevant variables is obtained from Central Statistics Agency (CSA), Ethiopian Investment Agency (EIA) and the National Bank of Ethiopia (NBE). All the data is analyzed on a quarterly basis from the year 1992 quarter one to 2010 quarter four with 76 observations. Though data for some variables are available only on an annual basis, different disaggregation techniques are used to get quarterly series of these variables. All these methodological issues and disaggregation methods will be discussed in Chapter Three.

1.6 The Scope and Limitation of the Study

Due to the conflicting findings in the relationship between inflation and economic growth several studies have analyzed this topic. Some studies use panel data for several countries while others use time series data for a specific country. In this study, the later one is in use since the study focuses on the relationship between inflation and growth in a specific country, Ethiopia. The scope of this study is to analyze the relationship between inflation and growth in Ethiopia, limited to the period 1992 quarter one to 2010 quarter four.

The main reason why the scope is limited to the year 2010 is due to the lack of data. Many of the variables used in the inflation and growth models do not have adequate quarterly data. Due to this reason different techniques of data disaggregation are used. These techniques are discussed in section 3.1.3. Some of the techniques require data for the subsequent Ethiopian fiscal year which is not yet published. Due to this reason, the study is limited to analyze the issue up to the year 2010. In addition, the disaggregation method of annual RGDP to quarterly RGDP is driven from simple algorithm chosen by the National Bank of Ethiopia. The fact that the natural data generating process is not applied can also be stated as a limitation of the study.

The other limitation of the study is the lack of data on the consumer price index (CPI) at the national level for the study period before 1998. Therefore, for the time period 1992-1998 the CPI of the capital city, Addis Ababa, is used as a representative of the national CPI since it is the only data available on CPI.

1.7 Organization of the Study

This study is organized in five chapters. Following the introductory chapter, chapter two presents the review of the literature on the relationship between inflation and economic growth both theoretically and empirically. Chapter three discusses the methodological issue and the econometric modelling. In this chapter, econometric techniques that are used in the study are discussed in detail. Chapter four analyzes the data using the methods explained in chapter three and interprets the results obtained from E-views. Finally the last chapter concludes the study and provides policy implications.

Chapter Two

Literature Review

The discussion in this chapter will have three main sections. It starts with relevant theoretical studies regarding inflation and economic growth. The second part discusses the global empirical studies and their findings. The last part will focus on the studies carried out on the relationship between inflation and economic growth in Ethiopia.

2.1 Theoretical Literature Review

Different theories have different conclusions about the relationship that exists between inflation and economic growth. For example, to compare the two mega theories, monetarists assert that inflation hinders growth while the structuralists argue that inflation promotes growth. Different economic theories are studied in this section regarding their views on the relationship between inflation and growth.

2.1.1 The Mercantilists View

This view was popular from 1650 up to 1776, the time when Adam Smith's book "Wealth of Nations" was published. During the time of enlightenment Britain achieved rapid economic growth that was highly based on trade and commerce. According to the Mercantilists, export surplus is a source of growth while balance of payment (BOP) deficit was considered as a negative growth factor. Thus, in order to have export surplus imports are discouraged and exports are encouraged, so that economic growth can be secured (Pentecost 2000: 3-5).

Precious metals were used as money in most places of the world during the time of enlightenment and export surplus was interpreted as an accumulation of gold bars and coins. This large amount of bars and coins in the market thus led to an increase in the price level. Though Mercantilists support the idea of export surplus, they were also aware of the general price increase that will be caused by the export surplus (Pentecost 2000: 4-6).

William Petty was one of the first Mercantilist philosophers to identify the negative effects of the rise in inflow of gold bullions in a given country. To Petty, an increase in inflow of gold bullions causes inflation which in turn reduces economic growth of a given country. He explains further that inflation reduces international competitiveness of a nation. The rise in inflation makes locally produced goods expensive in the international market and that reduces the demand for the product overseas. In such cases, exports decline followed by reduced economic growth (Pentecost 2000: 4-8).

For Richard Cantillon, another Mercantilist economic philosopher, export surplus does not cause serious harm to the economy. For him accumulation of bullion through export surplus does not have a damaging effect on the economy. He claims that an accumulation of precious metals through production of gold and silver, without an increase in the real output, creates inflation that can severely reduce the growth of the economy (Pentecost 2000: 6-9). This is similar to the modern thinking of Monetarists which will be discussed in one of the following sub-sections.

2.1.2 The Classical View

The publication of "Wealth of Nations" in 1776 is considered as the birth of Classical economic thinking. This economic thinking was popular until it was questioned by John Maynard Keynes in 1936 with his publication of "The General Theory of Employment, Interest and Money".

Early classical economists, in particular Adam Smith and David Ricardo, adopted Richard Quesnay's social class analysis and revised these classes as landlords, capitalists and workers. Based on the self interest assumption of classical economists, capitalists compete with each other even in the labour market. Such competition increases labour wage. The rising cost of production through an increase in labour wage reduces the profit of the capitalist benefiting workers and landlords. The fall in the profit level discourages the capitalist who is the source of wealth creation. Thus, the price increase will have a negative impact on productivity of the capitalist leading to decline in the level of the economic growth (Pentecost 2000: 7 - 11).

In later Classical economics output and employment is not determined by the creation of money but rather it is explained by the short-run production function where output Y is explained as a function of labour L and capital K, given by

Y= A f(K,L) , where Y is output, A is the level of technology, K is capital accumulated, and L is the labour force.

According to this explanation in order to achieve economic growth either the labour force or capital accumulation must rise. The rise in the level of technology also helps to postpone the diminishing returns of growth caused by the rise in capital or labour force (Snowdon and Vane 2005: 38 – 45).

One of the known Classical economic thinkers Jean Baptiste Say states that money has no other function than serving as medium of exchange. According to him, the major determinant of the economic growth, i.e., investment is determined by the level of saving. When saving falls interest rate rises and investment spending will be discouraged. On the other hand, if saving increases interest rate falls and investment expenditure rises to offset the fall in consumption

expenditure caused by higher saving. Saving is, therefore, the creator of investment and hence economic growth. This popular classical thinking is well known as Say's law (Baumol 1999:196-201).

The other feature of Classical thinking, the quantity theory of money (QTM), states that in the long-run money does not have an effect on real variables but can pressure the price level. To the Cambridge economists, the theory is stated as

$$M = kPY$$

where, M is money supply, k is the fraction of the national income, P is the price and Y is the total national income (Snowdon and Vane 2005, 50-52). Classicals assume that there is always a full employment of resources and thus Y and k remain constant so that an increase in money supply will not have any effect on economic growth but directly increases P which is the general price level (Cottrell 1997: 1-4).

To the income version the quantity theory of money is given as

$$MV = PY$$

where, V is the velocity of money in the economy. V is the reciprocal of k and it remains constant as Y. Again in the Fishers' equation of the QTM an increase in money supply leads to an increase in the amount of money at hand among producers and consumers having no effect on the level of output. The rise in the level of money at the hand of agents increases the demand for goods and services produced at full employment. This rise in demand leads to a rise in inflation (Dimand 2005: 3-5).

Though the relationship between inflation and economic growth is not stated clearly in the classical economic thinking as indicated by many Classical economists, it is implicitly stated that there is a negative relationship between the two variables.

2.1.3 The Keynesian View

The empirical finding, on the relationship between wage inflation and unemployment, by Bill Phillips in 1958 asserts that there is a long-run negative relationship between the two variables. This finding was quickly adopted by Keynesian economists because it has filled the gap in explaining inflation that was missed in the Keynesian IS – LM model. The majority of Keynesian economists interpreted the Phillips curve as a sustainable negative long-run relationship between inflation and unemployment providing policy choice for authorities between inflation and growth. In other words according to Keynesians, in order to lower unemployment and improve economic growth there must be a permanent increase in the level of inflation (Snowdon and Vane 2005: 135 – 38).

In the study of Phillips, wage inflation was explained as a function of unemployment only. For Keynesians it is difficult to include inflation expectation in their model of wage inflation since expectations are exogenously determined (Snowdon and Vane 2005: 136 – 38).

Richard Lipsey was the first Keynesian economist to provide a theoretical foundation for the Phillips curve. According to his analysis wage is positively related to the demand for labour and the demand for labour is negatively related to unemployment where both relationships are non-linear (Snowdon and Vane 2005: 136 -7).

Price is determined by the cost of input, i.e., wage in this case and any change in the wage level will have a direct impact on the general price level. Thus, following Lipsey's formulation to

achieve economic growth and reduce the level of unemployment there must be an increasing rate of price inflation. Yet the policy maker has policy choice on every point on the Phillips curve. If the policy objective is to reduce the level of unemployment, the rate of inflation rises and if stable inflation is the macro-economic goal it will be at the scarification of the economic growth (Leeson 1997: 2-5).

The full employment assumption is dropped in the Keynesian school and an economy in a stable income and zero inflation, an expansionary fiscal policy (a more effective policy measure in Keynesian economics) increases output, employment and income. Such increase in productivity increases the general price level. Thus, according to Keynesians economic growth and inflation have a stable long term positive relationship (Aaron 1967: 189 – 92). To this school, wages and prices are rigid and it takes time to get the economy at the equilibrium. Due to this reason, there is no visible short run relationship between inflation and economic growth (Snowdon and Vane 2005: 145 – 6).

2.1.4 The Monetarist View

Based on the Quantity Theory of Money (QTM), the Monetarists view argues that monetary changes are seen as a cause rather than consequences of major economic recessions and booms. Regarding the relationship between inflation and economic growth, monetarists interpreted the Phillips curve differently from how it was interpreted by Keynesians. Milton Friedman, known as the father of the Monetarist school, argues that wage inflation should not only be explained by unemployment but it is also explained by inflation expectations (Leeson 1994: 158 -61).

For monetarists, there is a positive relationship between inflation and economic growth in the short-run but in the long run an expansionary monetary policy (effective policy measure for Monetarists) will have no real impact except the general price increase (Friedman 1968: 7-11).

For an economy at the natural rate of unemployment (zero inflation, zero growth), if authorities want to reduce unemployment by raising aggregate demand through an increase in the money supply, then workers consider the associated wage increase as a real one. Such belief of workers motivates them to increase their labour supply and hence productivity rises. However, this situation stays only for the short-run. Once workers take into consideration that the wage increase is not in real terms but in nominal terms and when they realize that their real wage did not change they reduce their labour supply. Thus, productivity and economic growth can be raised in the short-run through expansionary monetary policy. In the long-run, after expectations are adjusted, economic growth will not be affected and only the price level will change (Friedman 1976: 269 – 72).

Unlike the Keynesian exogenous expectation, the Monetarists analysis is based on adaptive expectation (error learning expectations). Inflation expectations in this case are made using past information. Due to this reason there are numerous curves related to different expected rate of inflation (Ramalho 2011: 24-5).

This is explained well in figure 2.1, where initially the economy is at point A in which unemployment is at its natural rate and wage rate is zero. If policy makers want to reduce unemployment below the natural rate (U_n), say to U_1 using expansionary monetary policy, then wage rises to W_1. Assuming that the policy measure is not anticipated, this increase in wage will be perceived by workers as an increase in their real wages. In this case, the economy will be at

point B where unemployment is reduced and money wage has risen while real wage is declining. After adjusting their expectations, workers start to seek for additional money wages to compensate the decline in their real wages. Since firms cannot pay the high wage rate that workers seek, unemployment returns back to its natural rate and the economy settles at point C. Hence, in the long-run unemployment is at its natural rate but wage is inflated to W1 (Friedman 1976: 270 - 74).

After expectations are adjusted the short-run Phillips curve shifts from $SRPC_1$ to $SRPC_2$. If inflation is expected to be higher, the short-run Phillips Curve is also expected to shift to the right. If higher inflation is anticipated then there will be no short-run effect for expansionary monetary policy. However, if the policy measure is not anticipated then there will be a short-run effect (Friedman 1976: 270 - 74).

Figure 2.1

Expectations Augmented Phillips Curve
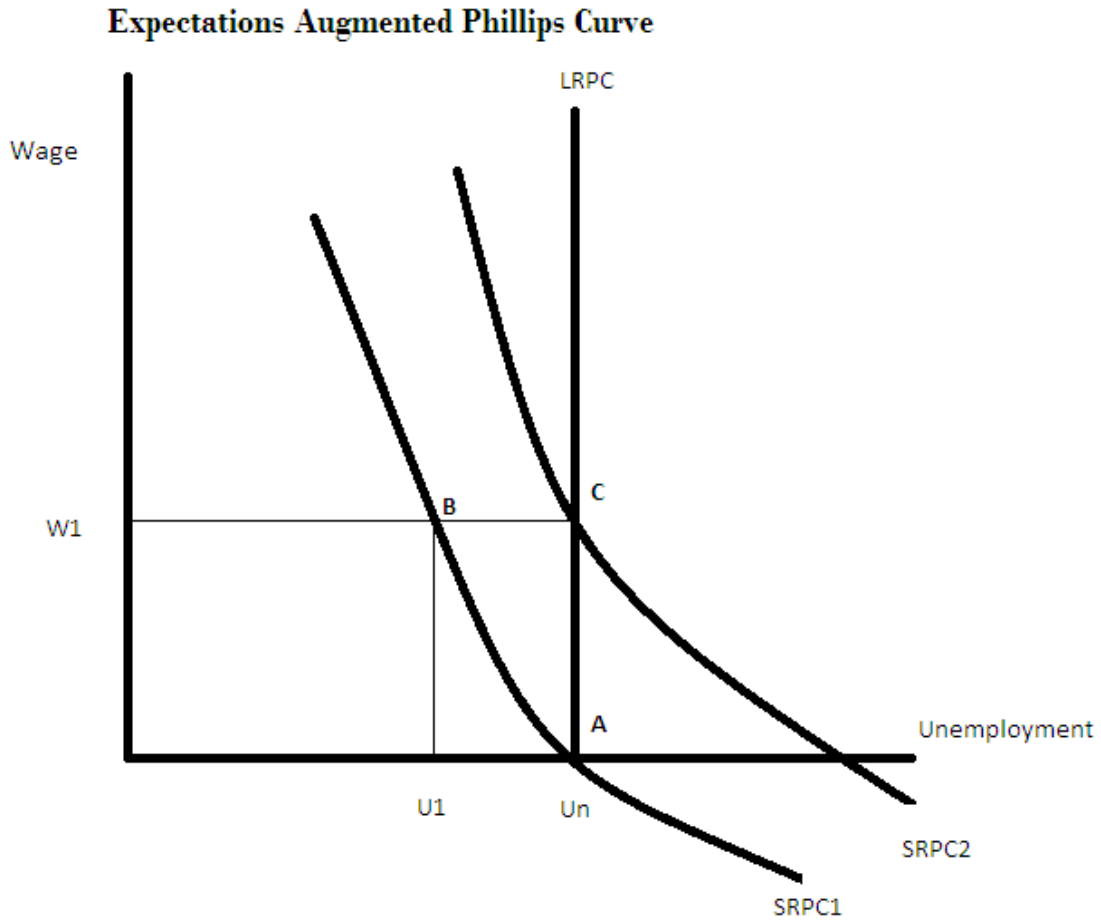
Source: Friedman 1976: 272 and Snowdon and Vane 2005: 177

Thus, according to Monetarists, there is a positive short-run relationship between inflation and economic growth, provided that the growth is accompanied by the decline of unemployment and rise in the cost of production leading to price inflation. This short-run relationship exists if and only if the policy measure to raise the aggregate demand is not anticipated. In such cases, when workers adjust their expectations output adjusts to its natural rate at the vertical long-run Phillips Curve leaving the price higher. As a result, an increase in money supply will increase the price

level without having any effect on output and hence there will be no long-run trade-off between inflation and economic growth (Friedman 1976: 272 - 3).

2.1.5 The New Classical View

Based on the rational expectations and continuous market clearing approach, the relationship between inflation and economic growth is explained by the inter-temporal substitution approach and the surprise model in the New Classical economics (Lucas 1996: 254 - 55).

According to the inter-temporal substitution approach rational workers supply more labour when real wage increases and they take more leisure when real wage falls. When workers supply more labour, productivity is expected to move up leading to economic growth. An increase in nominal wage however, will not have an impact on real economic variables such as employment and growth (Lucas and Rapping 1969: 726 – 33).

The surprise model explains more about the goods market in the economy than the labour market. A rational firm decides to increase its productivity only when price of its product increases. However, the price increase should be in relative terms. If the price increase is in absolute terms, then rational firms do not change their production and will have no real impact in the economy (Lucas 1973: 333 – 4).

For New Classicals, if there is any unexpected increase in wage or price, the increase surprises suppliers of labour and goods. Such surprises will have a real impact on the economy in the short-run until economic agents adjust their expectations. Such surprises are usually related to an unannounced increase in money supply that causes the general price increase. If the money supply increase is announced and was expected by economic agents, then it will not have any real effect on the economy (Lucas 1973: 333).

Even if there is an unannounced increase in money supply, output might deviate from its natural rate only for the short-run and in the long-run it will be back to its natural rate when workers realize that the price increase is in absolute terms (Lucas 1996: 262).

Unlike Keynesians, wages and prices are assumed to be fully flexible and if future inflation is anticipated there will be zero sacrifice ratios for reducing inflation. This means if tight monetary policy is announced inflation can be reduced in the short-run with no trade-off. In such a case there will be no short-run effect since the level of inflation is anticipated (Lucas 1996: 260 – 2).

Unlike Monetarists, monetary policy is used not to increase aggregate demand but to control inflation. To achieve higher economic growth supply side policies play a more major role than the monetary policy (Lucas 1996: 261).

2.1.6 The New Keynesians View

Based on the major assumptions of Orthodox Keynesians, prices and wages are rigid for New Keynesians as well. These rigidities play an important role in exaggerating economic shocks that arise from either the demand or the supply side (Blanchard and Gali 2005: 15 – 7). If money supply is tightened then aggregate demand declines leading to lower economic growth and higher unemployment. But prices and wages are assumed to be rigid and thus the level of inflation remains unchanged (Vaona 2011: 95).

The fall in the aggregate demand is the reason for lower productivity by firms and unlike the New Classicals it is not the price that is discouraging production but it is the lack of demand. Firms produce only up to the point where they get demand for their production. If firms exceed this production then there will be no market for the additionally produced goods even at lower price since prices take a long time to adjust (Ball, Mankiw and Romer 1988: 8 – 9).

Furthermore, the New Keynesians claim that even if prices and wages are flexible output still varies due to the uncertainty that exists with prices. During a period of recession, risk avoiding firms prefer to reduce their output rather than dealing with the fluctuation of prices and the associated uncertainties. This implies that high and unstable prices affect productivity negatively (Krause and Lubik 2003: 25).

For New Keynesians high inflation has a negative impact on economic instability and hence growth. To achieve rapid economic growth and to have fair distribution of income there must be low and stable inflation. For them reducing money supply to reduce inflation leads to recession due to price rigidities. Thus, in order to set monetary policy there has to be prior information about future values of inflation and output. In inflation targeting monetary policies, credibility of the policy is very important and hence the Central Bank's independence plays a crucial role in this case (Ambler 2008: 5 – 9).

Inflation creates costs in the economy. These costs can be seen as costs of anticipated inflation and costs of unanticipated inflation. Costs of anticipated inflation include shoe leather costs, menu costs and costs created by distortions in the non-indexed tax system. Costs of unanticipated inflation include distortions in the distribution of income, distortions in the price mechanism, and losses due to uncertainty. According to New Keynesians, inflation whether anticipated or unanticipated, has an overall negative impact on economic growth (Ambler 2008: 2 – 3).

2.1.7 Proximate Growth Theories

Some of the well known proximate growth models are the Harrod – Domar Model, Solow-Swan Model and the Romer-Lucas Model. Inflation is not included in the framework of proximate theories of growth; however it is necessary to see the driving factors of growth in these models.

2.1.7.1 The Harrod-Domar (Neo-Keynesian) Growth Model

This model is the dynamic version of Keynes's prescription that investment is the driving force of growth. Growth can be achieved only at a higher rate of investment if the labour force and technology are exogenously determined. According to this model investment is mainly financed by local saving. An increase in saving directly leads to an increase in investment and hence growth (Domar 1946: 137 – 8).

Though the model does not explain well the relationship between growth and inflation, Domar mentioned that a failure to save, accumulate capital and invest leads to prolonged inflation and higher unemployment. This shows that unemployment and growth goes hand in hand with the level of investment (Domar 1947: 45 – 6).

Similarly, Harrod indicated that for an economy that is operating at full employment inflationary conditions are expected to be down. Inflation shifts profit level upward and increases saving. He further argues that inflation is a sign of the natural rate above the normal growth rate and any anti-inflationary measures are considered as ineffective (Harrod 1938: 269 – 71).

2.1.7.2 The Solow-Swan (Neo-classical) Growth Model

For Solow-Swan growth model, a short-run production function is used where labour and capital are production inputs. If one input of production is assumed to be fixed an increase in another input of production leads to a decline in output productivity. For example, an increase in capital in the production process leads to diminishing returns of output assuming labour as a fixed input of production (Solow 1956: 67).

Technological advancement plays a crucial role in the economy according to the Neo-classical growth model. Technological advancement that increases productivity of capital and labour postpones the diminishing returns and it accelerates the speed of economic growth. Technical advancement is enough for the growth process and does not require high capital accumulation unlike the Harod – Domar model. With a given capital, higher technology gives higher output (Solow 1956: 85 – 6).

In Solow's analysis of growth, assuming the general price is constant, money demand depends on real output and with this assumption the choice between holding liquid money and capital stock depends on the real rewards of the capital. However, Solow himself has said that considering the general price level constant is the most unnatural thing to do (Solow 1956: 92).

2.1.7.3 The Romer-Lucas (Endogenous) Growth Model

In the Romer-Lucas model of growth, unlike the Solow-Swan growth model, technological change is not exogenously determined but it is derived from the capital accumulation process. Accumulations of capital goods that are used to produce consumer goods enable workers to learn how to operate high technology machinery and modify them (Lucas 1988: 25 - 6). Such a learning process allows technological advancement. According to this theory there will be no diminishing returns of output because of the associated technical advancement of the capital accumulation as there occurs capital deepening. Thus capital accumulation is still the important factor in achieving economic growth (Romer 1994: 15 - 9).

Theories such as proximate growth theories, do not openly discuss inflation and its relationship with growth. Other theories especially theories after the Great Depression have analyzed the relationship between inflation and growth. For instance, Keynesians say that there exists a long-

run positive relationship between inflation and growth where there is no visible short-run relationship. Monetarists, on the other side, state that there is no long-run relationship between the two variables. In the short run, until expectations are adjusted, there is a positive relationship between them. New Classicals affirm that anticipated inflation has neither long-run nor short-run effect on growth. However, if inflation is unanticipated it has a negative impact on the growth of the economy. Based on the wage and price rigidities assumption, to the New Keynesians, inflation anticipated or unanticipated has a negative impact on the economic growth of a country.

From these theories one can clearly understand that there are conflicting results among theories regarding the relationship between inflation and economic growth. Keeping in mind these conflicting theories, the next section will examine in detail global empirical studies regarding the two macro-economic variables.

2.2 Empirical Literature Review

There are numerous global studies done on the relationship between inflation and growth. Some of them are on a cross-country basis and others have studied it on a specific country basis. In this part of the literature review studies on short-run and long-run relationships between the two variables will be explored in one sub-section and threshold analysis will be studied in another sub-section. In these two sub-sections the case of both the developed and developing countries will be assessed giving more attention to the studies on the latter.

2.2.1 Global Empirical Findings on Inflation and Growth

Barro (1995) is one of the economists to see the relationship between inflation and growth using panel data from 100 countries over the period of 1960-1990. His methodology is based on the

Neo-classical growth model and incorporates inflation as one of the explanatory variables in the model. He kept other determinants of growth constant and has tried to see the impact of inflation on growth in countries he studied. His finding reveals that inflation has a statistically significant negative impact on growth and investment.

Bruno and Easterly (1996) have analyzed the effects of inflation on long-term growth. To study this, panel data of 26 countries over a period of thirty one years from 1961 – 1992 was used. They identified countries that exhibited more than 40% inflation rate and the growth performance of these countries is assessed before, during and after the occurrence of the high inflation crisis. The finding of their analysis indicates that a higher level of inflation harms the growth and lower inflation has less cost on the economy. Their analysis also concludes that the high inflation in the 70's and 80's had affected temporarily the economic growth of the countries under study.

The study of Abbott and De Vita (2011) revisits the relationship between inflation and growth in different exchange rate regimes. A panel data for 125 countries, both from developing and developed countries is used over the period 1980 – 2004. A growth model is employed explained by the rate of inflation, fixed exchange rate and intermediate exchange rate (measured as a dummy variable), investment, civil unrest and hyperinflation (both measured as dummy variable). The results of the study suggest that the cost of inflation on the economic growth becomes higher and significant for the case of developing countries that adopt flexible exchange rate regimes compared to the ones that use fixed or intermediate exchange rates. Based on these findings the authors recommend macro-economic policy makers in developing countries to adopt fixed or intermediate exchange rate regimes.

Malla (1997) has studied how inflation affects the rate of economic growth using a small data sample for OECD and Asian countries. The study is undertaken independently for Asian countries and OECD countries using a growth equation explained by capital accumulation and labour force. The finding for 11 OECD countries reveals that there exists no relationship between inflation and growth which is contrary to the theories. However, for the Asian countries there exists strong negative relationship between the two variables.

Dotsey and Sarte (2000) studied the effects of inflation variability on economic growth for the US economy. They used the neo-classical endogenous growth model with money included as an explanatory variable. The finding of the authors shows that higher average inflation has a negative impact on the steady state growth. This is because of the higher cost of transaction that inflation causes to the money market. On the other hand, the authors argue that inflation has a positive impact on growth in the short-run through precautionary savings. During inflation volatility, precautionary savings rise and that is positively related to growth and negatively related to welfare. In the overall finding, the negative effect of inflation outweighs the positive impact of inflation, thereby supporting the view that higher inflation has a negative impact on growth.

The study of Ozdemir (2010) aims to assess the dynamic linkages between inflation uncertainty, inflation and output growth for UK. The vector auto-regressive fractionally integrated moving average (VARFIMA) model is employed for quarterly data of GDP and CPI from 1957 Q2 – 2006 Q4. The author has selected this method since it enables one to see the causal effect between inflation and growth. To get robust results the author has split the sample data into three sub-periods: from 1957Q2 – 1973Q2, 1973Q3 – 1988Q1 and 1988Q2 – 2006Q4. He also analyzed the full period to compare the results. For all types of samples, Toda – Yamamato

(1995) non-causality test is used to determine the direction of the causality between the two variables. The result of the study for the full period indicates that inflation uncertainty has a positive impact on the rate of inflation and economic growth. However, for the study of the sub-periods, it is found that there exists no relationship between inflation and output growth. Thus according to this study, inflation uncertainty is one of the important determinants of growth. This finding is similar to the study undertaken for the US economy by Dotsey & Sarte (2000).

Gillman and Harris (2010) investigate the effect of inflation on economic growth for countries under transition. The study is undertaken by using a panel data evidence for 13 transition countries over the period 1990 – 2003. The data is obtained from World Bank Development Indicator (WDI). The estimation process has three equation systems namely the growth, inflation and money demand equations. The maximum likelihood estimation technique using full information is applied. The results obtained from the study are similar to the findings for the OECD countries that there exists strong negative relationship between growth and inflation. This confirms that the growth in the region is similar to that of developed countries implying the convergence of growth. The authors thus suggest monetary policies to be inflation targeting and fiscal policies to keep budget deficits within acceptable range.

Boyd and Champ (2006) also explained how high inflation affects economic growth through financial intermediaries. Their analysis starts with the theoretical insight that states inflation reduces the real return on assets. This is through discouraging saving and encouraging borrowing which raises nominal interest rate. A rise in the nominal interest rate in turn discourages investment and hence growth. Based on this the authors tested two testable hypotheses from the theoretical literature. These are (a) whether higher inflation reduces bank lending or does not and (b) whether inflation reduces the return on real assets or does not. To test these hypotheses

averaged data of relevant economic variables for 100 countries across various time periods in the 80's and 90's is used. To Boyd and Champ averaging data for long time horizon allows them to see the long-run effects of inflation on growth. According to the finding of the analysis, keeping other factors that affect bank lending constant, high inflation reduces the amount of money that banks lend. Inflation has also a negative effect on the return of real assets through the real bank interest rates. The authors have then concluded that inflation has a negative effect on economic growth. Boyd and Champ have also noted the necessity of finding the critical point where inflation becomes harmful.

Erbaykal and Okuyan (2008) have tried to explain the relationship between inflation and economic growth in Turkey using quarterly time series data from 1987Q1 – 2006Q2. To see the relationship between the two variables, co-integration and causality tests between the series is undertaken. The Bound test is used to examine the co-integration relationship and the WALD test developed by Toda & Yamamoto (1995) to see the causal relationship between the two time-series variables. Unlike other studies, Erbaykal and Okuyan have used the Bound test approach, developed by Pesaran, Shin and Smith (2001), because even if variables are not found to be stationary in the same order it is still possible to have a co-integration test. In this approach regardless of the series whether they are I(0) or I(1) the existence of the co-integration relationship can still be examined. Autoregressive Distributed Lag (ARDL) models are used to see the long-term and short-term relationship between the two variables under study. Unlike the Vector Error Correction (VEC) model developed by Engle and Granger (1987), the WALD method developed by Toda and Yamamoto does not require co-integration relationship between the series. According to this approach co-integration relationship is not a necessary condition to examine causal relationship. Using these methods Erbaykal and Okuyan have found no

statistically significant long-term relationship between the two macro-economic variables under study. They found a negative and statistically significant short-term relationship. In the causality analysis, an unidirectional causal relationship running from inflation to economic growth is obtained. The authors suggest that macro-economic policies must offer a stable environment so that steady and sustainable growth can be achieved.

The study of Xiaojing (2008) examined the trade-off between inflation and economic growth in China using annual time series data from 1978 – 2007. He used the Phillips curve equation to see what the relationship would look like between the two variables. The finding of his study reveals that growth can be affected differently at different steady state levels. At the socially accepted steady state of inflation, 5%, GDP growth will be 9.39%. However a rising inflation above its steady state will have a negative effect on growth and tight monetary and fiscal policies are recommended in these cases. Nevertheless, tight policies can harm the economic growth of the country if they are still adopted when the rate of inflation is below the steady state.

Gokal and Hanif (2004) have analyzed the relationship between inflation and economic growth in Fiji. Their study focuses mainly on whether there is any meaningful and causal relationship between the two variables in the country. To achieve their objectives they used annual observation of 34 years (1970 – 2003) for variables of Real GDP, annual average CPI, and year on year CPI inflation rate. To test the causal relationship Granger causality test is applied but before that the authors have examined the time series properties of the data using Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests and the variables are found to be integrated of order I(1). The findings of the analysis reveal that both inflation measures (annual average CPI and year on year CPI) have negative weak relationship with the GDP growth. The finding of the Granger causality test indicates that causality runs one way from economic growth to

inflation. The authors conclude that inflation in Fiji is highly influenced by international factors and there is a weak and negative relationship between inflation and economic growth. They further recommend that Fiji's monetary policy must aim to reduce inflation and inflation expectations to promote economic growth.

The study of Hodge (2005) aims to check the findings of the numerous empirical findings that inflation has negative long-run impact on the economic growth in South Africa. The study also examines the level of growth sacrificed in the short-run to achieve lower inflation. To attain the results of the study annual time series data for the period of 1950 – 2002 is used. A growth equation is used with explanatory variables of CPI, labour productivity, investment, tax on income and wealth, and terms of trade to see the long-run relationship between the two variables. OLS regression results have shown that there exists a strong and statistically significant negative long-run relationship between inflation and economic growth in South Africa. To see the short-run relationship between the two variables, an inflation equation explained by lagged inflation, lagged GDP growth rate, lagged change in labour cost and change in import prices is used. The finding shows that there has to be accelerating inflation in order to achieve growth in the short-run. Hence, inflation targeting has to be ignored to achieve short-term growth. But in the long-run the two variables have a negative relationship and thus an increase in inflation to achieve short-term growth will have higher cost in the long-run.

Baharumshah, Hamzah and Sarbi (2011) analyzed the effects of inflation and inflation uncertainty on the economy for five ASEAN (Association of South East Asian Nations) countries namely; Malaysia, Singapore, Thailand, Indonesia and Philippines. The L_1-ARCH (Autoregressive conditional heteroscedastic) model is adapted to measure inflation uncertainty which is helpful to measure extreme observations. Based on the model employed the finding of

the study shows that there exists a negative relationship between inflation uncertainty and economic growth. The authors indicated that measures that are undertaken to reduce inflation uncertainty have a positive impact on the overall growth of the economy. But the authors mentioned that their study is not a full analysis. It only focuses on inflation uncertainty and it ignores other growth determinants.

The study of Mallik and Chowdhury (2001) examines the relationship between inflation and economic growth in four South Asian countries namely Bangladesh, India, Pakistan and Sri Lanka. The long-run and short-run relationship between the two variables is examined using Johansen and Juselius (1990) co-integration test and the Engle and Granger (1987) Error Correction Model (ECM). Accordingly, the empirical finding reveals that the two variables are co-integrated showing a positive long-run relationship between them for all four countries. However, Mallik and Chowdhury did not prescribe an increase in the rate of inflation to secure sustainable growth rather they suggested that the four economies under study are at a knife edge i.e. any level of inflation above the current level may lead them to higher economic recession.

Dholakia and Sapre (2011) studied the trade-off between inflation and economic growth in India for the period 1950 – 2009. Specifically the study aims to estimate the short-run aggregate supply curve, analyze the inflation unemployment trade-off and address inflationary expectations. To estimate the short-run trade-off between inflation and growth, the regular Phillips Curve based on adaptive expectations is used. For the period under study, a trade-off between the two variables exists in India enabling them to capture the speed of the recovery. The finding of the analysis also reveals that there exists a positively sloped short-run aggregate supply curve responsive to market prices showing that the economy is being more exposed to the international market.

Salian and Gopakumar (2012) too have studied the relationship between inflation and growth in the short-run and in the long-run for the Indian economy. Annual data for the period 1972-2007 obtained from Reserve Bank of India is used to execute the research. To see the long-run relationship, the two step co-integration procedure is used and an error correction model is employed to see the short-run dynamics between the two variables under study. The finding of the study is similar to Dholakia et al (2011). In this study inflation and growth are negatively related. The study also found that inflation is more sensitive to changes in the economic growth while growth is less sensitive to the changes in inflation. These authors then concluded that higher inflation from the previous year is harmful to the economic growth. Thus, no matter what the threshold level is, policy makers must pressure inflation downwards.

Mallick (2008) is the other study that analyzes the impact of inflation on growth for the case of India. Annual time series data from 1960/61 to 2004/05 obtained from Reserve Bank of India (RBI) and Handbook of Statistics on Indian Economy is used. The study applies co-integration techniques, the error correction model (ECM) approach and auto-regression distributive lag model (ARDL) to see the long-run and short-run relationships between the two variables. In this setup the result of the study indicates that inflation has a significant negative impact on the growth level while investment has a positive effect on growth. Other variables such as real interest rate and government budget deficit do not have any significant impact on economic growth. The author recommends a policy that aims for macro-economic stability, i.e. price stability to attain rapid economic growth.

The relationship between inflation, capital accumulation and growth is also studied separately for import dependent developing countries by Ahortor and Adenutsi (2009). In order to see the relationship among the variables under study, a hexa-variate vector autoregressive (VAR) model

is used with inflation, investment, growth, import, money supply and exchange rate variables. Samples of 30 import dependent countries are studied in the paper. Co-integration test and the associated error correction model are used to see the long-run and short-run relationships between the relevant variables. The findings of the study indicate that capital accumulation and economic growth have a long-run negative impact on the level of inflation. But in the short-run, real exchange rate has a positive impact on the growth rate while it negatively affects the level of inflation. The authors also recommend that inflation should be controlled in the short-run using tight monetary policy. To control inflation in the long-run, according to the authors, both demand management and supply side policies must be carried out.

The study of Bittencourt (2010) has examined how higher inflation affected the growth of four Latin American countries (Bolivia, Peru, Argentina and Brazil). He used panel data for the period 1970 – 2007 obtained from the Bureaux of Census of the four countries, World Bank's World Development Indicators (WDI) and Penn World Table (PWT). To execute the study Bittencourt used a growth equation with explanatory variables: inflation, government expenditure, openness, investment, money supply, political regime and interaction between education and urbanization. Among the explanatory variables only inflation is relevant for the study. Accordingly, inflation was found to have harmful effects on the growth of these countries. To him measures taken to lower inflation were effective. Some of the measures taken were introduction of the central bank independence, inflation targeting policies and fiscal responsibility laws.

Yap (1996) analyzed the inflation and growth experience in the Philippines. He used descriptive analysis of the data to see the development of the two macro-economic variables. In this analysis, Yap indicated that 10% to 15% inflation is tolerable. He also considered the measures

taken during the period of the crisis as suitable but measures taken during the time of recovery (1985-95) as short sighted. He recommends the importance of macro-economic stability that can be gained by strong fiscal performance. He also indicated that inflation in Philippines is not only caused by lack of strong fiscal performance but also by the oligopolistic nature of the economy.

Lupu (2012) examined the interdependence between inflation and economic growth in Romania for the period 1990 – 2009. The two decades are analyzed separately using a quantitative and ideological approach. During the first period, i.e. 1990 – 2000, high and volatile inflation was a major source of macro-economic instability that led to the fall of GDP. However, starting from the year 2000 Romania has taken measures to control inflation that led to positive results. From the year 2001 – 2009 the country has witnessed lower level of inflation accompanied by higher economic growth. Thus, according to the study of Lupu, there exists a negative relationship between inflation and economic growth.

Ahmed and Mortaza (2005) explored the relationship between inflation and economic growth in Bangladesh using annual data of real GDP and CPI for the period 1980 – 2005 obtained from Bangladesh Bureau of Statistics. In their study, long-run and short-run dynamic relationship of the two variables is assessed using the Engle-Granger co-integration test and error correction model. The model developed by Khan and Senhadji (2001) is employed to estimate the threshold level of inflation. The empirical finding of the study shows that there is a statistically significant long-run negative relationship between CPI and real GDP. The estimated threshold model of inflation also suggests 6% as a threshold point for the Bangladesh economy. Thus, macro-economic policy makers of Bangladesh are advised to keep inflation below this threshold point.

Ismail, Zaman, Atif, Jadoon and Seemab (2010) studied the long-run and short-run effects of investment, exports and inflation on the economic growth for the Pakistan economy. Time series data over the period 1980 – 2009 obtained from International Financial Statistics (IFS) and World Development Indicators (WDI) is used. Co-integration and Error Correction tests are used to see long-run relationship and short-run dynamics respectively. The empirical finding of the authors affirms that export and investment have a positive impact on economic growth on Pakistan's economy while inflation drags it down both in the long-run and in the short-run. Thus, inflationary conditions do not create a healthy environment for the growth of a nation. Therefore, the authors recommend that the government of Pakistan take measures to reduce inflationary pressures.

Fielding (2008) studied inflation volatility and economic development in Nigeria. The study aims to address: the determinants of inflation volatility, whether economic development brings more or less inflation volatility and what government can do to reduce this volatility further. Fielding used monthly price data of 96 specific items in the 37 states of the country for the period 2001 – 2006 obtained from Nigeria Bureau of Statistics. He preferred the disaggregated data for two reasons. First, unequal distribution of income and hence heterogeneity of consumption is the major characteristic of developing countries. Thus a more aggregated data tends to give more weight to the consumption of the rich and will not be more informative about the cost of living of the poor. Second, the majority of consumers in poor countries are producers too, thus any price volatility on a specific commodity can easily affect the welfare of society. The finding of Fielding states that better transport and communication infrastructure is associated with lower inflation volatility. More access to credit, average inflation and urbanization are associated with higher inflation volatility. Public spending on infrastructure and development are

therefore likely to reduce inflation volatility. Public spending on financial deepening such as extending credit access is likely to increase inflation volatility. According to Fielding, if government policy makers desire to lower inflation volatility the focus should not be on financial development but on communication and transport infrastructural development.

Another study in the case of Nigeria is the study of Chimobi (2010). He employed GDP and CPI time series data for the period 1970 – 2005 as proxy for growth and inflation, respectively. The Johansen and Juselius (1990) co-integration test and VAR based Granger Causality tests are used to see the co-integrating and causal relationships. The result obtained shows that there is a unidirectional causality that goes from inflation to economic growth. Though the study did not check whether there is a positive or negative relationship between the two variables, it assumed that inflation has a harmful impact on growth, as revealed from recent literature. Hence the one way causality that runs from inflation to growth shows the negative effect of inflation on economic growth, according to the author.

The findings of the global literature on the relationship between inflation and growth are conflicting as seen in the empirical literature review. Barro (1995), Ahmed and Mortaza (2005) and Hodge (2005) have found a negative relationship between inflation and growth. On the other hand, Bruno and Easterly (1996) and Boyd and Champ (2006) have indicated that higher inflation leads to lower economic growth but lower inflation promotes economic growth. The other group of economists such as Dotsey and Sarte (2000), Ozdemir (2010) and Mallik and Chowdhury (2001) argue that there exists a positive relationship between inflation and growth. On the other hand economists such as Malla (1997), found out that there is no relationship between inflation and growth. Different studies have different findings in the relationship between inflation and growth. However, most of the economists agree that there is a non-linear

relationship between the two macro-economic variables, i.e., lower inflation promotes growth while higher inflation discourages growth. Some economists take this study further by questioning how low inflation should be in order to promote growth. These economists analyzed the possible threshold level of inflation for specific countries and for groups of countries. The findings of these studies will be discussed in the next sub-section.

2.2.2 Empirical Studies on Threshold Analysis

Most of the studies indicated above show that higher and volatile inflation is bad for the economy. On the other hand, lower and stable inflation is considered as a promoter of the economy. The question is how high inflation should be to affect the economic growth negatively. Many economists have made researches on estimating the threshold level of inflation using panel data for a number of countries and time-series data for single country cases.

Khan and Senhadji (2001) are among the economists who examined the nature of the relationship between inflation and growth by focusing on statistically significant threshold level of inflation. These researchers mainly assessed the threshold level in developed and developing nations. They also tried to verify the findings of Bruno and Easterly (1996) that a negative relationship between inflation and growth exists for high frequency data. Khan and Senhadji used panel data from 140 countries in the world for the period 1960 – 1998. One of the drawbacks of the study is the use of an unbalanced panel due to short-span of data mostly in developing countries. The data for the study is mostly obtained from the World Economic Outlook (WEO) database. In finding the threshold point Conditional Least Square (CLS) is employed. CLS is a method of estimation using Ordinary Least Squares (OLS) for each assigned values for the threshold level in the model. The values assigned have ascending order that

usually starts from one. Among the given values the one that minimizes the Residual Sum of Square (RSS) will be the threshold level of inflation. Using this CLS approach for all countries surveyed, 11% of threshold level of inflation is estimated for developing countries while 1% of inflation is estimated for industrialized countries. To see the preciseness of these estimates computation of confidence region is executed around the threshold estimates. The computation has revealed that confidence intervals are tight implying that thresholds are precisely estimated. Confirming the findings of Bruno and Easterly (1996), the empirical analysis of this study with high frequency data reveals that high inflation (above 1% for industrialized countries and 11% for developing countries) negatively affects the growth of the economy. The authors also recommend that macro-economic policy makers bring inflation down to single digits and make it stable.

The other panel study of estimating threshold level of inflation is undertaken by Kremer, Nautz and Bick (2009). A data set of 124 countries from both developed and developing countries is included in the unbalanced panel of their study over the period 1950 – 2004. The data is obtained from International Financial Statistics (IFS), Penn World and World Trade Organization (WTO). A dynamic panel threshold model is employed in the analysis for the growth equation. The empirical finding reveals 2.5% as a threshold level of inflation for developed countries and 17.2% for developing countries. Kremer et al suggested for the necessity of country specific inflation threshold estimation in order to set inflation targeting monetary policy at a national level. This finding however, differs from Khan and Senhadji (2001) because of the slight difference in data and in the methodology employed.

Jha and Dang (2011) studied the effect of inflation variability on the economic growth when inflation exceeds its threshold point. A panel data of 182 developing countries and 31 developed

countries is used for the period 1961 – 2009. The threshold level is estimated first by using threshold regression developed by Khan and Senhadji (2001). Based on this result, when inflation exceeds its threshold level, the effect of inflation variability on growth will be assessed by using a bootstrap method as suggested by Hansen (1999). The result obtained is quite similar to that of Khan and Senhadji showing the similarity of methodology leading to similar results. The threshold level of inflation for developed countries is 1% and for developing countries is 11%. The overall threshold level of inflation for all countries is 10%. Having this result, inflation variability has no significant effect on the growth of the developed countries. But for the developing countries the case is different. For a level of inflation above the threshold point, inflation variability negatively affects economic growth of a country. Thus, it is necessary to keep inflation within the threshold level so that growth can be promoted.

Pollin and Zhu (2005) studied the relationship between inflation and growth by estimating the threshold level of inflation using panel data from 80 countries from 1961 – 2000. Pooled ordinary least square (OLS) estimation is used in order to achieve the objectives of the study. The findings indicate that for OECD countries there is no statistically significant relationship obtained between the two variables. For the middle income countries, inflation coefficients have positive values with turning band between 14-16%. For developing nations however, the turning point of inflation on growth from positive to negative lies between 15-23%. The authors also recommend monetary policy measures in developing countries to keep inflation between 15-23%.

Bick (2010) independently studied the threshold level of inflation for developing countries by introducing a regime intercept in the panel model. Based on the empirical findings he found that including the regime intercept has importance from statistical and economical perspectives. In order to estimate the threshold level of inflation for developing countries a panel data of 40

growing economies through the period 1960 – 2004 is used. In the model developed, GDP growth rate per capita, regime dependent inflation rate, threshold variable, and semi-log transformation of inflation are used as explanatory variables. In addition, investment as a share of GDP, population growth, log of initial income per capita, and standard deviation growth rate of terms of trade are included in the control variable. The finding of the regression shows regime dependent coefficients are consistent with the implications of standard growth theory. In the absence of the regime intercepts, inflation below 19% has significant positive effect on growth. But when regime intercepts are allowed the threshold level becomes 12%. Based on these findings, Bick suggests that the severe effect of inflation above the threshold doubles in magnitude. He also suggested that keeping inflation below the threshold has stronger beneficial effects.

Munir, Mansur and Furuoka (2009) examined the relationship between inflation and economic growth in Malaysia using a threshold auto-regressive (TAR) analysis. Annual data from the period 1970 – 2005 is used. In the GDP model, inflation rate, broad money supply and gross fixed capital accumulation are used as explanatory variables together with the two regime inflation thresholds. The finding reveals that the threshold level of inflation for Malaysia is 3.89%. A rate of inflation below the threshold has a positive impact on growth and a rate of inflation above the threshold has a negative impact on the economic growth. This finding is similar to the finding of Khan and Senhadji (2001) for developed countries.

Mubarik (2005) has studied the threshold level of inflation for a single country, Pakistan, using annual time series data from 1973 to 2000. The study employs the method used by Khan and Senhadji (2001). Among the variables used in the growth model are: CPI (based on 1990/1), real GDP at constant factor cost, population and total investment obtained from economic survey of

Pakistan. Like Khan and Senhadji, Mubarik also transformed the variables used in the model to log version so as to get rid of asymmetry in inflation distribution. The finding of the study shows 9% threshold level for the economy of Pakistan. The causality test also shows that causality runs one way from inflation to economic growth. Mubarik also recommends macro-economic policy makers of Pakistan to keep inflation below 9%.

Hussain (2005) has revisited the analysis of Mubarik (2005). He states that Mubarik's analysis has shortcomings: because he used the Hodrick - Prescott (HP) filter that lacks substantive economic content, spurious results with high R^2 and low DW statistic, non-linear approach of estimating threshold without checking if there exists non-linear relationship and doubtful Granger causality results. However, Hussain has also used a non linear approach developed by Khan & Senhadji (2001) and annual data for the period 1973 – 2005. In the growth model of his analysis CPI, GDP, population, money supply and investment are used. Data for all variables used are obtained from Pakistan Economic Surveys except broad money supply which is obtained from the State Bank of Pakistan. The result of Hussain's analysis reveals that the threshold level of inflation for Pakistan's economy is 5%. This shows that there is a positive relationship between growth and inflation if inflation is below 5% and this relationship becomes negative if inflation rate exceeds 5%. Hussain further argues that Mubarik's threshold level of 9% is high and incorrect.

Iqbal and Nawaz (2009) analyzed the relationship between inflation and investment and also tried to assess if a second threshold point exists in the inflation growth relationship for the Pakistan economy. Annual time series data is used from 1961 – 2008 obtained from Economic Survey of Pakistan (ESP) and the State Bank of Pakistan (SBP). A growth model is used to address the research objective that is explained by the rate of inflation, population growth,

investment to GDP ratio, money supply to GDP ratio, and the rate of openness of the country to the external world. The finding of the study states the existence of two threshold points at 6% and 11%. Below 6% (the first threshold) there is a positive relationship between inflation and growth. When inflation is in between the two thresholds (6% - 11%), the relationship becomes negative. However, if inflation exceeds the second threshold, it has a negative effect on growth but the effect diminishes. The authors recommend keeping inflation below the first threshold. Low inflation minimizes uncertainties and hence promotes investment. Thus, monetary and fiscal policies are required to co-ordinate to keep inflation low and sustain growth.

The study of Sergii (2009) focuses on the non linear relationship between inflation and growth by estimating the threshold level of inflation in CIS countries. The study is undertaken in two parts (1) for all members of CIS countries and (2) a sample of the CIS countries. The CIS countries include: Belarus, Georgia, Kazakhstan, Moldova, Russia, Ukraine, Armenia, Azerbaijan, Kyrgyz Republic, Tajikistan and Uzbekistan. Out of these CIS countries the sample countries that are separately studied are: Belarus, Georgia, Kazakhstan, Moldova, Russia and Ukraine. Data for the period of 2001 – 2008 is used. Conditional least squares technique applied by Khan and Senhadji (2001) is also employed here. The finding of the study verifies 8% of threshold for sample countries which is statistically significant. For all CIS member countries a threshold level of 9% is obtained that is not statistically significant. The reason for this might be explained as the heterogeneity between countries taken as a sample and CIS countries that are not in the sample. The study concludes 8% as the threshold level of inflation for CIS countries and member country policy makers should keep inflation down to this threshold point.

Hasanov (2011) has studied the inflation growth nexus by estimating the threshold point for a CIS member country, Azerbaijan. The research covers annual data for the period 2001 – 2009 for

variables CPI, real GDP and gross fixed capital formation obtained from statistical bulletin of the Statistical Committee and Central Bank of Azerbaijan. The usual non-linear approach of Khan and Senhadji (2001) is again employed. The growth equation is estimated for each value of threshold point (k) assigned in ascending order. Least square and two stages least square estimation model is used in the estimation process to prevent specification bias. Both methods have close estimation results indicating 13% of inflation as a threshold level. This result is also checked that it has no problems with residuals non-normality, auto-correlation, serial correlation, hetroscedasticity and misspecifications of results. The author concludes that in Azerbaijan, a positive relationship between inflation and growth exists when the inflation rate is below 13% and above this level of inflation the relationship turns to be negative. He further recommends monetary authorities to work to keep inflation below 13%.

Frimpong and Oteng-Abayie (2010) have estimated the level of inflation that is harmful to economic growth in the case of Ghana. Time-series annual data for the period 1960 – 2008 obtained from the World Bank Report and Bank of Ghana quarterly digest of statistics is used to estimate the threshold level. As most of the papers do, this study also uses the model of Khan and Senhadji (2001). In the growth equation the explanatory variables include inflation as measured by CPI, threshold level of inflation that will be assigned in ascending order from 6-12, domestic investment, population growth, terms of trade and the growth in money supply. By estimating the regression for each value that minimizes the residual sum of square (RSS) and maximizes R^2 the optimal value of inflation that positively relates to growth is found. In the inflation threshold regression R^2 is maximized at 11%. The two stage least square estimation results also confirm that R^2 is maximized at 11%. Having this finding, the authors concluded that

for the medium term 7% inflation target is below the threshold level inflation. They suggest the Bank of Ghana and the government to revisit its target of inflation.

One more study of threshold analysis in an African country, Lesetho, is conducted by Seleteng (n.d). Quarterly time series data from 1981 – 2004 is used based on 1995 constant prices having 93 observations. He used the regression technique of Khan and Senhadji (2001) and employed: inflation, threshold level of inflation, population growth and investment as explanatory variables. Before estimating the threshold point, causality test is undertaken to see the causal relationship between inflation and growth. The result of the causality test asserts that there are two directional relationships between the two variables implying that there is a long-run relationship. The estimation of the threshold model shows that the RSS is minimized when the threshold point of inflation (k) is at 10%. Diagnostic tests undertaken for the results include normality test, serial correlation test, heteroscedasticity test and stability test. All these tests were satisfactory making the result statistically significant. The Central Bank of Lesotho (CBL) conducts its monetary policy in line with the South African monetary policy due to the close economic relation between the two countries. Due to this reason CBL is forced to set its monetary policy to keep inflation from 3 to 6%, similar to that of South Africa, which is much lower than the threshold point of Lesotho.

Singh and Kalirajan (2003) examined the relationship between the two economic variables in India by estimating the threshold point of inflation. Annual time-series data over the period of 1971 – 1998 is used in the study. In the growth equation, the explanatory variables include the rate of inflation, inflation lag, rainfall, population growth, education level, investment rate in the public sector and private sector, government consumption and the terms of trade are used. The finding of Singh and Kalirajan is different from other threshold analysis made. In their finding no

matter what the threshold level of inflation, any increase in general price from its previous period affects economic growth. The average inflation level in India 1971 – 1998 was 8.2% which is much higher than its then trading partners. In India inflation needs to be kept parallel to its trading partners. During the time of the study its major trading partners: UK, US, France, and Japan had average inflation of around 5.24%. Accordingly, these authors reject the recommendations of Khan and Senhadji (2001) that single digit inflation has a positive correlation with growth. Though Singh and Kalirajan have ambitious conclusions in combating inflation, they also mentioned that central banks in developing countries have difficulties in targeting inflation in isolation. These banks have multiple goals such as developing the finance system, credit creation, and achieving external balance. Developing countries highly depend on assistance from international financial institutions such as IMF and the World Bank, to have their multiple goals achieved. Singh and Kalirajan continue arguing that such dependencies on these institutions reduce the independence and credibility of central banks. In their conclusion the authors suggested that developing countries must work hard to reduce inflation as much as possible, in spite of the multiple objectives that distract their focus from targeting inflation.

As in the discussion above, empirical findings regarding the threshold level of inflation vary across countries. The difference in the threshold points is found to be larger between developing and developed countries. For developed countries, the inflexion point at which the sign of the relationship between inflation and growth becomes negative is below 3%. Jha and Dang (2011) and Khan and Senhadji (2001) have found 1% as inflation threshold point while Kremer, Nautz and Bick (2009) have found it to be 2.5% for developed countries.

In the case of developing countries, the range of the threshold varies from 9 – 17% in different studies. However, there are exceptions such as Munir, Mansur and Furuoka (2009) and Hussain (2005) who found 3.89% and 5% as a threshold point for Malaysia and Pakistan, respectively. Studies such as Iqbal and Nawaz (2009) have found two threshold points for a developing country, Pakistan. The reason for large differences in the finding of the threshold points in developing countries mainly seems to be the type of data used, structure of the economy and differences in the explanatory variables in the models. In general, one can conclude that developed countries have lower threshold points whereas developing countries have higher threshold points. Keeping this in mind, the next section discusses the literature on inflation and growth relationships in the Ethiopian context.

2.3 Inflation and Growth in Ethiopia

Since the major target of this study is to see the relationship between inflation and growth in Ethiopia, it will be important to see the relationship between these variables in the Ethiopian context. The relationship between the two variables is not studied as well in the country as it is studied globally. The reason for this might be the low and stable history of the macro-economic condition of Ethiopia. Studies undertaken so far will be summarized in this section.

Ayalew (2000) studied the trade-off between inflation and unemployment in Ethiopia. The study aims to find out if there is: a trade-off between inflation and unemployment, long-run determinants of inflation in the country and whether the Ethiopian economy affords stabilization. He used quarterly data over the period of 1973(Q2) – 1999(Q4). To show the trade-off between inflation and unemployment, Ayalew has measured unemployment by estimating the potential

output and taking the difference from the actual output. In other words, the output gap derived is used as a proxy for unemployment. To estimate the trade-off between unemployment and inflation, inflation is explained as a function of unemployment. The estimation result disclosed that there is no trade-off between the two variables under study. A 100% rise in the rate of unemployment increases inflation by 47%. Thus, the traditional Phillips Curve is not applicable to Ethiopia. To see the long-term determinants of inflation in the country, the explanatory variables that are used are inflation inertia, money supply, world price index, unemployment, drought and war. The estimation result has revealed that structural variables such as unemployment of resources explain inflationary pressures quite well in Ethiopia. Generally, the major finding of this study implies that as the unemployment level declines then inflation falls. This shows that in the Ethiopian context there is a positive relationship between economic growth and inflation assuming that the lower rate of unemployment is accompanied by higher economic growth.

Michael (2008) has examined the basic factors that determine the rate of inflation and has also assessed the long-run and short-run relationships between inflation and economic growth in Ethiopia. The study has tried to estimate the threshold level of inflation for Ethiopia. To execute the study Michael used annual data of relevant variables for the period 1971 – 2006. To see the long-run and short-run relationships between inflation and growth, he employed co-integration and error correction model. The threshold estimation is conducted using the technique developed by Khan and Senhadji (2001). The findings of the study show that money supply is the major factor for the rising inflation and that an increase in GDP has a price reducing effect. From the study it appears that there exist a negative relationship between inflation and economic growth. The co-integration test however confirms that a statistically significant long-run negative

relationship exists between inflation and growth in Ethiopia. The estimated threshold level of inflation is 16%. It is therefore recommended that policy makers keep inflation below the 16% threshold level.

Asaminew (2010) has estimated the threshold level of inflation by using annual data from 1970 – 2010. He used the method developed by Khan and Senhadji (2001) and the model includes explanatory variables such as: inflation, investment, access to credit and drought. The finding of the study shows the threshold level of inflation in the case of Ethiopia as 8 – 10%. Assaminew recommends the need for smooth interaction between fiscal and monetary policies to maintain the inflation level close to the threshold. The difference in the threshold findings between the study of Michael (2008) and Asaminew is not methodological (since the methods used in both cases are similar) but it has more to do with model specification and estimation procedure error.

Teshome (2011) assessed the relationship between inflation and growth in Ethiopia. Descriptive analysis of the data from 2004 – 2010 is conducted. In the analysis Teshome has compared the Ethiopian situation with the other Sub-Saharan African (SSA) countries. The author points out that on the average Ethiopia's economic growth and inflation rate are higher than the SSA countries by 4.5% and 9% respectively. After analyzing the nature of the economic growth in the country he concluded that inflation does not affect the economic growth because of the broad based nature of the growth. He then concluded that from 2004 – 2010 average economic growth in Ethiopia is 11% and average rate of inflation during the same period is 16%. The period understudy has witnessed a positive relationship between inflation and economic growth. According to the author, no matter what happens to inflation, economic growth is not an affair of choice.

Geda and Tafere (2008) have also analyzed the forces behind the recent inflationary pressure in Ethiopia. Quarterly data for the period 1994/5 – 2007/8 is used. In the formulation of the VAR model explanatory variables for the Ethiopian inflationary process are: exchange rate, world price index, world non-food prices, real income, excess money supply, food imports, food aid, marketed surplus, unit wage costs and the exogenously administered prices. In order to avoid spurious regressions, unit root tests were conducted and all variables are found to be stationary at the first order I(1) that allows undertaking the VAR based co-integration test. After the co-integration vectors are identified for the models of food and non-food inflation, a single error correction model is estimated for both models. Among the explanatory variables of inflation income growth is the relevant variable in our case. In this study it is found out that one of the sources of food inflation is the rise of income. The reason given for this is the low level of income among households. Given the low level of income, an increase in income leads to higher food inflation because households spend their additional income on food items. These authors recommend that policy makers cool down economic growth through fiscal and monetary conservatism. Since the main source of the recent inflation in the country is food inflation, an increase in income is found to be the major determinant of food inflation. Hence, it can be concluded that there is a negative relationship between inflation and economic growth in Ethiopia.

Like the global empirical evidences, studies undertaken in Ethiopia have different findings on the relationship between inflation and economic growth. Studies conducted by Ayalew (2000), Geda and Tafere (2008) and Teshome (2011) suggest that there is positive relationship between economic growth and inflation. Ayalew and Teshome suggest that growth must take priority while Geda and Tafere suggest the importance of macro-economic stabilization. However,

studies like Michael (2008) show a negative relationship between inflation and growth. In the threshold analysis of Assaminew (2010) there is a positive relationship between inflation and growth when inflation is below 11%, but the relationship becomes negative when inflation exceeds this point. The main differences in the results of these studies can be attributed to the model, methodology and the data.

In general there are conflicting theories and empirical findings regarding the relationship between inflation and economic growth. The relationship between these two macro-economic variables is widely studied both in cross country panel data and single country time series data. In Ethiopia however, because of stable macro-economic history of the country, the subject is not exhaustively studied with formal modelling and appropriate econometric procedure. The topic started to be discussed mainly after 2004/5 when the economy began achieving rapid growth associated with higher inflation. Mainly due to this reason, there are two main literature gaps identified on the research papers that are undertaken in Ethiopia.

The first gap is the exclusion of drought from the inflation equation. Except Ayalew (2000), none of these researches included drought in the inflation equation. From simple data observation, inflation is highly related to the level of rainfall prior to 2004/5. This shows how the macro-economic condition of the country is highly dependent on the rain fed agriculture, which makes it necessary to include drought in the inflation equation. It has been 12 years since the paper of Ayalew is conducted and thus the high growth high inflation period is not included in his research.

The second literature gap identified is the issue of methodology. It is only Michael (2008) who has undertaken a co-integration test to see the long-run relationship between inflation and growth

in Ethiopia. He employed the Engle and Granger (1987) co-integration test to see the long run relationship.

The current study tries to fill these gaps by including drought in the inflation equation. The Johansen and Juselius (1990) co-integration technique and the associated Vector Error Correction model will also be employed as it is used by Mallik and Chowdhury (2001). It further employs Conditional Least Squares (CLS) method to estimate the threshold level of inflation for the Ethiopian Economy. The next chapter will discuss these methodologies in detail.

Chapter Three

Methodology and Econometric Modelling

This chapter focuses on developing methods of analysis that will address the objectives of the study. Accordingly, two main econometric models are used. The first model is the one utilized to examine the relationship between growth and inflation and the second is applied to estimate the threshold level of inflation.

The long-run and short-run relationship between inflation and growth is examined using the inflation model given in Equation 1. The co-integration test and the associated Error Correction Mechanism of Engle and Granger (1987) approach, on one hand and on the other hand, the Johansen (1991) approach are used to study the long-run and short-run relationships between the two macro-economic variables. The other model employed is the economic growth model, which is used to estimate the threshold level of inflation. This model is quite parallel to the one used by Khan and Senhadji (2001). All the estimations, unit root tests and diagnostic tests are carried out using Econometric Views (E-views) version 6.

This chapter has four main sections. The first section focuses on model specification and data characteristics. The second section discusses time series issues that are related to unit root problems. The third section deals with co-integration and error correction tests of both Engle-Granger's and Johansen's approaches. The last section explains how the conditional least square (CLS) technique is employed in order to find out the maximum level of inflation that the economy can hold without being affected negatively. Each section will be discussed in detail and different sub-sections are assigned when necessary.

3.1 Model Specification and Data Characteristics

As mentioned above, two separate econometric models for inflation and economic growth are developed to address the objectives of the study. The inflation equation is used to see the long-run and short-run relationship between the two macro-economic variables under study, and the growth model is used to estimate the threshold level of inflation. In the following sub-sections these two models are discussed.

3.1.1 The Inflation Equation

Ethiopia had a stable and low inflation in its history compared to other developing countries, but since the year 2004/5 the average rate of inflation was estimated to be 17.5 (Teshome 2011: 3 - 4). There are a number of factors for the current galloping rate of inflation in the country. Based on theoretical grounds, some of the most plausible factors behind the increasing inflation can be specified in the inflation equation as:

$$\mathbf{CPI_t = f(RGDP_t, REER_t, CPI_{t-1}, \ drought_t)} \qquad \text{………….} \qquad (1)$$

where, CPI_t = Consumer Price Index at time t

$RGDP_t$ = Real Gross Domestic Product at time t

CPI_{t-1} = Inflation Inertia (Inflation Expectation)

$REER_t$ = Real Effective Exchange Rate at time t

$Drought_t$ = measured in binary form using "0" and "1"

Most of the independent variables that explain inflation in the model are derived from international literature. The discussion paper of Honohan and Lane (2004) confirms the importance of the exchange rate channel on inflation dynamics. On the other hand, the Nobel

memorial lecture by Friedman (1976) indicates that inflation expectation is one of the most important factors of price stability.

Real GDP is included in the inflation model mainly because in an economy where there exists supply scarcity, an increase in production leads to reduced prices. However, in an economy producing above its full employment level, an increase in productivity may lead to inflationary pressure as well. Hence, productivity may lead to lower prices or it may lead to higher prices. In order to see the effect of changes in output on inflation in Ethiopia real GDP is included as one of the explanatory variables in the inflation model.

In the model given below, among the explanatory variables REER is expected to influence the inflation rate locally. This is because a large amount of consumer and capital goods are imported from abroad. An increase of the exchange rate of local currency to foreign currency leads to an increase in local price level even if the price of the good does not change in the foreign country. Thus, any observed change in the real exchange rate has a direct impact on the local general price level (Salvatore 2004: 515).

Inflation inertia explains the current inflation by capturing expectations. This kind of expectation is highly linked to "adaptive expectations" where expectations are formed based on past history. The inflation expectations of economic agents are highly dependent on the past records of inflation so that it is included as one of the explanatory variables of the current inflation in the model.

In a predominantly rain fed agrarian economy, such as Ethiopia, aggregate output is erratic. The price level also follows the output pattern in the economy. In the years where there is no drought, output rises and prices fall whereas in the drought years yield declines and prices increase

(Dinssa and Kifle 2009: 123-24). Due to this reason drought is highly influential in macro-economic variables and is included in the inflation equation. Drought is measured using a dummy variable, as one of the factors that affect inflation. The dummy is defined as "0" during the years where there is no occurrence of drought and "1" in the years where there occurs drought.

Equation (1) can be formally written as:

$$\text{logCPI}_t = \alpha_0 + \alpha_1 \text{logRGDP}_t + \alpha_2 \text{logREER}_t + \alpha_3 \text{logCPI}_{t-1} + \alpha_4 \text{drought}_t + \mu_t \qquad (2)$$

where, log stands for natural logarithm

α's - coefficients of the explanatory variables

μ_t. – residual term

Transforming variables to their natural logarithm form has two basic advantages. First, in the non-logarithmic linear equation, slope coefficients (α's in this case) measure only the rate of change of the mean of the dependent variable (CPI in this case). However, a transformation of variables to their natural log enables slope coefficients (α's) to measure not only the change of mean but also the elasticity of the dependent variable with respect to the percentage change in the independent variables. Second, the log transformation reduces the problem of hetroscedasticity since it compresses the scale in which variables are measured. Though the problem of heteroscedasticity mostly arises in cross-sectional studies, it can also occur in time series analysis such as ours (Gujarati 2003: 420 – 22).

Based on prior knowledge from economic theories, coefficients of real effective exchange rate and inflation expectation are believed to have positive coefficients. On the other hand, in the years where there is no drought inflation is expected to decline and in the years of drought

inflation is expected to rise. However, as mentioned in the literature review there is still wide disagreement in the direction of the coefficient for real GDP which shows its relationship with the dependent variable inflation. For example, the study of Barro (1995) and Hodge (2005) shows the existence of negative relationship between inflation and growth while the study of Dotsey and Sarte (2000) and Ozdemir (2010) exhibits the positive relationship between the two variables. One of the objectives of this study is to identify the coefficient of the real GDP in the long-run model to see its relationship with inflation.

3.1.2 The Growth Equation

A growth model similar to the one developed by Khan and Senhadji (2001) is used to detect the threshold level of inflation in Ethiopia. This model permits us to estimate the threshold level of inflation through a technique known as conditional least square (CLS). This technique will be discussed in detail in the last section of this chapter. The growth equation has six explanatory variables consisting of inflation, inflation threshold, population growth rate, investment growth rate, openness of the country and drought.

These explanatory variables are selected based on macro-economic theoretical framework and empirical growth literature. In many theoretical growth models such as Harrod (1938) and Domar (1946) population growth and capital accumulation are considered as essential determinants of economic growth. International trade theories, on the other hand, suggest that a country engages in trade because it benefits from the trade economically. Due to this reason, openness of the economy to the rest of the world is considered as one contributor to the economic growth of a country (Salvatore 2004: 62-71). Depending on the structure of the economy different empirical studies include different variables that can potentially affect the

growth of the economy. In this growth model, drought is included as one of explanatory variables since the economy of the country under study is highly dependent on rain-fed agriculture (Dalle 2009: 77-79).

Arithmetically, the economic growth model of the country is thus specified as,

$$\textbf{Growth}_t = \beta_0 + \beta_1(\textbf{inf}_t) + \beta_2 * D_t(\textbf{Inf}_t - \Pi^*) + \beta_3(\textbf{pop}_t) + \beta_4(\textbf{inv}_t) + \beta_5(\textbf{open}_t) + \beta_6(\textbf{Drought}_t) + \varepsilon_t$$

(3)

where, Growth = growth rate of real gross domestic product ,

Inf$_t$ = inflation rate at time t measured by the consumer price index,

pop$_t$ = population growth rate at time t ,

inv$_t$ = investment growth rate at time t,

Π^* = the threshold level of inflation

open$_t$ = openness of the economy to the rest of the world,

Drought = the index of years of drought

β's = slope coefficient of explanatory variables

In the process of estimating the threshold level of inflation, the variables in the equation are computed as:

$Growth_t = Dlog\ (RGDP_t)\%,$

$Inf_t = Dlog\ (CPI_t)\ \%,$

$Pop_t = Dlog\ (pop_t)\%,$

$Inv_t = Dlog(inv_t)\%,$

$Open_t = Dlog\ (open_t)\%,$

where, D = dummy variable that takes the value of one when inflation level becomes greater than the threshold and zero otherwise

$$D_t = 1: 100*D \log CPI > \Pi^*$$

$$0: 100*D \log CPI \leq \Pi^* \quad \text{………………………………….} \quad (4)$$

By estimating equation **(3)** for different values of Π, which is assigned in an ascending order, the optimal value of Π will be the one that maximizes R^2 and minimizes the residual sum of square (RSS). This estimation process will be discussed in detail in the last section of this chapter.

3.1.3 The Types and Sources of Data

All the data in this research are obtained from published and unpublished sources of the Central Statistics Agency (CSA), Ethiopian Investment Agency (EIA) and the National Bank of Ethiopia (NBE). Data for some relevant variables are not provided on a quarterly basis. However, various techniques are used in order to convert the annual data to quarterly ones. In this sub-section it is important to discuss these techniques and the type of the data used in the research.

Real Gross Domestic Product (RGDP)

The real gross domestic product of the country is recorded by the Central Statistics Agency (CSA). Nevertheless, real GDP is recorded annually and the data on quarterly basis is not available. Since this research employs quarterly data for relevant variables, it becomes necessary to disaggregate the annual data into quarterly ones. Numerous time series studies that employ GDP quarterly data (for countries where there is no data on quarterly basis) use Lisman and Sandee (1964) method of GDP disaggregation. In this study, the same technique is employed for GDP disaggregation.

Lisman and Sandee (1964) use weighted mean of quarterly values of the years t – 1, t and t + 1 using two steps. The first step is to build the quarters as

$$\psi 1_t = \psi 2_t = \psi 3_t = \psi 4_t = \tfrac{1}{4} Y_t \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (5)$$

The second step is to get the weighted arithmetic mean of ψ_i t-1, ψ_i t, and ψ_i t+1 to estimate the variable that will be disaggregated, which is GDP in this case. Lisman and Sandee (1964) proposed the use of prior information on seasonal figures. Accordingly, the National Bank of Ethiopia (NBE) uses the formulae given from (6) – (9) for the quarterly disaggregation of the annual data as given by

Quarter 1 $\rightarrow \tfrac{1}{4} * (0.291 * AGDP_{t-1}) + (0.793 * AGDP_t) - (0.084 * AGDP_{t+1})$ **.... (6)**

Quarter 2 $\rightarrow \tfrac{1}{4} * (-0.041 * AGDP_{t-1}) + (1.207 * AGDP_t) - (0.0166 * AGDP_{t+1})$ **.... (7)**

Quarter 3 $\rightarrow \tfrac{1}{4} * (-0.166 * AGDP_{t-1}) + (1.207 * AGDP_t) - (0.041 * AGDP_{t+1})$ **... (8)**

Quarter 4 $\rightarrow \tfrac{1}{4} * (-0.084 * AGDP_{t-1}) + (0.793 * AGDP_t) + (0.291 * AGDP_{t+1})$ **.... (9)**

where, t is the current year, t-1 is the previous year and t+1 is the subsequent year. The figures in the data are given in millions of birr (the currency of Ethiopia). The real GDP is obtained by taking the ratio of the nominal GDP to the GDP deflator so that GDP is used in real terms.

Consumer Price Index (CPI)

Regarding CPI, quarterly data is available at the country level only starting from 1998. There exists no record of the CPI at national level for the years before 1998. This paper uses the Addis Ababa CPI as a proxy for the national CPI for the period before 1998. Studies that use inflation

as a variable in their model for the case of Ethiopia use the same procedure. Ayalew (2000), Wolde-Rufael (2008), Michael (2008) and Asaminew (2010) are few of those ones.

Population Growth Rate

Population census is undertaken in Ethiopia every 10 years. Based on the census, the Central Statistics Agency (CSA) estimates annual population growth using an exponential growth equation given as

$$P_t = P_0 \, e^{rt} \qquad \text{…………………………….} \qquad (10)$$

Where,

P_t = population at time t,

P_0 = population at base year,

e = natural exponential value

r = the rate of population growth,

t = time of projection

Using this annual population projection equation, the same equation is used to estimate the growth of population on a quarterly basis (CSA 2008). All the figures given are in thousands.

Investment

Data regarding investment is obtained from the Ethiopian Investment Agency (EIA). The data on investment refers to only private investments (domestic and foreign) that are licensed under EIA. This data is available for the time period under study. The figures given are in thousands of birr.

Openness

Openness of the country measures the openness of the economy to the rest of the world. Openness of a country's economy can be measured using different techniques. In this study, it is measured using trade intensity ratio (TIR). TIR refers to the ratio of $import_t$ plus $export_t$ to the GDP_t so as to indicate the level of openness of the country at a specific time t (Serranito 2003: 7). To measure the rate of openness data for imports, exports and GDP are required. As discussed above, GDP is disaggregated using Lisman and Sandee (1964) method of disaggregation while imports and exports are found to be in order for the period under study. All the values for exports and imports given in the data are in thousands of birr.

Drought

Based on the definition of the Advanced Learners English Dictionary, drought is an extended period of dry weather without rain. Most sub-Saharan African countries are rain dependent agrarian economies and Ethiopia is no exception. Country specific studies such as this one, allow incorporating a country's specific problem in the models. In this study drought is considered as one variable that affects the two main macro-economic variables: the level of inflation and GDP growth. This is explained in the models of inflation and growth in the form of dummy variables. As mentioned above, the quarters of years of no drought are represented by "0" and for the quarters of years of drought "1" is used.

3.2 Time Series Issues and Unit Root Tests

In a time series analysis, a great deal of attention is given to stationarity of the variables in order to get rid of the problem of spurious regression. It is often said that most macro-economic variables follow a random walk model, i.e., exhibiting a unit root behavior. According to

Studenmund (2011) a random walk process can be identified as stationary when its mean and variance are found to be constant across time; and the value of the co-variance between the two time periods is dependent on the lag between them and not the actual time of computing the co-variance. A random walk model can be justified when the following properties hold:

$$\text{Mean: } E(Y_t) = \mu \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

$$\text{Variance: Var } (Y_t) = E(Y_t - \mu)^2 = \sigma^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

$$\text{Co-variance: } \gamma k = E[(Y_t - \mu)\,(Y_t + k - \mu)] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

where, Y_t is a series of random walk

γk is the auto covariance at lag k

If one or more of the above conditions fail, the random walk process Y_t is said to be non-stationary exhibiting a unit root problem. Mostly, macroeconomic and financial time series variables are found to be non-stationary (Koop 2009: 180 – 3).

The concern for stationarity of time series variables gives rise to analysis of unit root tests. Unit root tests are statistical procedures that are designed to make judgment as to whether a given sample of time series data implies a unit root or the time series is found to be stationary. In most cases a time series that exhibits stationarity is denoted as I(0) and a series that shows unit root is indicated as I(1) (Wooldridge 2009: 192 – 5).

The stationarity test that has become widely popular in time series econometric analysis is the unit root test. In this paper, two unit root tests are employed namely: Augmented Dickey Fuller test and Phillips Perron test. However, to better understand these tests, it is important to know how to perform the Dickey Fuller test and its limitations as well.

To start with, a random walk model (RWM) that resembles the Markov first order auto-regressive model is assumed. The RWM can be given as in the equation **(14)**

$$Y_t = \theta Y_{t-1} + \varepsilon_t \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \qquad \textbf{(14)}$$

where, Y_t – is a given time series

ε_t is the white noise error term.

If $\theta = 1$ the equation given is said to exhibit unit root and the series is said to be a non stationary stochastic process. In practice, however, if the time series is not found to be stationary at levels there is a possibility that its first difference becomes stationary (Dickey and Fuller 1981: 1057 – 8). Thus taking the first difference of equation **(14)**,

$$Y_t - Y_{t-1} = \theta Y_{t-1} - Y_{t-1} + \varepsilon_t$$

$$= (\theta - 1) \, Y_{t-1} + \varepsilon_t \qquad \dots\dots\dots\dots\dots\dots \qquad \textbf{(15)}$$

Equation (15) can the be re-written as

$$\Delta Y_t = \gamma Y_{t-1} + \varepsilon_t \qquad \dots\dots\dots\dots\dots\dots \qquad \textbf{(16)}$$

where, $\gamma = (\theta - 1)$,

Δ is the first difference operator.

At this level it is possible to estimate equation **(16)** using the sample time series data. If the estimated slope coefficient in the regression $(\hat{\gamma})$ is negative, then it can be concluded that Y_t is stationary. If, on the other hand, the estimated slope coefficient $(\hat{\gamma})$ is zero then the series can be considered as non-stationary (Gujarati 2003: 813 – 16).

Testing the null hypothesis that $\theta = 1$ or $\gamma = 0$ turns out to be difficult since the distribution of the t-test is non-standard under null hypothesis and will not be normally distributed as N(0,1). Under the null hypothesis $\gamma = 0$ the estimated t-value follows the tau (τ) statistic. The tabular values for the τ statistic are given by Dickey and Fuller (1979). The critical points in the τ statistic

distribution are larger than those of the t statistic. The border line of rejection of the null hypothesis at the 95% level for a one tailed t test is -1.658. On the other hand, for the τ test the critical value at the same level is -1.95 for sample T = 100. In numerous literatures, the τ test is also known as the Dickey-Fuller test, in honor of its discoverers.

A random walk process may have a drift or no drift and it may have a deterministic or stochastic trend. To permit these possibilities the Dickey-Fuller test is estimated in three different forms

Y_t is a random walk: $\Delta Y_t = \gamma Y_{t-1} + \varepsilon_t$ ………………………….. **(17)**

Y_t is a random walk with drift: $\Delta Y_t = \beta_1 + \gamma Y_{t-1} + \varepsilon_t$ ………………….. **(18)**

Y_t is a random walk with drift around a stochastic trend: $\Delta Y_t = \beta_1 + \beta_{2t} + \gamma Y_{t-1} + \varepsilon_t$ … **(19)**

where, t is the time trend variable. In each case the null hypothesis H_0: $\gamma = 0$ and $\beta = 0$, i.e., no deterministic trend where the time series is non-stationary and there exists unit root. The alternative hypothesis H_1: $\gamma < 0$ and the time series is stationary. Thus, if the null hypothesis that H_0: $\gamma = 0$ is rejected Y_t is stationary with zero mean, non zero mean and around deterministic trend for equations **(17)**, **(18)** and **(19)**, respectively (Gujarati 2003: 812 – 16).

By estimating the three equations using OLS and dividing γ, the estimated coefficients of Y_{t-1} by its standard error, it is possible to work out the τ statistic. By referring to the tabulated values for the Dickey-Fuller tables, if the absolute value of the τ statistic ($/\tau/$) exceeds the Dickey-Fuller τ critical values the null hypothesis will be rejected, in which the time series is stationary. On the other hand, if the computed $/\tau/$ value is less than the τ critical value, the null hypothesis H_0: $\gamma = 0$ will not be rejected making the time series non-stationary (Dickey and Fuller 1979: 427 – 29).

This test assumes that the error terms ε_t in equation **(17)**, **(18)** and **(19)** are uncorrelated. However, in practice error terms are correlated so that the test loses its power significantly making the results obtained less credible. To deal with these issues in most cases the "Dickey-Fuller" test is often used as "Augmented Dickey Fuller" test. In the ADF test, unlike DF test the number of lags of the dependent variable is included to the regression to whiten the errors (Gujarati 2003: 816 – 7).

3.2.1 Augmented Dickey-Fuller (ADF) Test

As discussed above conducting the Dickey-Fuller test using the three equations, the error terms ε_t's are assumed to be serially uncorrelated. In order to reduce the problem of correlation among the error terms, Dickey and Fuller developed the Augmented Dickey Fuller (ADF) test. Assuming the random walk model with drift around the stochastic trend, i.e., equation **(19)**, as correctly specified by augmenting the lagged values of the explained variables ΔY_t, the ADF test can be estimated using the equation **(20)** below. However, it has to be noted that there is no way of identifying which equation is specified correctly and thus the trial and error method cannot be avoided (Cheung and Lai 1995: 277 – 8).

$$\Delta Y_t = \beta_1 + \beta_{2t} + \gamma Y_{t-1} + \psi_1 \Delta Y_{t-1} + \psi_2 \Delta Y_{t-2} + \ldots + \varepsilon_t$$

$$\Delta Y_t = \beta_1 + \beta_{2t} + \gamma Y_{t-1} + \sum_{i=1}^{k} \psi_i \Delta Y_t + \varepsilon_t \qquad \ldots\ldots\ldots\ldots\ldots \qquad (20)$$

Where, ε_t is the white noise error term,

$$\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2}), \Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$$

The most important concern of the ADF test is to estimate γ, similar to the Dickey-Fuller test (Ng and Perron 2001: 1519 – 20). In equation **(20)**, *k* refers to the number of lags included into the model to guarantee the error terms ε_t are white noise, i.e., error terms have zero mean and

constant variance (uncorrelated) across different time t. Schwarz Information Criteria (SIC) is automatically used to select the maximum lag length for *k*.

The same critical values of the tau (τ) statistic are applied in the ADF test since both DF and ADF follow similar asymptotic distribution. The rejection of the null hypothesis that H_0: $\gamma = 0$ implies that the series is stationary and the non rejection of the null hypothesis H_0: $\gamma = 0$ indicates that the time series is non stationary.

3.2.2 Phillips Perron (PP) Test

The basic assumption of the Dickey and Fuller (1981) unit root test is that the error terms are assumed to be independently and identically distributed (*iid*). The ADF test adjusts the DF test by adding lags of the dependent variable to generate *iid* errors in the model. The Phillips and Perron (1988) unit root test is the alternative approach that lets non *iid* errors in the model.

To deal with the problem of serial correlation in the errors, non parametric statistical methods are used in the Phillips Perron test without including the lag difference terms. The Phillips and Perron (1988) test solve the serial correlation problem among error terms by using a correction factor which estimates the long-run discrepancy of the error process with the modification of the Newey-West formula. The Perron test does not require the disturbance term to be serially uncorrelated or to be homogeneous. The test allows dependence and heterogeneity of disturbances of either autoregressive (AR) or moving average (MA) form (Phillips 1987: 286).

Since the asymptotic distribution of the Phillips and Perron (1988) test is the same as the Dickey Fuller test, the same critical values are used for both ADF and Phillips Perron test. Generally, the Phillips Perron test is found to be more powerful than the ADF test.

As discussed above, there are numerous techniques that are used for testing the unit root of time series data. However, there is no consensus reached on which type of test to utilize without any drawbacks. For this reason with their negative features the Augmented Dickey Fuller and the Phillips Perron tests are employed in this study.

3.3 Co-integration and Error Correction Mechanisms

The idea of co-integration was first introduced by Granger (1981) and developed by Engle and Granger (1987) giving it a foundation for representation, estimation, testing and modelling of co-integrated non stationary time series variables. In this approach of co-integration analysis non stationary time series data sets are allowed to be used and spurious regression can also be avoided. In doing so, long-run models can properly be estimated and tested.

As discussed in the previous section, if individual time series variables are not stationary in levels there is a possibility that their first difference becomes stationary. If the variables utilized in the study are found stationary at the same order, say in their first difference I(1), it is possible to continue the regression. After the regression takes place if the error terms are found stationary at levels, then the linear combination of the individually non stationary I(1) variables is said to be stationary I(0). In such a case, the two variables are integrated. This is simply the two step procedure of the Engle and Granger (1987) that will be discussed in detail in the coming sub-section.

The economic interpretation of co-integrated variables shows the long term relationship between the two variables under study (Engle and Yoo 1987: 149 – 51). The co-integration test in this study will be carried out using the Engle and Granger (1987) approach and the Johansen (1988) approach. These techniques of estimating co-integration test are discussed below.

3.3.1 The Engle – Granger Approach

Once relevant variables are checked for their stationarity using unit root tests, the regression of the inflation equation **(2)** takes place, even in the presence of the unit root. It is rational to worry about the spurious regression at this stage, but the regression still continues to see the combined effect of the two non stationary variables. After carrying out the regression on the inflation equation unit root test is applied on the residuals of the equation (μ's) obtained.

Given that the error terms obtained are based on the estimated parameters (β's), the Augmented Dickey Fuller critical values are not suitable in this case. As a result, Engle and Granger (1987) calculated critical values that are appropriate to estimate stationarity of the error terms.

Continuing on the regression of equation **(2)**, assuming that the variables are non stationary individually, the Engle-Granger approach checks for the mixed effect by checking the stationarity of the error terms. If the error terms are found to be stationary I(0) at their levels, using the Engle and Granger (1987) critical τ values, then the regression of the inflation equation will not be spurious.

In the process of avoiding spurious regression, the regression of equation (2) can also be considered as a co-integration test. The co-integration relationship between the two variables can be interpreted as a static long-run equilibrium relationship and the co-integrating parameters are interpreted as long-run parameters (Campbell and Shiller 1988: 4).

Long-run relationships are mostly explained in static equilibrium form. Due to these reasons it is difficult to explain the dynamics structural and institutional changes that occur in the economy in the short-run. Due to this reason, it is necessary to study the short-run relationships and short-run dynamism of the variables under study. The Error Correction Mechanism (ECM) is the best

possible alternative for assessing the short-run dynamic structure of the model and hence is used in this study (Campbell and Shiller 1988: 5 – 6).

As stated in the "Granger Representation Theorem" if two time series variables are co-integrated then the relationship between the co-integrated variables can be expressed as an Error Correction Model. As mentioned above when error terms of the equation **(2)** are stationary at their levels, using ADF unit root test, then the variables are said to be co-integrated (Engle and Granger 1987: 256 – 8). The ADF test for the error term is computed as

$$\Delta\mu_t = \alpha + \pi\mu_{t\text{-}1} + \sum_{i=1}^{k} \gamma\, i\Delta\mu_t - i + v_t \qquad \text{.......................} \qquad (21)$$

where, α is the constant term

and π implies the integral level. After having the co-integrating long-run relationship the basic structure of ECM looks like

$$\mathbf{lnCPI_t = \omega_0 + \omega_1\, lnGDP_t + \omega_2\, lnREER_t + \omega_3\, lnCPI_{t\text{-}1} + \omega_5\, Drought_t + \delta_1\, ECT_{t\text{-}1} + \varepsilon_t}$$

$$\text{......................} \qquad (22)$$

where, ω's capture the short-run effects of the explanatory variables on the dependent variable, δ_1, captures the rate at which the dependent variable (inflation) adjusts to the equilibrium state after structural or institutional shocks that occur. In other words, δ_1 captures the speed at which the error is corrected after shocks that occurred (Engle and Yoo 1987: 148 – 52).

However, it should be noted that the inclusion of the Error Correction Term (ECT) creates changes in all the variables in the ECM equation. At this stage it is important to discuss how the ECM equation is derived. To explain the derivation of the ECM equation a two variable model is developed for simplicity. As specified in Engle and Granger (1987) having Y_t as the dependent

variable (inflation in our case) and X_t as the explanatory variable, the long-run equilibrium relationship equation can be explained as

$$Y_t = \alpha_0 + \alpha_1 X_t + \varepsilon_t \quad \text{..} \quad (23)$$

And the error correction mechanism for the short-run dynamics can be written as

$$Y_t = \beta_0 + \gamma_0 X_t + \gamma_1 X_{t-1} + \beta_1 Y_{t-1} + \varepsilon_t \quad \text{..} \quad (24)$$

This equation helps to identify how changes in the independent variable affect the independent variable in the short-run. Subtracting Y_{t-1} from both sides, equation **(24)** becomes

$$Y_t - Y_{t-1} = \beta_0 + \gamma_0 X_t + \gamma_1 X_{t-1} - Y_{t-1} - \beta_1 Y_{t-1} + \varepsilon_t$$

$$\Delta Y_t = \beta_0 + \gamma_0 X_t + \gamma_1 X_{t-1} - (1-\beta_1) Y_{t-1} + \varepsilon_t \quad \text{..} \quad (25)$$

Again subtracting $\gamma_0 X_{t-1}$ from both sides

$$\Delta Y_t - \gamma_0 X_{t-1} = \beta_0 + \gamma_0 X_t - \gamma_0 X_{t-1} + \gamma_1 X_{t-1} - (1-\beta_1) Y_{t-1} + \varepsilon_t \quad \text{........................} \quad (26)$$

Or equation **(26)** can be re-written in another form as

$$\Delta Y_t = \beta_0 + \gamma_0 \Delta X_t + (\gamma_0 + \gamma_1) X_{t-1} - (1-\beta_1) Y_{t-1} + \varepsilon_t \quad \text{...................................} \quad (27)$$

Equation **(27)** can be reduced as

$$\Delta Y_t = \gamma_0 \Delta X_t - (1 - \beta_1)\left(Y_{t-1} - \frac{\beta_0}{1-\beta_1} - \left(\frac{\gamma_0 + \gamma_1}{1-\beta_1}\right) X_{t-1}\right) + \varepsilon_t \quad \text{...............} \quad (28)$$

If $\alpha_0 = \frac{\beta_0}{1-\beta_1}$ and

$$\alpha_1 = \frac{\gamma_0 + \gamma_1}{1-\beta_0} \quad \text{...} \quad (29)$$

then by substituting equations **(29)** in **(28)** equation **(30)** can be obtained as

$$\Delta Y_t = \gamma_0 \, \Delta X_t - (1 - \beta_1) \, [Y_{t-1} - \alpha_0 - \alpha_1 X_{t-1}] + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(30)}$$

Based on the co-integration equation with one lag

$$\varepsilon_{t-1} = Y_{t-1} - \alpha_0 - \alpha_1 X_{t-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(31)}$$

and hence equation **(30)** can be re-written as

$$\Delta Y_t = \gamma_0 \Delta X_t - (1 - \alpha_1) \varepsilon_{t-1} + \varepsilon_t$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(32)}$$

The term ε_{t-1} is the error correction mechanism that measures how in the short-run structural and institutional changes affect the equilibrium. The term **(1-α_1)** can be expressed as δ_1 and it indicates the speed of adjustment towards equilibrium. Thus, the error correction mechanism in its simplest form can be put as

$$\Delta Y_t = \gamma_0 \Delta X_t - (\delta_1) \varepsilon_{t-1} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(33)}$$

This is the error correction mechanism that is explained in a two variable model, for simplicity. In the case of multiple variables equation the error correction instrument is similar to the one indicated in equation **(22)**. The value of δ_1 is expected to be negative so that the system converges to equilibrium.

The error correction mechanism is based on the assumptions of Classical Linear Regression Model (CLRM), that residuals are normally distributed, no autocorrelation on the residuals and absence of correlation among explanatory variables (Jarque and Bera 1980: 255).

As a consequence, diagnostic tests are required to check if these assumptions are violated or not. The diagnostic tests in this study include the normality test, autocorrelation test, heteroscedasticity test and misspecification test.

3.3.1.1 Normality Test

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

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

$$JB = n\left[\frac{S^2}{6} + \frac{K-3^2}{24}\right] \quad \text{..} \quad \textbf{(34)}$$

 where, n is the sample size,

S is the skewness coefficient

and K is the kurtosis of the coefficient.

In this case, we use the *JB* test to determine whether the ECM is normally distributed or not. The null hypothesis and the alternative hypothesis are given as

    H_0: Residuals are normally distributed

    H_1: Residuals are not normally distributed

Under the null hypotheses where the residuals are normally distributed, if the *p*-value of the statistics is sufficiently low or lower or equal to the level of significance, then it will be rejected. But if the *p*-value is found to be reasonably higher, then the normality assumption will not be

rejected. In other words, the normality assumption is not rejected mostly when the value of the statistic is close to zero. The Jarque–Bera test statistic follows the chi square distribution with two degrees of freedom (Jarque and Bera 1987: 167 – 71).

3.3.1.2 Serial Correlation Test

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

The problem of serial correlation can be detected using the graphical method, Geary test, Durbin - Watson d test and Breusch–Godfrey (BG) test. In this study, the BG test that is based on the Lagrange Multiplier principle is chosen since other tests have drawbacks that made the BG test to be favoured. Though the graphical method is powerful and suggestive, its detection power is more of a qualitative nature than others making it less preferred. The drawback of the Geary test is that it has no assumptions about the probability distribution from which the observations are drawn. The Durbin-Watson test on the other hand, is not applicable when a lagged dependent variable is used as one of the explanatory variables. For the reason that the lagged value of CPI is used as one of the explanatory variables in the model, the Durbin –Watson test cannot be applied (Gujarati 2003: 462-71). Due to these reasons the Breusch–Godfrey (BG) test of serial correlation is the best option at hand.

The BG test can be explained using the two variable model of regression where Y_t is the dependent variable and X_t is an independent variable

$$Y_t = \beta_1 + \beta_2 X_t + \varepsilon_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (35)$$

Assuming the error term follows AR(P) such as

$$\mu_t = \rho_1 \mu_{t-1} + \rho_2 \mu_{t-2} + \dots + \rho_p \mu_{t-p} + \varepsilon_t \qquad \dots\dots\dots \qquad (36)$$

where, ε_t is the white noise error term. In the Breusch–Godfrey test equation **(35)** is estimated using OLS and after having the residuals, $\hat{\mu}_t$, that are autoregressive of order P, equation **(36)** is derived. These residuals are explained by explanatory variables, X_t, and the lagged values of the residuals itself $\hat{\mu}_{t-1}, \hat{\mu}_{t-2}, \dots, \hat{\mu}_{t-p}$. In short,

$$\hat{\mu}_t = \alpha_1 + \alpha_2 X_t + \hat{\rho}_1 \hat{\mu}_{t-1} + \hat{\rho}_2 \hat{\mu}_{t-2} + \dots + \hat{\rho}_p \hat{\mu}_{t-p} + \varepsilon_t \qquad \dots\dots\dots \qquad (37)$$

Assuming that X_t's are exogenous and uncorrelated with $\mu_{t-1}, \mu_{t-2}, \dots, \mu_{t-p}$, X_t's can be omitted from equation **(37)**. Thus, the null hypothesis for the equation **(37)** can be tested as

$$\mathbf{H_0}: \rho_1 = \rho_2 = \dots = \rho_p = 0 \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \qquad (38)$$

In the Breusch – Godfrey test for serial correlation, the Lagrange multiplier is used as

$$LM = (n - p)R_{\hat{u}}^2 \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \qquad (39)$$

where, R^2 is obtained from equation **(37)**. If $(n-p)$ R^2 exceeds the critical values of chi-square at the level significance chosen, then the null hypothesis will be rejected.

In the Breusch–Godfrey test the lag length p cannot be specified in advance. Some experimentation with the p – value is expected using the Akaike Information Criteria (AIC) and Schwarz Information Criteria (SIC) to choose the lag length (Wooldridge 2002: 386).

3.3.1.3 Heteroscedasticity Test

As mentioned in Asteriou and Stephen (2007), heteroscedasticity is a Greek word, hetero means different and scedasticity means variance to sense the word different variance. One of the Classical Linear Regression Model (CLRM) assumptions is that the variance of disturbance terms is constant. As pointed out by Engle (1982), in this time series analysis, the problem of heteroscedasticity can be captured using Autoregressive Conditional Heteroscedasticity (ARCH) test.

In the ARCH test the variance, σ_t^2, can be tested by running the equation **(40)**.

$$E\left(v_t^2 \mid v_{t-1}^2, v_{t-2}^2, \ldots\right) = E\left(v_t^2 \mid v_{t-1}\right) = \hat{\alpha}_0 + \hat{\alpha}_1 \hat{v}_{t-2}^2 + \ldots + \hat{\alpha}_p \hat{v}_{t-p} \quad \ldots\ldots\ldots \quad (40)$$

where, v_t is the OLS variance obtained from the original regression.

The null hypothesis test procedure goes as

$$H_0: \alpha_1 = \alpha_2 = \ldots = \alpha_p = 0$$

$$H_1: \alpha_1 = \alpha_2 = \ldots = \alpha_p \neq 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (41)$$

where the variance of the error term $var(v_t) = \alpha_0$.

In the case of the null hypothesis, there is no heteroscedasticity; the test can be calculated using the nR^2, where R^2 is the coefficient determination from the regression equation **(40)** and n is the number of observations. Thus, the Engle (1982) ARCH Lagrange Multiplier test statistic is

$$LMe = nR^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (42)$$

The null hypothesis is rejected if the *p*-value is less than or equal to this level of significance (Bera and Higgins 1993: 354 – 8).

3.3.1.4 Misspecification Test

There are fundamentally four techniques of testing specification errors namely: BAMSET, WSET, Q – Sum test and the RESET test. Among these tests, RESET is found to be robust to non-linearity, heteroscedasticity and autocorrelation problems. However, other tests such as BAMSET are robust against the heteroscedasticity problem only. On the other hand, WSET is robust only for non-normality problem. Finally, the Box Jenkins Q-sum test is robust only against autocorrelation problem (Ramsey and Alexander 1982: 2). Accordingly in this paper, (RESET) Regression Specification Error Test suggested by Ramsey (1969) is used to test specification error in regression. The RESET test is based on 3 steps. The first step is assuming Y to be dependent variable and X an explanatory variable as follows

$$Y_t = \lambda_1 + \lambda_2 X_t + \mu_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad \textbf{(43)}$$

and obtain the estimated value of $\widehat{Y}_t$.

The second step is again to regress equation **(43)** by including the estimated $\widehat{Y}_t$, as a regressor in different forms such as

$$Y_t = \alpha_1 + \alpha_2 X_t + \alpha_3 \widehat{Y}_t^2 + \mu_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad \textbf{(44)}$$

Finally, from the last regression of equation **(44)** and **(43)** R^2 will be obtained and F test is used to test the null hypothesis of the misspecification model. The higher the F-value of the test, the more it indicates that the model does not have misspecification.

As mentioned by Utkulu (1997), though the Engle-Granger two step procedure is easy to execute it has its own drawbacks. Some of these problems are:

1. Even if the estimations of long-run static regression are consistent it does not mean that they are necessarily efficient

2. Given that estimators of the co-integrating vector have non-normal distributions no sensible judgment can be made about the significance of the parameters

3. It is up to the researcher to identify variables as endogenous and exogenous

Fortunately, there are other methods to test co-integration that avoid the drawbacks of the Engle-Granger two step procedure. Among these methods, Johansen's procedure for co-integration that is based on vector autoregressive modeling is applied in this study. This procedure is more complicated conceptually and computationally than the Engle-Granger two steps procedure and it is explained and discussed in the next sub-section.

3.3.2 Johansen's Procedure

The Johansen's procedure is an alternative to the Engle-Granger approach. This approach considers all variables as endogenous variables in the multivariate model. The single equation error correction model given in equation 22 can be extended as an endogenous variable in the multivariate model given in equation **(45)**

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \ldots + AKZ_{t-k} + \mu_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(45)}$$

Where $Z_t = [Y_t, X_t]$ and the model is assumed to have two variables both endogenous. Equation **(45)** can be rearranged in the VECM model as

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \ldots + \Gamma_{k-1} \Delta Z_{t-k-1} + \Pi Z_{t-1} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots (46)$$

Where $\Gamma_i = (I - A_1 - A_2 - \ldots -A_k)$ (i = 1,2, …k)

$\Pi = -(I - A_1 - A_2 - \ldots -A_k)$

According to the Johansen and Juselius (1990) the Π matrix has the information of the long-run relationships in the variables X_t and Y_t. The matrix Π can be written as

$$\Pi = \alpha\beta' \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (47)$$

Where, α = the speed of adjustment to equilibrium coefficient

β' = the long-run matrix coefficient

Based on equation **(46)** and **(47)** the vector error correction model for the two variable can be given as

$$\begin{pmatrix} \Delta Y_t \\ \Delta X_t \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta Y_{t-1} \\ \Delta X_{t-1} \end{pmatrix} + \Pi \begin{pmatrix} Y_{t-1} \\ X_{t-1} \end{pmatrix} + \varepsilon_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (48)$$

in another form equation **(48)** can be re-written as

$$\begin{pmatrix} \Delta Y_t \\ \Delta X_t \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta Y_{t-1} \\ \Delta X_{t-1} \end{pmatrix} + \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{pmatrix} \begin{pmatrix} \beta_{11} & \beta_{21} \\ \beta_{12} & \beta_{22} \end{pmatrix} \begin{pmatrix} Y_{t-1} \\ X_{t-1} \end{pmatrix} + \varepsilon_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(49)$$

Given that Zt is a vector of I(1) variables their first difference, i.e. ΔZ_t, are I(0) and hence ΠZ_{t-1} is also taken as I(0) so that the error terms are stationary and thus the system can also be considered as a well behaved model (Johansen 1988: 231 -2).

The Johansen procedure follows 5 major steps in analyzing the co-integrating relationships. Similar to the Engle-Granger approach the first step is to test the stationarity of the variables understudy. If all variables are found to be integrated at the same order then the co-integrating analysis continues without suffering from spurious regression (Johansen 2006: 2).

The second step in the Johansen's procedure is the selection of the optimal lag length. The optimal lag length selection is very important because the error terms do not suffer from non normality, autocorrelation and heteroscedasticity problems. The Akaike Information Criteria (AIC) and Schwartz Information Criteria (SIC) are frequently used to select the optimal lag length. This is mainly because they impose harsher penalty for adding more regressors than other lag length selection criteria. By estimating the VAR model from higher number of lags to lower (till it reaches zero) the model that minimizes the AIC or the SIC is selected as the one with the optimal lag length (Gujarati 2003: 535 – 40).

The third step is the identification of whether the constant term or trend enters the long-run and short-run models. The Pantula principle test is used to select which model to include in the co-integrating equation and in the VAR model from the given five choices provided in E-views. From the five choices that E-views provide, the first and the fifth choices are less likely to happen and are unrealistic in terms of economic theory. Thus, the Pantula principle involves the estimation of the remaining three models. The model selection procedure goes from the most restrictive model and stops when the first time the no co-integration is found by comparing the trace test statistic to its 5% critical value (Asteriou D. and Hall S.G. 2007: 324).

However, Agung (2009) mentioned the difficulty of choosing the best possible selection using the Pantula principle test and suggests the default setting where an intercept in the co-integrating equation (CE) and VAR is included, and the trend excluded in both the CE and VAR model.

The fourth step is followed by determining the number of co-integrating vectors using two methods which both involve the estimation of matrix Π. The first method is based on the maximum eigen-value statistic denoted by λ_{max}. This method tests the null hypothesis that the rank Π is equal to r against the alternative hypothesis r+1. The null that is tested is that there are up to r co-integrating relationships and the alternative hypothesis is that there is r+1 vectors. To test if the numbers of characteristic roots are significantly different from zero, the test uses

$$J_{max} = \lambda_{max}(r, r+1) = -Tln(1 - \hat{\lambda}_{r+1}) \quad \text{……………………………………….. (50)}$$

where T is the sample size and

λ's are the characteristic roots

The second method tests the trace of the matrix. The null hypothesis in this case is that r is equal to or greater than the number of the co-integrating relationships. The test checks whether the trace statistic increases as eigen-value. The trace statistic is calculated as

$$J_{trace} = \lambda_{trace}(r) = -T\sum_{i=r+1}^{n} ln\ (1 - \hat{\lambda}_i) \quad \text{…………………………………… (51)}$$

The asymptotic critical values for these statistics is developed by Johansen and Juselius (1990) which is provided in E-views 6 after conducting the test for co-integration (Johansen and Juselius 1990: 174 – 5).

After identifying the number of co-integrating vectors, the last step is the test for weak exogeneity. According to Engle, Hendry and Richard (1983), weak exogenous test is defined as

testing short-run feedbacks to deviations from the long-run relations. The long–run relationship is contained in the Π matrix given in equation **(47)** where α represents the spread of adjustment and β is the matrix of the long-run coefficient. The weak exogeneity test with respect to the long–run parameters is carried out by testing which of the rows of α, in equation **(49)**, are equal to zero. If the first row of the α matrix is found to be zero then β's would be ignored from the equation and Y is said to be weakly exogenous. If a variable is weakly exogenous then it can be considered as an endogenous variable of the model and continues to operate on the right side of the equation (Urbain 1992: 187 – 9).

3.4 Threshold Detection Technique

The second objective of this study is to estimate the threshold level of inflation in the economy. In estimating a growth model given in equation **(3)**, ordinary least square (OLS) could have been used if the threshold level of inflation (*Π*) was known in advance. In such cases Non Linear Least Squares (NLLS) method seems the appropriate method of estimation. However, in this technique the threshold point (*Π*) enters into the model in a non-differentiable and non linear way that makes the method of NLLS inappropriate to use. The best way of identifying the threshold point is thus the technique of Conditional Least Square (CLS) that is originated by Hansen (1999) and developed by Khan and Senhadji (2001). This method is employed in this paper and the technique will be explained in this section.

In the CLS technique, the basic idea is to find the level of inflation that minimizes the sum of squared residuals (RSS) or the one that maximizes the R^2 for different values of the threshold points assigned. As Hansen (1996) suggests, the growth equation (3) is estimated using the OLS

method for different values of the threshold (Π^*) which is assigned in an ascending order as (1, 2, 3, … etc).

The value of the threshold (Π) is obtained by finding the maximum point among the assigned values of Πs in the estimation process that maximizes the R^2 or minimizes the residual sum of squares (RSS) from the respective regressions. As explained in the study of Khan and Senhadji (2001) the identification of the threshold point is given as:

$$\Pi^* = Arg_\Pi \, Max \, R^2 \left(\underline{\Pi}, \dots, \overline{\Pi} \right)$$

$$\Pi^* = Arg_\Pi Min \, RSS \left(\underline{\Pi}, \dots, \overline{\Pi} \right) \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad \textbf{(52)}$$

where, Π^* is the threshold level of inflation, $\underline{\Pi}$ and $\overline{\Pi}$ are the range at which the ascending numbers are given. Thus, according to equation **(52)**, among the values between the range, the one that maximizes the R^2 is the threshold level of inflation, i.e. Π^*.

In the method of Conditional Least Squares (CLS) before under taking the regression it is necessary to assign dummy values for the threshold level of inflation. For the threshold level of inflation say, 2%, dummy variable should be assigned 0 for all values that are less than or equal to 2% and 1 for all values that are higher than 2%. In the method of Conditional Least Squares (CLS) the researcher has to undertake a regression for each value assigned from $\underline{\Pi}$ to $\overline{\Pi}$. This way of estimating the threshold level of inflation is monotonous and tiresome. However, this is the only alternative so far to estimate the threshold point of inflation (Khan and Senhadji 2001: 6-7).

To estimate the long-run trend of the series, the Hodrick-Prescott filter of smoothing data is employed. This method of data smoothing is widely used among macro-economic researchers

such as Hodge (2005), Mubarik (2005) and Hussain(2005). The HP filter computes the smoothed series of α of Y by minimizing the variance of Y around α (E-views 2007: 375). Technically the HP filter chooses α to minimize

$$\sum_{t=1}^{T}(Y_t - \alpha_t)^2 + \lambda\sum_{t=2}^{T-1}((\alpha_{t+1} - \alpha_t) - (\alpha_t - \alpha_{t-1}))^2 \quad \text{.......................................} \quad \textbf{(53)}$$

The larger the λ, the more smooth the series is, since the penalty parameter λ controls the smoothness of the series. For quarterly data such as ours, Hodrick and Prescott (1997) suggest the value of λ to be 1600.

In order to check for the reliability of the estimation, different diagnostic tests are implemented on the estimation where the R^2 is maximized and the RSS is minimized. The LM test is used to check for autocorrelation. The problem of Heteroscedasticity is detected using the Autoregressive Conditional Heteroscedasticity (ARCH) test. The normality test is carried out by the Jarque-Bera (JB) test. Finally to verify the stability of the model the Cumulative Sum of recursive residuals (CUSUM) test is employed.

Though most of the diagnostic tests are discussed in section 3.3.1, the CUSUM test for stability is missed. It is therefore important at this point to discuss the CUSUM test for stability. The CUSUM test for stability is carried out based on

$$CUSUM_{\tau} = \sum_{t=K+1}^{\tau}\hat{v}_t^{(r)}/\hat{\sigma}_v \quad \text{.......................................} \quad \textbf{(54)}$$

where, $\hat{\sigma}_v$ is the variance of the residual,

$\hat{v}_t^{(r)}$ represents the recursive residuals

and τ = K+1,…,T.

If the CUSUM value exceeds far from the zero line, it shows that the model is unstable. The 5% significance level of the test is obtained by rejecting stability when CUSUM crosses the lines ± 0.948 [$\sqrt{T-K}$ + 2(τ-K)/$\sqrt{T-K}$ (Lutkepohl and Kratzig 2004: 53 – 55).

The research questions of this study are addressed using methodologies described in this chapter. The next chapter analyzes the data and interprets the results of descriptive and inferential analysis using these methodologies. The Econometric Views (E-Views) 6 statistical software is employed to carry out the different estimations and diagnostic tests.

Chapter Four

Data Analysis and Interpretation of Results

In the preceding chapter methods of analyzing the long-run and short run relationships between inflation and growth have been discussed. In addition, the conditional least square (CLS) technique is discussed to find out the threshold level of inflation for the economy. Econometric techniques that are discussed in the previous chapter are employed in this chapter and the results are discussed in detail.

The initial part of this chapter deals with descriptive summary of the data. This can be used to evaluate the scores of each variable for more advanced statistical analysis and the data can easily be understood in the form of tables and graphs.

In the next sub-sections of the chapter unit root tests are performed using the Augmented Dickey Fuller (ADF) test and the Phillips Perron (PP) test. The results of these stationarity tests will then lead to the testing of long-run relationships between the variables understudy. The long-run relationship is captured using the Engle-Granger and the Johansen co-integration tests. The error correction method follows to capture the short-run dynamics in the relationship between inflation and growth.

The last part of the chapter deals with analysis of the threshold level of inflation for the Ethiopian economy. All equations in this study are estimated in the natural logarithm form since it enables the interpretation of coefficients in terms of elasticity. These estimations and diagnostic tests are carried out using Econometric Views (E-Views) version 6.0 statistical software.

4.1 Descriptive Summary

The summary statistics for the series of the data set is given in table 1

Table 1: Descriptive Summary

	LOG(CPI)	LOG(RGDP)	LOG(INV)	LOG(POP)	LOG(REER)	LOG(OPEN)
Mean	4.506193	6.679466	14.91341	11.12606	4.878931	5.480565
Median	4.430139	6.560809	14.61219	11.11430	4.806497	5.587767
Maximum	5.282188	7.550504	17.76734	11.40649	6.086546	6.012582
Minimum	4.127134	6.134798	8.341625	10.88701	4.508708	4.060786
Std. Dev.	0.324295	0.393192	1.658253	0.160567	0.336764	0.393816
Skewness	1.015171	0.643288	-0.784593	0.173412	1.570538	-1.196422
Kurtosis	3.078891	2.151740	5.629523	1.693824	6.318630	4.488915
Jarque-Bera	13.07362	7.520277	29.69298	5.783546	66.11895	25.15148
Probability	0.001449	0.023281	0.000000	0.055478	0.000000	0.000003
Sum	342.4707	507.6394	1133.419	845.5804	370.7988	416.5229
Sum Sq. Dev.	7.887531	11.59502	206.2352	1.933639	8.505734	11.63182
Observations	76	76	76	76	76	76

The first two rows in the table show the average value of the series as a mean and the middle values of the series as the median. For all the series, the value of means and medians are close to each other indicating minor symmetry.

The maximum and minimum values of the series are also given for each series under the row maximum and minimum, respectively. The measure of dispersion around the mean in the series is calculated as the standard deviation. Standard deviation is difficult to interpret in absolute terms. However, it can be interpreted in relative terms by comparing the standard deviation for two different distributions, i.e., the distribution with smaller standard deviation exhibits less dispersion and larger standard deviation shows higher dispersion. Accordingly, in Table 1, log(pop) is a less dispersed series with the value of 0.160567 while log(inv) is the highly dispersed series with a value of 1.658253. The larger the dispersion between the values is the higher the standard deviation that shows greater volatility in investment. Volatility of an

investment refers to uncertainty associated to the value of security. However, due to the absence of security market in Ethiopia in this case volatility does not refer to the unpredicted movement of price of a given value of security but largely refers to unexpected return of an investment.

Skewness measures the asymmetry of the distribution of the series around the mean. Symmetric distribution has zero skewness value. Thus, among the values of skewness in Table 1, only log(pop) is close to symmetric distribution with the value of 0.17. Series such as log(inv) and log(open) are negatively skewed implying that these distributions have a long left tail. On the other hand, log(RGDP), log(CPI), log(REER) and also log(pop) are positively skewed implying that these distributions have a long right tail.

The row under kurtosis in the above table, measures the flatness and peakedness of the distribution of the series. A normal distribution has a kurtosis value of 3 and hence log(CPI) is said to be near the normal distribution with the kurtosis value of 3.07. Other series such as log(RGDP), and log(pop) have flatter distribution (platykurtic) with kurtosis value less than 3 while log(inv), log(REER) and log(open) have peaked (leptokurtic) distribution relative to the normal since they have a kurtosis value higher than 3.

However, by simple observation of the values of skewness and kurtosis it is difficult to tell whether a given series is normally distributed or not. In Table 1 above, the result for Jarque Bera (JB) test for normality is given for each variable. Under the null hypothesis of normal distribution JB statistic follows a chi-square (χ^2) distribution with two degrees of freedom.

According to the results of Table 1, the null hypothesis of normal distribution is rejected for the series such as log(RGDP), log(CPI), log(inv) and log(open) due to the sufficiently low p-values of the JB statistic. Whereas the null hypothesis of normal distribution cannot be rejected for

log(pop) since the value of the statistic is close to zero and its *p*-value is reasonably high. Figure 2 presents the graphical illustration of variables in their natural logarithmic form.

Figure 4.1: Time plots of variables in natural logarithmic forms
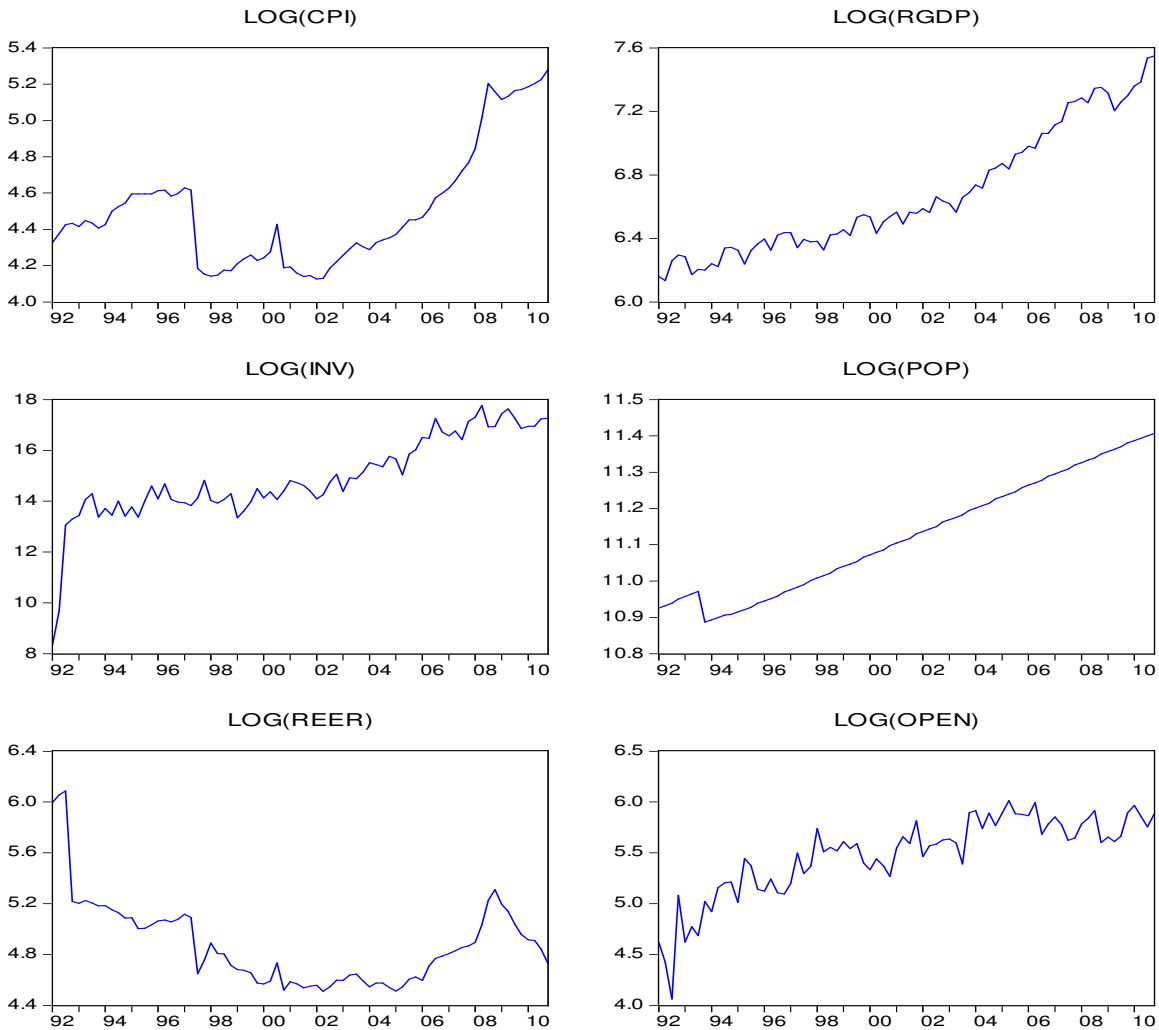
The graphs of the log(RGDP), log(pop), log(open) and log(inv) clearly show that they have a positive growth rate. For log(CPI) and log(REER) the trend exhibits fluctuations from time to time. For log(CPI) the trend shows oscillation up to the year 2002 and from then on it keeps on increasing at an accelerated rate. The log(REER) however, fluctuates for all the years understudy.

Although log(pop) clearly shows a positive growth rate in the year 1994 it has exhibited a considerable fall. The reason for this is that the year 1994 was a census year and up to the year 1993 population growth was projected based on the census of 1984. The 1994 census, however, revealed lower census results than the estimation of the 1984 census mainly due to the civil war and drought that had occurred in the country during the time. Generally, it can be said that all variables except log(REER) have positive growth even if some variables have continuous swings.

If the time plot of two series have similar trend then one variable can be used as a predictor for the other (Agung 2008: 12 – 3). Accordingly, from the time plots indicated in Figure 2, it can be said log(REER) can be used as a predictor for log(CPI) since the two time plots clearly show similar trends, i.e., decreasing up to the year 2002 and increasing from then on. On the other hand, log(inv), log(pop) and log(open) can be used as a predictor for log(RGDP) since all of them have an increasing trend.

Figure 2 also reveals that series log(RGDP) and log(pop) do not vary on a fixed level indicating non stationarity in the mean but not in the variance. On the other hand, the plot for the series log(CPI), log(inv) and log(open) vary about a fixed level implying non stationarity both in the mean and the variance. Nevertheless, a unit root test should be carried out to confirm the non stationarity of the series which will be treated in the next section.

4.2 Results of the Unit Root Tests

 As mentioned in the previous chapter, in studying economic relationships one of the problems faced is spurious regression. This problem can be solved by checking if the variables are co-integrated so that a long-run relationship exists between them. In co-integration analysis, the first

step is to study the order of integration that is determined by unit root tests. In this paper two unit root tests are applied and their results are discussed below.

4.2.1 Augmented Dickey Fuller (ADF) Test

The result of Augmented Dickey Fuller (ADF) unit root test is summarized in Table 2 and 3 below at levels and at their first differences, respectively.

Table 2: ADF test Results at Levels

Variable	Test Equation				Decision
	Intercept	Critical Values at 5% level of significance	Intercept and trend	Critical Values at 5% level of significance	
log(CPI)	0.469335	-2.900670	-0.451016	-3.470851	Do not reject the null hypothesis
log(RGDP)	1.439185	-2.904848	-0.834166	-3.477275	Do not reject the null hypothesis
Log(REER)	-3.538395	-2.900670	-3.124002	-3.470851	Do not reject the null hypothesis
log(pop)	-0.730114	-2.905519	-3.878246	-3.471693	Reject the null hypothesis
log(inv)	-3.524245	-2.901217	-6.624902	-3.470851	Reject the null hypothesis
log(open)	-3.968947	-2.901779	-4.874431	-3.470851	Reject the null hypothesis

Table 3: The ADF test Results at the First Difference

Variable	Test Equation				Decision
	Intercept	Critical Values at 5% level of significance	Intercept and trend	Critical Values at 5% level of significance	
dlog(CPI)	-7.548559	-2.901217	-7.813501	-3.471693	Reject the null hypothesis
dlog(RGDP)	-6.481044	-2.901779	-6.819320	-3.472558	Reject the null hypothesis
dlog(REER)	-8.645933	-2.901217	-8.935761	-3.471693	Reject the null hypothesis
dlog(pop)	-9.223084	-2.905519	-8.665078	-3.478305	Reject the null hypothesis
dlog(inv)	-8.648269	-2.901217	-8.712702	-3.471693	Reject the null hypothesis
dlog(open)	-10.59321	-2.901779	-11.01292	-3.472558	Reject the null hypothesis

The ADF unit root test estimated in Table 2 reveals that log(CPI), log(RGDP) and log(pop) have a unit root when only the intercept is included in the test equation at 5% level. When both intercept and trend are included in the test equation, still log(CPI) and log(RGDP) have unit roots but log(pop) becomes stationary replacing log(REER) to be non-stationary. Hence, log(pop), log(inv) and log(open) remain stationary at levels with 5% level of significance, assuming decision is made when intercept and trend are included in the test equation.

Taking a look at Table 3, all variables become stationary at their first differences when intercept and trend are included. When the intercept is the only variable included in the model still the variables become stationary at their first differences. Looking at each series one by one is necessary in this regard.

The first difference of log(CPI), where the test equation includes only the constant term and the lag length automatically selected using Schwarz Information Criterion (SIC), has the calculated

value of -7.548559. Its critical value at 5% level of significance is -2.901217 implying that the null hypothesis is rejected making log(CPI) stationary at its first difference. When the intercept and trend are included in the test equation the calculated value becomes -7.813501 while its critical value at 5% is -3.471613, again making the series log(cpi) to be stationary at its first difference.

The unit root tests conducted for log(RGDP) at its first difference having the intercept in the test equation at a fixed lag length of 1, the calculated ADF test statistic has a value of -6.481044. The critical value at 5% level of significance is -2.901779 and since the critical value is higher than the calculated statistic the null hypothesis that log(RGDP) has unit root is rejected. For the same series, when the test equation includes intercept and trend the calculated ADF statistic is -6.819320 while its critical value at 5% is -3.472558. This result also confirms that log(RGDP) is in order at its first difference.

The null hypothesis that log(REER) has a unit root is rejected having the constant term as an exogenous variable in the equation test. By using Schwarz Information Criterion for choosing the lag length the calculated ADF test statistic is -8.645933 with a 5% level of critical value of -2.901217. When the trend is added in the equation test with the constant term, the ADF critical value becomes -8.935761 and the 5% test critical value is -3.471693. In both cases the null hypothesis is rejected and log(REER) has I(1) order of integration.

At the first difference log(pop) is found to be stationary by having an ADF test statistic -9.223084 and 5% critical value -2.905519. Similarly, using SIC for lag length selection with trend and intercept, the calculated value is -8.665087 and at 5% is -3.478305. Thus, from these results it is evident that log(pop) is I(1) variable.

Similarly, log(inv) is an I(1) variable both at intercept and with trend included in the test equation. Using SIC lag length selection, the calculated ADF test value is -8.648269 with 5% critical value -2.901217 where only the intercept is an exogenous variable. When a linear trend is included in the test equation, the calculated value is -8.712702 and its 5% critical value is -3.471693. Hence, log(inv) is stationary and the null hypothesis that log(inv) has a unit root is rejected at its first difference.

Finally, the unit root test on the null hypothesis that log(open) has a unit root is rejected at 5% level. Using SIC lag length selection criterion where the intercept is the only exogenous variable in the test equation the ADF calculated value shows -10.59321 with 5% critical value of -2.901779.

When the trend is added in the test equation together with the constant term the ADF test becomes -11.01292 with a -3.472558 critical value. Similarly, this result shows that the null hypothesis can be rejected implying that log(open) is an I(1) series.

Decisions on rejection and non-rejection of the null hypothesis are based on critical values of 5% level of significance as shown in Table 2 and 3 above. In most cases, the ADF test decisions are by and large similar to 1% and 10% critical values. In most cases, decisions are made based on 5% critical values as used in this study.

Based on the ADF test some variables are stationary and some have unit root at levels. In such condition it is impossible to carry out either short-run or long-run analysis and hence taking the first difference is necessary to have all the relevant variables stationary in the same order. Accordingly, by taking the first difference all variables are found to be stationary at their first difference. However, these results are rechecked using the Phillips Perron unit root test. This test

as mentioned in the previous chapter is recommended to resolve the problem of serial correlation. The results of Phillips Perron unit root test results are discussed next.

4.2.2 Phillips-Perron (PP) Test

The Phillips-Perron (PP) unit root tests results are given in Table 4 at levels and Table 5 at their first differences.

Table 4: The Phillips-Perron (PP) Unit Root test at Levels

Variable	Test Equation				Decision
	Intercept	Critical Values at 5% level of significance	Intercept and trend	Critical Values at 5% level of significance	
log(CPI)	0.349740	-2.900670	-0.451016	-3.470851	Do not reject the null hypothesis
log(RGDP)	2.243942	-2.900670	-0.502285	-3.470851	Do not reject the null hypothesis
log(REER)	-3.647931	-2.900670	-3.118367	-3.470851	Do not reject the null hypothesis
log(pop)	1.060083	-2.900670	-2.817655	-3.470851	Do not reject the null hypothesis
log(inv)	-4.158809	-2.900670	-6.464098	-3.470851	Reject the null hypothesis
log(open)	-2.508071	-2.900670	-4.704924	-3.470851	Reject the null hypothesis

The PP test undertaken shows that all variables have unit root at their levels except for log(inv) and log(open). For log(inv) when the intercept term is the only exogenous variable in the test equation then the null hypothesis is rejected by having the PP calculated value -4.158809 with a 5% critical value -2.900670. Having the intercept and trend treated as the exogenous variable in the test equation, the null hypothesis is again rejected by having -6.464098 test statistic with 5% level critical value -3.470851.

Table 5: Phillips-Perron (PP) Unit Root test at First Difference

Variable	Test Equation				Decision
	Intercept	Critical Values at 5% level of significance	Intercept and trend	Critical Values at 5% level of significance	
dlog(CPI)	-7.548559	-2.901217	-7.801754	-3.471693	Reject the null hypothesis
dlog(RGDP)	-11.29693	-2.901217	-26.60918	-3.471693	Reject the null hypothesis
dlog(REER)	-8.645933	-2.901217	-8.962242	-3.471693	Reject the null hypothesis
dlog(pop)	-8.524792	-2.901217	-8.758449	-3.471693	Reject the null hypothesis
dlog(inv)	-8794529	-2.901217	-8.832979	-3.471693	Reject the null hypothesis
dlog(open)	-18.73231	-2.901217	-25.44787	-3.471693	Reject the null hypothesis

For log(open) however, the null hypothesis is rejected when the trend and intercept are both included in the test equation. If only the constant term is taken into the test equation the null hypothesis can not be rejected due to the higher value of the calculated PP statistic than its 5% critical value. Thus, the null hypothesis is rejected for log(open) implying the variable to be stationary at its first difference. Similar to the ADF test, decisions are made when both intercept and trend are included in the test equation.

Though most of the variables have unit roots at their levels, according to Table 5 the null hypothesis is rejected for all of the variables in their first differences proving the stationarity of the variables under study. The Phillips-Perron unit root test once again proves that variables under study are stationary at the same order, i.e. I(1). Even though the PP unit root test has more power in correcting serial correlation problems, but in this case such a problem did not arise and both the ADF and PP unit root tests display similar results as shown in Table 3 and 5.

In Table 5, the PP unit root test for log(CPI) at the first difference is calculated using Bartlett Kernel spectral estimation method with Newey-West bandwidth selection. Accordingly, with the inclusion of trend and intercept in the test equation, the PP test statistic has a value of -7.801754 and when intercept term is the only included variable the test statistic is -7.548559 with their respective 5% level of critical values -3.471693 and -2.901217. This result implies that the null hypothesis that log(CPI) has a unit root at its first difference is rejected at 5% level of significance making the variable to be I(1).

The null hypothesis test that log(RGDP) has a unit root is rejected at 5% level of significance using the Bartlett Kernel spectral estimation method with fixed bandwidth at 2. In this view, the test statistics value for dlog(RGDP) where the constant and trend are included as exogenous variables is -26.60918 with critical value -3.471693. Since the calculated value is lower than the critical value the null hypothesis is rejected making log(RGDP) to be stationary at its first difference.

The series for log(REER) is stationary at the first difference in both the ADF and PP unit root tests. In an equation test where the intercept is the only exogenous variable using Newey-West formula for bandwidth selection, the calculated value is -8.645933 with 5% critical value of -2.901217. When a linear trend is included in the test equation the test statistics becomes -8.962242 with a critical value of -3.471693. In both cases the null hypothesis that log(REER) has unit root is rejected at the first difference.

Similarly, as shown in Table 5 for log(REER), log(pop), log(RGDP) and log(CPI) the PP test rejects the null hypothesis that variables have unit root. For all variables, the critical value is

higher than the PP test statistic. Although decisions are made based on 5% level, the level of significance at 1% and 10% are similar to the ADF test.

As a conclusion, the unit root test reveals that some of the variables used in the inflation and the growth models are I(0) while others are I(1) in both the ADF and PP unit root tests. In order to continue with the analysis, all variables in each model should be integrated in the same order. As shown in the tables above, all variables become integrated at the first order and not at levels. Due to this reason the analysis will continue with the co-integration technique studying the long-run relationship.

4.3 Long-run Relationships and the Short-run Dynamics

4.3.1 The Engle - Granger Co-integration Test

At this stage, before running the econometric experiments it is worth mentioning theoretically expected signs of the coefficients in the model. As discussed in the literature review, there is no consensus reached on the relationship between general price and aggregate output growth. In this study the two variables are measured in terms of consumer price index (CPI) and Real Gross Domestic Product (RGDP), respectively. In the inflation model given in equation (2) the coefficient of the real GDP can not be theoretically guessed and hence it may either have a positive or negative sign.

In the case of the coefficient for real effective exchange rate (REER) one would expect a positive sign since a sustained increase in the exchange rate is expected to boost the general price level. Similarly inflation expectation is expected to have a positive sign for its coefficient. This is because higher inflation expectation among economic agents leads these agents to raise their

prices. For a rain dependent agrarian economy such as Ethiopia, occurrence of drought is expected to boost the rate of inflation since it causes a reduced supply of agricultural output. Accordingly, one would expect the coefficient for drought to have a positive sign.

Having these theoretically expected signs for the coefficients the ordinary least square (OLS) based econometric experiments can proceed. Accordingly, the regression results in table 6 show the regression coefficient, standard errors, t-statistic and the probability of t-statistic for the respective explanatory variables after correcting for serial correlation. The table also provides other results such as the R-squared, adjusted R-squared and value of the Durbin Watson test.

Table 6: Regression Result of Equation 2 after correcting for autocorrelation

Variable	Coefficient	Std. Error	t-statistic	Prob.
Dependent Variable: log(CPI) Method: Ordinary Least Square Number of observation: 74 after adjustment				
c	-1.582639	0.339856	-4.656792	0.0000
log(RGDP)	0.263188	0.053439	4.924981	0.0000
log(REER)	0.300328	0.060893	4.932089	0.0000
log(CPI_1)	0.640327	0.076698	8.348698	0.0000
Dr	-0.011445	0.026149	-0.437682	0.6630
AR(1)	0.391730	0.121875	3.214195	0.0000
R-squared	0.966208			
Adjusted R-squared	0.963724			
S.E. of regression	0.062408			
Prob. (F stat)	0.000000			
Durbin-Watson Stat	2.159846			

The *p*-values of the independent variables show a very small value (almost zero) which means that the regression coefficients are statistically significant both at 1% and 5% levels, with the exception of drought. In addition to this the adjusted R^2 has approximately a value of 0.97 which implies that the variations in inflation are well explained by changes in Real Gross Domestic Product (RGDP), Real Effective Exchange Rate (REER) and inflation expectation and drought.

The value of the Durbin-Watson is 1.771013 in the estimation before the first order autoregressive is included in the equation. This shows the existence of a positive serial correlation problem and in order to avoid this, first order auto regression is used. Using first order auto regression the value of Durbin Watson statistic becomes 2.159846 which shows slight negative correlation. As shown in Table 6, the new Durbin-Watson statistic is close to 2 implying that the problem of autocorrelation is treated.

From the estimation result shown in Table 6, two important outcomes can be specified. The first one is the positive sign of the coefficient of RGDP that implies the existence of a positive long-run relationship between inflation and growth. This finding is similar to the Keynesian theoretical finding that the two macro-economic variables have positive relationships. Having the positive direction of the relationship the second main finding from Table 6 is the magnitude of the relationship. The estimated coefficient of RGDP suggests that about a quarter of variations in the rate of inflation are explained by the real GDP. In other words, an increase in quarterly growth of RGDP by one percentage point is estimated to boost the growth of quarterly rate of inflation at 0.26 percentage point. For a rapidly growing economy such as Ethiopia, the strong positive relationship between the two variables is acceptable. The slow growth of the economy for the last several decades and the rapid growth of the economy in the last decade makes the estimation result in Table 6 an acceptable one since fast growing economy triggers a higher rate of inflation which is similar to the findings of Lucas (1973).

As indicated in the introduction, the main objective of this study is to assess the relationship between inflation and economic growth represented by CPI and real GDP, respectively. However, it is necessary to discuss the findings of the coefficients of variables that explain inflation in the model. According to the estimation result given in Table 6, 30% of the variations

in the consumer price index (CPI) are explained by changes in the real effective exchange rate (REER). An increase in one percentage point in the real effective exchange rate (REER) raises the rate of inflation by 0.3 percentage point. The explanatory power of REER is sufficiently high. This is because the country is largely import dependent and hence an increase in the real effective exchange rate (REER) of Ethiopian currency (birr) to foreign currencies directly increases local price though international price remains unchanged. Therefore, from the findings of Table 6, it can be seen that the expected sign for REER is obtained.

Similarly, inflation expectation that is captured by one quarter lag of the CPI roughly explains two-third of the disparities in the rate of inflation. If inflation expectation moves by one percentage point, the consumer price index increases at 0.64 percentage point. This finding shows that inflation expectation is the most important variable that determines the rate of inflation. An expectation formed by past information only is similar to the monetarists' adaptive expectation and thus past information about inflation plays a crucial role in determining the current inflation. This shows that keeping inflation low and stable helps to have stable future inflation since future expectations also become low. The expected positive sign for the coefficient of inflation expectation is similar to the empirical findings.

Drought is used as one of the explanatory variables in the inflation model. As mentioned above, for a rain dependent agrarian economy such as Ethiopia, in years of drought the rate of inflation is expected to rise due to reduced agricultural output. The lions' share of the income of a typical Ethiopian household is spent on food consumption that causes drought to have a direct link to the consumer's price index. However, the finding from Table 6 shows the unexpected negative coefficient which means an occurrence of drought has a price reducing effect. Even though the explanatory power of the regression coefficient is too low, the result can not be a serious concern

because the probability value of the t-statistic has a quite high value of 0.6630. This shows that the regression coefficient for drought is statistically insignificant both at the 5% and 10% level of significance.

From the first step Engle-Granger co-integration technique, it is shown that there exists a positive long-run relationship between inflation and growth. The co-integration estimation result not only shows the direction of the relationship but also reveals that a quarter of variation in the rate of inflation is explained by a one percentage change in the RGDP. Having the positive long-run association between inflation and growth, the short-run dynamics of the model on whether the economy converges to equilibrium or not and if it converges the speed of adjustment to the equilibrium is studied using the error correction model that will be discussed in the next section.

To analyze the short-run adjustment of inflation towards equilibrium, the model given in equation (22) is estimated. The error correction model differs from the co-integration model given in equation (2) because it takes the first difference of dependent and independent variables in the regression process. In addition to this, the one term lagged value of the residuals in equation (2) is included in the error correction model as one of the explanatory variables at its levels.

In carrying out the error correction model, the first step is to take the residual series of the equation (2), and check for stationarity of the residuals at levels. If the error term is found to be stationary at levels then, the dependent and independent variables are said to be co-integrated. Accordingly, inflation and growth are said to be co-integrated so that once again it can be proved that the long-run relationship between the two variables exist.

Before going to the unit root test, it is worth depicting the graph of the residual series from the co-integration test. By doing so, it is possible to see if the error correction term varies across time. After graphical observation the formal unit root test can be carried out.

Figure 3: Residual Series from Co-integrating Equation
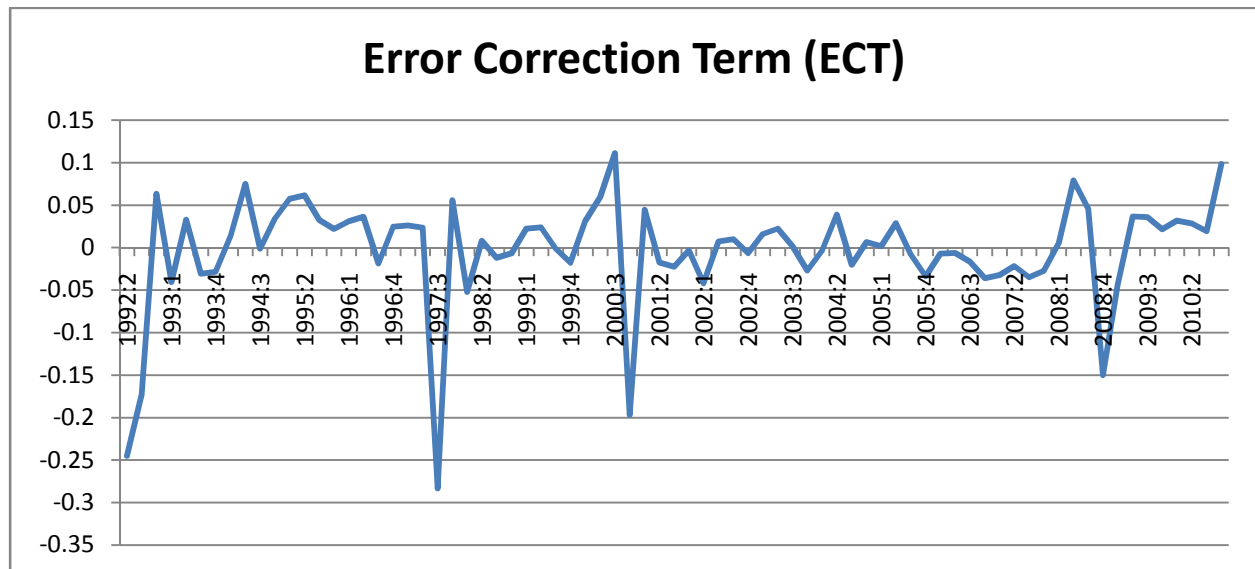
The graph of the error correction term shows neither increasing nor decreasing trend across different time periods. It can be seen that it fluctuates between -0.3 and 0.1. This shows that the mean and variance of the error correction term (ECT) is constant across time implying stationarity of the ECT. However, it is necessary to undertake a formal unit root test for the residual series so that the long-run relationship can certainly be stated.

The result of the unit root test for the error correction term is given in Table 7. The table shows the unit root test result of the Augmented Dickey Fuller (ADF) test and the Phillips-Perron (PP) test.

Table 7: ADF and PP unit root tests on the ECT

Variable	Type of the unit root test	Test Equation						Decision
		Intercept	Critical values at 5%	Critical values at 1%	Intercept and trend	Critical values at 5%	Critical values at 1%	
ECT_t	ADF	-9.19205	- 2.90121	-3.52157	-9.12425	-3.47169	-4.08687	Reject the null hypothesis
ECT_t	PP	-9.43772	-2.90121	-3.52157	-9.34322	-3.47169	-4.08687	Reject the null hypothesis

The Augmented Dickey Fuller (ADF) unit root test with zero lag length automatically selected using Schwarz Information Criterion (SIC) reveals that the ECT is stationary. The null hypothesis that the ECT has a unit root test is rejected at 5% and 1% level of significance.

According to Table 7, the calculated ADF test statistic where the constant term is the only variable in the equation has a value of 9.192053. This value is greater than the test critical values at both 5% and 1% level in which the values are 3.521579 and 2.901217, respectively since absolute value is used in the decision rule. If a trend is included with the constant term in the ADF unit root test equation, the test statistic becomes 9.124257 which is again greater than the test critical values at 1% and 5% with the value of 4.086877 and 3.471693, respectively. From these values the null hypothesis that the ECT has unit root is rejected both at 1% and 5% level, concluding that ECT is stationary.

To remove the drawbacks of the ADF test, the Phillips-Perron (PP) test carried out as an additional unit root test also shows similar results. The PP unit root test with zero bandwidth has a calculated value of -9.437724 when only intercept is included in the test equation. In this case the test critical values are -2.901217 and -3.521579 for 5% and 1% levels, respectively. If the

unit root test equation includes both trend and intercept, the calculated PP test will be -9.343225

and the associated critical values at 5% and 1% is -3.471693 and -4.086877, respectively.

From the two unit root tests undertaken it is shown that the residual term is stationary at its

levels. This shows that the explanatory variables where RGDP is one of them and the dependent

variable CPI are co-integrated. The co-integration among these two variables shows the

existence of long-run relationship between inflation and growth. The stationarity of the ECT also

allows us to continue the short-run analysis of the behavior of inflation using the error correction

model. The estimation result of the Error Correction Model (ECM) is given in Table 8.

4.3.1.1 The Error Correction Model

Table 8: The Estimation Result of the Error Correction Model

Dependent Variable: dlog(CPI)				
Method: Ordinary Least Square				
Number of observation: 74 after adjustment				
Variable	Coefficient	Std. Error	t-statistic	Prob.
c	0.009372	0.008250	1.136024	0.2599
dlog(RGDP)	0.004969	0.121883	0.040769	0.9676
dlog(REER)	0.336653	0.057036	5.902451	0.0000
dlog(CPI_1)	0.408017	0.130969	3.115367	0.0027
Dr	0.011458	0.019291	0.093936	0.5545
ECT_{t-1}	-0.434734	0.146667	-2.964080	0.0042
R-squared	0.360163			
Adjusted R-squared	0.313116			
S.E. of regression	0.060656			
Durbin-Watson Stat	1.983448			

From the ECM estimation result, the coefficient of the lagged error correction term (δ_1) has a

negative sign which satisfies the theoretical expectation that in the short-run the rate of inflation

converges to its equilibrium point. In other words, the negative coefficient of (δ_1) can be

interpreted that in case of any disequilibrium the inflation rate will be back towards its long-run

path. The speed of this adjustment however is determined by the magnitude of the coefficient. Based on the result of table 8, the value of the coefficient for the error correction term is -0.434734 implying 43% of the shock to the rate of inflation is adjusted in each quarter.

On the other hand, the coefficient of RGDP in the error correction model shows the impact multiplier that measures the immediate impact that a change in log(RGDP) will have on CPI. This shows the short-run effect of economic growth on the rate of inflation. According to the ECM result given in Table 8, the coefficient for RGDP is too small and insignificant. Though in the long-run quarter of the variation in inflation rate is explained by RGDP, but in the short-run a one percentage point in the real GDP leads to only 0.05% of variations in CPI. However, this result is statistically insignificant because the probability value of the t-statistic is quite high, i.e., more than 0.05.

Similar to the estimation in step 1 of the Engle Granger technique, it is worth discussing the short-run effects of other variables in the model, though the main point in this study is the coefficient of the change in RGDP. Accordingly, the short-run impact of the change in real effective exchange rate (REER) on the change of inflation rate is roughly similar to the long-run relationship. In the long-run, a one percentage change in the REER causes 33% of the variations in the rate of inflation. Similarly, in the short-run a one percentage change in the REER leads to 33% of variations in the general price level. This result is statistically significant both at 5% and 10% levels.

Inflation expectation is the other explanatory variable that explains 40% of the short-run variations in the inflation rate. Once again inflation inertia is a key variable that largely explains changes in the general price level both in the long-run and in the short-run. In both cases the

coefficients of inflation expectation are statistically significant having the p-values less than 0.05 and 0.01 proving the significance at 5% and 1%, respectively.

The short-run impact of drought on the rate of inflation is again statistically insignificant. However, the sign of the coefficient is positive and it goes parallel to the theoretically expected sign, unlike the co-integration test. The results in Table 8, also show how the model explains the variations of Δlog (CPI) using R^2 and adjusted R^2. These results however, show that explanatory variables did not adequately describe the model as the co-integration test carried out in Table 6. On the other hand, the Durbin-Watson statistic has a value of 1.983448 which implies the non-existence of serial correlation and heteroscedasticity.

In conclusion, short-run changes in economic growth do not have a strong and significant impact on the change of the inflation rate as it has in the long-run. The other important economic interpretation in the error correction model is the coefficient of the lagged error correction term (ECT). It reveals that in a case of shock and disequilibrium, the model converges to its equilibrium position in the long-run. From the estimation result, it is revealed that 43% of the disequilibrium is adjusted in each quarter. The next step after estimating the error correction model is to check for the adequacy of the model by performing diagnostic tests.

4.3.1.2 Diagnostic Tests

For the error correction model, four diagnostic tests are employed to check the problem of serial correlation, misspecification, heteroscedasticity and non-normal distribution. The Breusch-Godfrey lagrange multiplier (LM) test is used to check for the problem of serial correlation, Autoregressive Conditional Heteroscedasticity (ARCH) LM test is used to verify whether a problem of heteroscedasticity exists and to check if the error terms are normally distributed, Jarque-Bera (J.B.)

normality test is used. Finally Ramsey RESET test is employed to see if the model is specified correctly or not. Table 9 below summarizes the results of these diagnostic tests.

Table 9: Diagnostic Error Tests

Test	Test Statistic	*p*-value
Jarque Bera	240.2348	0.0000
Breusch-Godfrey LM	0.423240	0.8093
ARCH LM	0.101255	0.7503
Ramsey RESET	1.060386	0.3031

The normality test for the residual series is undertaken using the Jarque-Bera (J.B.) statistic. The J.B. test from Table 9 shows that the error terms are not normally distributed. This is due to the high t-statistic which is 240.2348 and very low p-value which is equal to zero. According to Agung (2008), normality tests are usually presented in specific cases and are not for use for any model selected because the statistics used for testing the normal distribution is assumed to have its own specific distribution function. This leads to testing the assumptions of the given specific distribution function leading to circular problem. Due to this reason, it is very difficult to give a concrete result for the normal distribution of the residual series using the normality test. Hence, the result in Table 9 does not necessarily mean that estimation errors are not normally distributed with zero mean.

The Durbin Watson statistic that detects the serial correlation problem shows that the error correction model does not suffer from autocorrelation problem. The formal Breusch-Godfrey serial correlation Lagrange Multiplier (LM) test once again confirms that the residual terms in the model are serially independent. The F-statistic has a value of 0.19829 with a probability value of 0.8276. The observed R-squared which is used to make decision of the correlation test has a value of 0.423240 with a p-value of 0.8093. The large Chi-square probability value implies the nonexistence of the serial correlation problem.

The Heteroscedasticity test is carried out using Autoregressive Conditional Heteroscedasticity (ARCH) LM test. The F-statistics of the test has a value of 0.098618 with a p-value of 0.7544. On the other hand, the observed R-squared of the ARCH LM test has a value of 0.101255 and the one lagged Chi-squared probability value is 0.7503. From these results, ARCH LM test strongly suggests that there exists no heteroscedasticity in the residual terms of the model. Hence, the null hypothesis of no heteroscedasticity can not be rejected implying that the variance of the error term is constant. Since most of the time the problem of heteroscedasticity is observed in cross sectional studies rather than in time series framework, the finding of no heteroscedasticity is not unique.

The last row of Table 9 shows the result for specification test using Ramsey RESET test. The test basically verifies whether the model specified (additive or multiplicative) is correct or not. Accordingly, the RESET test confirms that the multiplicative model is rejected based on the log likelihood ratio of 1.060386 with a p-value of 0.3031. Hence, the data supports the additive model and therefore the error correction model has no specification error.

As a conclusion, the diagnostic tests show that the error correction model does not suffer from non-normality, serial correlation, heteroscedasticity and misspecification problems. The Jarque – Bera normality test shows the non-normal distribution of the error terms which does not necessarily mean that the distribution is not normally distributed with non zero mean. The model is free from serial correlation which means that the error terms are independently distributed or serially independent. In such cases the error that occurs at a time is not correlated with the one that occurs at another time. Though most of the time the problem of heteroscedasticity takes place in cross-sectional framework there is still a possibility of its occurrence in time series models that forces us to conduct a heteroscedasticity test in this study. The result in Table 9 shows that the error correction model does

not face a problem of heteroscedasticity which means the variance of the error term has a constant variance. At last, the Ramsey RESET test shows that the model is specified correctly.

The error correction model that has information about long-run and short-run relationship between inflation and growth passes all the diagnostic tests. Therefore, the findings given in the two step procedure of Engle-Granger co-integration test are dependable and reliable. However, one of the drawbacks of the Engle-Granger co-integration approach that is worth mentioning here is the issue of the order of variables. The test remains quiet about which variable is dependent and which one is not. For example in this study, one can either regress inflation on growth or growth on inflation. In practice, one order of regression may show co-integration and if the order of the variables is reversed it may not show the co-integration relationship. Due to this drawback of the Engle-Granger approach of co-integration, it is necessary to have an alternative approach which removes this problem. Since the Johansen's approach considers both inflation and growth together as endogenous variable, the issue of order of variables is removed. The Johansen approach of co-integration is discussed in the next section.

4.3.2 The Johansen's Approach

In the Johansen's co-integration approach, similar to the Engle-Granger approach of co-integration the first step is to check for stationarity of the concerned variables in the study. As discussed in sub-section 4.2, variables that are relevant for this study are found to be integrated in different orders, i.e., some are I(0) and others I(1). Given that all variables become stationary at their first order, it became the most desirable case in order to continue with the Johansen's approach of co-integration test.

The next step in the Johansen's approach is the search for the appropriate lag length selection in order to have Gaussian error terms where the standard normal error terms do not suffer from non-normality,

autocorrelation and heteroscedasticity problems. In choosing the appropriate optimal lag length the most common procedure is to estimate a VAR model of all variables at their levels. Estimating the VAR model starts with a large number of lags and then continues by reducing down by re-estimating the model for one lag less until it reaches zero lags. In this study, the model is estimated for 12 lags.

Table 10, shows the Vector Autoregressive (VAR) lag order selection criteria having log(CPI) and log(RGDP) as endogenous variables and constant (c) as exogenous variable. In the VAR lag length selection criteria, though other lag length selection criteria are presented in the table, decisions are made using the minimized values of Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC). Table 10 also provides the sequential modified LR test statistic (each test at 5% level), Final Prediction Error (FPE) and Hannan-Quinn Information Criterion (HQ).

Table 10: VAR Lag Order Selection Criteria

Lags	LogL	LR	FPE	AIC	SIC	HQ
0	-21.45395	NA	0.007135	0.732936	0.800401	0.759514
1	169.7968	364.5717	-2.05e-05	-5.118650	-4.916255	-5.038916
2	173.5387	6.899160	-2.07e-05	-5.110585	-4.773259	-4.977695
3	175.0677	2.723504	2.24e-05	-5.033366	-4.561110	-4.847320
4	188.7707	23.55210	1.66e-05	-5.336586	-4.729400	-5.097384
5	206.6120	29.54959	1.08e-05	-5.769125	-5.027009	-5.476768
6	236.6489	47.87139	4.80e-06	-6.582780	-5.705733	-6.237267
7	246.7342	15.44300*	3.99e-06*	-6.772943*	-5.760966*	-6.374274*
8	249.8864	4.629787	4.13e-06	-6.746449	-5.599542	-6.294625
9	250.2447	0.503901	4.68e-06	-6.632647	-5.350810	-6.127667
10	252.8013	3.435434	4.97e-06	-6.587541	-5.170774	-6.029405
11	256.6432	4.922431	5.08e-06	-6.582600	-5.030903	-5.971308
12	257.5090	1.055165	5.71e-06	-6.484655	-4.798028	-5.80208

Based on AIC lag length selection criteria, Table 10 shows that the optimum lag value that minimizes the AIC value is 7. The AIC and the SIC values that are minimized at the seventh lag are -6.772943 and -5.760966, respectively. In addition from AIC and SIC, other VAR lag order selection criteria such as LR, FPE and HQ confirm that lag 7 is the optimum lag order with their

respective values of 15.44300, 3.9e-06 and -6.374274. All these values have (*) sign in the table to show that they are the optimum lag order. Lag length of seven however should not be regarded as high considering that quarterly data is used in the study. Though the major point of discussion here is to select the optimum lag and continue to the co-integration test, it is possible to explain the results of the VAR model in Table 11.

Table 11: VAR Estimation Result at the 7th Lag

	Log(CPI)	Log(RGDP)
Log(CPI(-1))	1.004788 (0.13691) [7.33887]	0.077247 (0.03544) [2.17981]
Log(CPI(-2))	-0.088632 (0.19417) [-0.45647]	-0.100392 (0.05026) [-1.99759]
Log(CPI(-3))	-0.036095 (0.19634) [-0.18384]	-0.023085 (0.05082) [-0.45427]
Log(CPI(-4))	0.103524 (0.19536) [0.52991]	0.063715 (0.05057) [1.26006]
Log(CPI(-5))	0.013081 (0.19827) [0.06598]	-0.074273 (0.05132) [-1.44729]
Log(CPI(-6))	-0.058613 (0.19787) [-0.29622]	0.026534 (0.05121) [0.51810]
Log(CPI(-7))	0.021951 (0.14087) [0.15583]	0.021896 (0.03646) [0.60053]
Log(RGDP(-1))	0.056896 (0.46010) [0.12366]	1.943039 (0.11909) [16.3159]
Log(RGDP(-2))	0.407609 (0.76975) [0.52954]	-1.698267 (0.19924) [-8.52393]
Log(RGDP(-3))	-0.238332 (0.57483) [-0.41461]	0.563837 (0.14879) [3.78961]
Log(RGDP(-4))	-0.064984 (0.23856) [-0.27240]	1.010565 (0.06175) [16.3664]
Log(RGDP(-5))	0.040437 (0.53770) [0.07520]	-1.888582 (0.13917) [-13.5699]
Log(RGDP(-6))	-0.223475 (0.74817) [-0.29870]	1.675632 (0.19365) [8.65289]
Log(RGDP(-7))	0.084785 (0.48862) [0.17352]	-0.589771 (0.12647) [-4.66326]
C	-0.240511 (0.22854) [-1.05236]	-0.059232 (0.05915) [-1.00131]

The output of the VAR in Table 11 is interpreted in a similar fashion to the OLS regression. The coefficient of the lags of the same variable estimated is not statistically significant. Probably this is because of the multicollinearity problem. The values in ( ) show the standard errors while values in [ ] show the t-statistic. To test the significance of the parameters, the VAR estimates do not have p-values. However, based on the t-statistic provided it is possible to determine whether or not the lagged variable has adjusted significant impact or not on the corresponding dependent variable. If the critical value of the t-statistic (in absolute value) is greater than two or 1.96, then it can be concluded that the corresponding independent variable has significant adjusted impact on the dependent variable.

Considering the regression of log(CPI), individually only log(CPI) at lag one is statistically significant and in the case of log(RGDP) regression, individually only the first and the second lag of log(CPI) are statistically significant and all the lags of (RGDP) are statistically significant. In both cases, the F-statistic is so high that the hypothesis of collectively all lagged terms is statistically significant cannot be rejected. Due to the insignificant impact of the lagged values of log(RGDP) in the regression of log(CPI) it is not practical to have a reduced form of the VAR. The main reason for this is the significant impact of all lagged values of log(RGDP) in the regression of log(RGDP).

From the coefficients given in Table 11, it is possible to forecast using the VAR model. Dealing with the individually significant coefficients, the first lagged value of log(CPI) has a positive effect on log(CPI). This result is similar to the OLS based estimation given in Table 6, that inflation inertia has a positive impact on the current inflation. In the log(RGDP) regression, the first lagged value of log(CPI) positively affects real GDP and the second lagged value of log(CPI) negatively affects log(CPI). Though all the lagged values of log(RGDP) in the log(RDP) regression are statistically significant, only the first, the third and the fourth lags have the positive effect on the real GDP. The

other lags of log(RGDP) have negative impact on log(RGDP) itself. After having the VAR estimation at its appropriate lag it is necessary to carry out joint diagnostic tests for the model. The results of the VAR diagnostic tests are shown in Table 12 and it reveals that the model passes all these tests.

Table 12: Joint Diagnostic Tests on the VAR model

Test	Test Statistic	*p*-value
Normality Test	260.5134	0.0000
LM Serial Correlation	7.591109	0.1078
White Heteroscedasticity Test	109.6418	0.0317

The VAR residual multivariate normality test with the Orthogonalization method of Cholesky of covariance is used. The Jarque-Bera result of the joint test statistic has a value of 260.5134 with the probability value of 0.0000. Due to the low p-value of the test and higher value of the test statistic, the null hypothesis that multivariate residuals are normal can be rejected. However, this does not mean that the multivariate error terms are not normally distributed with zero mean because of the circular problem of testing the assumptions of the given specific distribution function.

The VAR residual serial correlation LM test is carried out with 12 lags included. The 7th lag that is used to undertake the VAR model, selected based on AIC and SIC, has the LM statistic of 7.591109 and a probability from chi-square with 4 degrees of freedom has a value of 0.1078. With these figures of LM statistic and probability value, the null hypothesis of no serial correlation can not be rejected. Hence the error term in the multivariate model is serially independent.

The VAR residual white heteroscedasticity test with no cross terms, i.e., only levels and squares, shows that the model does not suffer from the heteroscedasticity problem. The value of the chi-square of the joint test is 109.6418 and the p-value with 84 degrees of freedom is 0.0317. This implies that the variance of the error terms in the multivariate model is constant. Therefore, the model with the 7th

lag selected with AIC and SIC, passes all the joint diagnostic tests and the lag length chosen can be considered as an appropriate one.

After performing unit root tests and choosing the appropriate lag length for the model, the third step is choosing the suitable model regarding the deterministic components in the multivariate system. In formulating the dynamic model, the most important feature is whether an intercept or trend should enter either the short-run or the long-run model, or both models. E-views provides five separate models on how the constant term and the trend enter in the co-integrating equation and the VAR model, where the previous one is the long-run model while the later is the short-run model.

Among the five models given in E-views, the first model has no intercept and trend both in the co-integrating equation and the VAR model. In practice this unlikely to occur since the intercept is needed to account for adjustments in measuring the units of variables. On the other hand, in the fifth model both the intercept and the trend are included in the co-integrating equation and in the VAR model without any restriction. Again this is not practical since it is very difficult to interpret such a model from economic point of view due to their ever increasing or ever decreasing rate of change as variables are entered as logs. Mainly due to these reasons, the first and the fifth models are unrealistic and will not be included in the choice category.

From the possible choices at hand (i.e. model 2, 3 and 4), the appropriate model is selected using the Pantula principle test. The Pantula principle involves the estimation of the three models and collects the trace statistic for all the three models together as shown in Table 13. The estimation starts with the smaller number of co-integrating vector (r) and the most restrictive model, which is model two and if the null hypothesis is rejected then the third and the fourth models will be checked until for the first time the null hypothesis of no co-integration is not rejected. However, the null hypothesis of no co-

integration is rejected for all the three models given, implying co-integration in all the cases. Due to this reason, the Pantula principle is difficult to choose the appropriate model.

In all the estimations log(REER) is treated as an exogenous variable since it is believed to affect the behaviour of the model. The first reason why log(REER) is not treated as an endogenous variable it is because the basic aim of the study is to assess the relationship between inflation and economic growth. However, the study of (Abbott and de Vita: 2011) states that exchange rate largely influences the relationship between inflation and growth. The second reason why log(REER) is included in the model is based on the finding from the Engle-Granger technique. In the E-G analysis, in both the first and second steps, more than 30% of the variation of inflation is explained by the exchange rate. Due to these reasons, log(REER) is included in the model as exogenous variable.

Based on the AIC and the SIC the seventh lag length chosen is applied in the Pantula Principle test. All decisions for rejection and non-rejection of the null hypothesis are based on 5% level of significance using the trace test. Table 13 below shows the result from the Pantula principle test where (r) is the rank or the number of co-integrating vector.

Table 13, Pantula Principle test results

r	n-r	Model 2	Model 3	Model 4
0	2	43.75353	35.15035	38.31991
1	1	3.586725	0.750804	2.331937

From the Pantula test result it is shown that the null hypothesis cannot be rejected in all the three models estimated and hence it is difficult to choose the model which is the appropriate one. Due to this difficulty in identifying the best possible model, Agung (2008) suggests the default option to be used. The default option that E-views provide is model three where intercept with no trend is included

both in the co-integrating equation and the VAR model. Since it is difficult to choose the appropriate model using the Pantula principle this study uses the default model selection suggested and hence model three is used to carry out the co-integration test with the seventh lag.

After checking the order of integration of variables, selecting the optimal lag length and choosing the appropriate model, the Johansen approach directly goes to the determination of the number of co-integrating vectors. The two methods that determine the co-integrating relations are the trace statistic test and the maximum eigen-value test. These two tests are discussed in detail in the following sections.

4.3.2.1 The Trace Test

The trace test is a test based on the likelihood ratio test about the trace of the matrix, as the name indicates. The trace statistic reflects whether the additional eigen-value beyond the rth eigen-value increases the trace. In general the trace test tests if the null hypothesis of the number of co-integrating vectors is less than or equal to r.

In undertaking the trace test, all the previous information such as the lag length and the model selected in earlier sections are included. Accordingly, the result of the trace test given in Table 14 shows the lag length is set at 7 and the test is estimated in the model where only intercept is included in the co-integrating equation and VAR model.

Table 14: Trace (Co-integration Rank) Test

Hypothesized No. of CEs	Eigen-value	Trace Statistic	Critical Value At 5% level of significance	Critical Value At 1% level of significance	Probability
None	0.397023	35.15035	15.49471	19.93711	0.0000
At most 1	0.010981	0.750804	3.841466	6.634897	0.3862

From Table 14, the trace test indicates the existence of one co-integrating equation both at 5% and 1% level of significance. When r (the hypothesized number of co-integrating equation) is zero, the trace statistic is higher than the 5% and 1% critical values implying the existence of co-integration among the series of log(CPI) and log(RGDP). In such cases, the null hypothesis of no co-integrating vector is rejected since the calculated trace statistic 35.15035 is higher than the critical values of 15.49471 and 19.93711 proving the significance at 5% and 1% level, respectively. Having a co-integration result in the trace statistic the next sub-section deals with the co-integration test based on the maximum eigen-value statistic.

4.3.2.2 The Maximum Eigen-value Test

Among the two methods of Johansen's approach of determining the number of co-integrating relations, trace test result shown in Table 14 reveals the existence of one co-integrating relation. The other test based on the maximum eigen-value statistic, basically tests how many number of characteristic roots (eigen-values) are significantly different from zero. The test statistic is based on maximum eigen-value where its name maximal eigen-value statistic is derived from. The result of maximum eigen-value test is given in Table 15.

Table 15: The Maximum Eigen-value Test Result

Hypothesized No. of CEs	Eigen-value	Max-Eigen Statistic	Critical Value At 5% level of significance	Critical Value At 1% level of significance	Probability
None	0.397023	34.39954	14.26460	18.52001	0.0000
At most 1	0.010981	0.750804	3.841466	6.634897	0.3862

The interpretation of the results of the maximum eigen-value test is similar to that of the trace test. Like the trace test, the maximum eigen-value test also indicates that there exists one co-integrating equation both at 5% and 1% level of significance. According to the result given in Table 15, one co-

integrating equation exists since the calculated maximum eigen-value statistic 34.39954 is greater than critical values of 14.26460 and 18.52001 implying the level of significance both at 5% and 1%, respectively.

Therefore, both tests of Johansen approach reveal the existence of one co-integrating vector in the log(CPI) and log(RGDP) series. This shows the existence of a long-run relationship between inflation and economic growth. Hence, the result of the Johansen's approach confirms the results obtained from the Engle-Granger co-integration approach. After determining the number of co-integrating relationships the next step is to conduct weak exogeneity test to check if the variables considered as endogenous are weakly exogenous.

4.3.2.3 Test for Weak Exogeneity

Based on the trace and maximum eigen-value tests the number of co-integrating relations obtained is one. On the other hand, the endogenous variables are two and to test whether each endogenous variable is weakly exogenous with respect to β, the restrictions that will be imposed are A(1,1)=0 and A(2,1) = 0. The restriction imposed for the first endogenous variable is A(1,1) = 0, where the first entry in the bracket, i.e., '1' shows the first endogenous variable to be tested for weak exogeneity. Similarly, to test the weak exogeneity for the second variable the restriction that is imposed is A(2,1) = 0, where the first entry in the bracket, i.e., '2' shows the second endogenous variable to be tested. The second entry in the bracket, i.e., '1' shows the number of co-integrating equation in the model which is obtained from trace and maximum eigen-value tests for co-integration. The test result of weak exogeneity is given in Table 16 with likelihood ratio (LR) statistic and its probability value.

Table 16: Weak Exogeneity Test for log(CPI)

Restrictions: A(1,1) = 0				
Hypothesized no. of CEs	Restricted Log Likelihood	Likelihood Ratio (LR) Statistic	Degrees of Freedom	Probability
1	266.6435	33.59588	1	0.0000

According to the results in Table 16, the coefficient α for the first endogenous variable, log(CPI), is not weakly exogenous based on the LR statistic of 33.59588 with a probability value of 0.0000, in which the decision is made based on 5% level of significance. Having this result it is vital to continue the weak exogeneity test for the second endogenous variable, log(RGDP).

The result of weak exogeneity test for the log(RGDP) is given in Table 17. The restriction imposed for log(RGDP) is A(2,1) = 0, which implies that the weak exogeneity test refers to the second endogenous variable where there is only one co-integrating vector. The result from Table 17 reveals that log(RGDP) is found to be weakly exogenous variable depending on the likelihood ratio statistic of 1.026179 with a p-value of 0.311058. The decision of weak exogeneity is made based on 5% level of significance for the restriction test.

Table 17: Weak Exogeneity Test for log(RGDP)

Restrictions: A(2,1) = 0				
Hypothesized no. of CEs	Restricted Log Likelihood	Likelihood Ratio (LR) Statistic	Degrees of Freedom	Probability
1	282.9283	1.026179	1	0.311058

When a variable is weakly exogenous it shows that it has a long-run impact and causation on the other endogenous variable. Accordingly, based on the results from Table 17, the weak exogeneity of the second variable in the model refers to the long-run impact of log(RGDP) on log(CPI). In addition,

the result from Table 17 implies that the weakly exogenous variable log(RGDP) causes log(CPI). Thus, the weak exogenous variable can be dropped as an endogenous part of the system.

Once the co-integrating vector is established then it is possible to proceed to the VAR based error correction model, i.e., vector error correction model (VECM) which is presented in the following section.

4.3.2.4 Vector Error Correction Model

As a restricted VAR model designed for non-stationary series, the vector error correction (VEC) model is used for series that are known to be co-integrated. The vector error correction (VEC) model restricts the long-run behaviour of endogenous variables so that their long run relationship converges by allowing short run adjustment dynamics. The estimation result of the vector error correction (VEC) model is given in Table 18 where the co-integrating term is regarded as the error correction term for the reason that the deviation from long-run equilibrium is adjusted through time with a series of partial short-run adjustments.

In Table 18, the co-integration (cointeq1) equation denotes the error correction term (ECT); and the negative significant coefficient of the ECT implies that in the short-run the economy converges to the equilibrium point. In the VEC model the lag is specified as seven lags ('1 7') used in the co-integration test identified by using the Akaike Information Criteria (AIC) and Schwarz Information Criteria (SIC). The seven lags selected allow the lagged impact of one variable on the other variable in recent quarters and years. Though, the large lagged terms could have been kept in a reduced form, due to the significant value of the dlog(RGDP(-7)) in the dlog(CPI) regression it is impossible to have the reduced form of the model. In the VEC estimation regarding the deterministic trend specification,

model three is chosen similar to what is used in the co-integration test which is selected using the default model selection as suggested by Agung (2008).

Due to the reason that there is only one co-integrating vector in the VEC, the VEC coefficient restriction that will be entered is B(1,1) = 1, where the first figure in the bracket shows the co-integrating relation while the second figure in the bracket shows the second variable in the VEC equation. The VEC coefficient restriction can also be used to test whether the second endogenous variable (i.e. log(RGDP)) is weakly exogenous with respect to β. The VEC model estimated in Table 18 includes the natural logarithm of real effective exchange rate, i.e. log(REER) as an exogenous variable in the model.

Table 18: The Estimation Result of the VEC Model

Vector Error Correction Estimates		
Co-integrating Eq.	CointEq 1	
log(CPI(-1))	1.000000	
log(RGDP(-1))	-0.694041 (0.07166) [-9.68508]	
C	0.155238	
Error Correction	**Dlog(CPI)**	**Dlog(RGDP)**
CointEq 1	-0.400065 (0.06911) [-5.78902]	-0.020126 (0.02266) [-0.88824]
Dlog(CPI(-1))	0.026550 (0.11041) [0.24047]	0.092971 (0.03620) [2.56827]
Dlog(CPI(-2))	0.037452 (0.11686) [0.32048]	-0.008754 (0.03832) [-0.22847]
Dlog(CPI(-3))	0.049190 (0.11842) [0.41537]	-0.011852 (0.03883) [-0.30525]
Dlog(CPI(-4))	0.119597 (0.11322) [1.05630]	0.051618 (0.03712) [1.39048]
Dlog(CPI(-5))	0.091859 (0.11159) [0.82322]	-0.033894 (0.03659) [-0.92644]
Dlog(CPI(-6))	0.088432 (0.11323)	0.007293 (0.03712)

	[0.78101]	[0.19645]
Dlog(CPI(-7))	0.037208	0.060418
	(0.10556)	(0.03461)
	[0.35248]	[1.74570]
Dlog(RGDP(-1)	0.461371	1.076536
	(0.42357)	(0.13888)
	[1.08924]	[7.75177]
Dlog(RGDP(-2)	-0.706451	-1.009431
	(0.57268)	(0.18776)
	[-1.23358]	[-5.37604]
Dlog(RGDP(-3)	0.802523	0.001530
	(0.45068)	(0.14776)
	[1.78071]	[0.01036]
Dlog(RGDP(-4)	-0.210480	0.772329
	(0.26773)	(0.08778)
	[-0.78616]	[8.79841]
Dlog(RGDP(-5)	-0.853651	-1.276879
	(0.44548)	(0.14606)
	[-1.91624]	[-8.74216]
Dlog(RGDP(-6)	0.447849	0.788662
	(0.54139)	(0.17750)
	[0.82723]	[4.44309]
Dlog(RGDP(-7)	-1.037302	-0.235010
	(0.47794)	(0.15670)
	[-2.17034]	[-1.49972]
C	-1.842235	0.002696
	(0.29912)	(0.09807)
	[-6.15889]	[0.02749]
Log(REER)	0.388727	0.002319
	(0.06317)	(0.02071)
	[6.15341]	[0.11196]

The vector error correction model (VECM) estimation given in Table 18 reveals that the restriction identifies all co-integrating vectors. Co-integrating equation (CointEq1) which is considered as the error correction term has a negative significant adjusted effect on d(log(CPI)) based on the t-statistic of -5.78902. The negative coefficient of the co-integrating equation which is considered as the error correction term satisfies the theoretical expectation that the model converges to its long-run equilibrium path. This result is similar to the findings of the error correction term (ECT) used in the two steps Engle-Granger co-integration approach. Not only is the sign of the CointEq1, but its magnitude also very similar to the value of the ECT obtained. In the Engle-Granger approach of co-integration, the ECT obtained is -0.434734 and the (CointEq1) is -0.400065. Interpreting these

values, in the Engle-Granger approach it is 43% of shock that is adjusted in each quarter and according to the result obtained from the Johansen approach, in each quarter 40% of a shock is adjusted to the long-run path in cases of any disequilibrium. However, the co-integrating equation does not have a significant impact on d(log(RGDP)) based on the t-statistic -0.88824. The lagged values of dlog(CPI)) do not have any significant effect on each of the endogenous variables. The exception however exists that the first lag of dlog(CPI) has a significant positive impact on the dlog(RGDP) with a t-statistic of 2.56827. Nevertheless, due to the insignificant impact of the lagged values of dlog(CPI)) it cannot be deleted since VEC model should have the lagged values of d(log(RGDP)) as a couple of independent variables. The dlog(RGDP(-3)) and dlog(RGDP(-7)) do not have a significant adjusted impact on dlog(RGDP) based on the t-statistic of 0.01036 and -1.49972, respectively. The others however, have a significant and adjusted impact on dlog(RGDP). The VECM estimation result also shows that the exogenous variable log(REER) has a positive, significant and adjusted effect on dlog(CPI) based on the t-statistics 6.15341.

After having such relationships in the VEC model, the next step is to check the stability status of the VEC model. Table 19 reports the inverse roots of the characteristic of the AR polynomial. According to the VECM stability condition report, the VEC model is stable and the model specification imposes one unit root which is required for the model. In the VEC model since the endogenous variables are two and there is only one co-integrating relation, the two endogenous variables minus one co-integrating relation, the root should be equal to unity as it is shown in Table 19.

Table 19: VEC Stability Condition Check

Roots of Characteristic Polynomial	
Roots	Modulus
1.000000	1.000000
-0.998141	0.998141
-0.005243 - 0.988730i	0.988744
-0.005243 + 0.988730i	0.988744
0.691732 - 0.589807i	0.909046
0.691732 + 0.589807i	0.909046
0.798811 - 0.291409i	0.850305
0.798811 + 0.291409i	0.850305
0.356373 - 0.763015i	0.842137
0.356373 + 0.763015i	0.842137
0.808838	0.808838
-0.032351 - 0.726099i	0.726819
-0.032351 + 0.726099i	0.726819
-0.524627 - 0.430233i	0.678479
-0.524627 + 0.430233i	0.678479
-0.663101	0.663101

In general, the findings from the Johansen's approach of co-integration and vector error correction are similar to the findings of Engle-Granger co-integration tests and the ECM. Both techniques reveal that there exists a long-run relationship between inflation and economic growth. The error correction model of single equation and multivariate equation also show that in the short-run the economy converges to the equilibrium point in both cases. The two techniques have similar results on the speed of adjustment to the long run equilibrium path of the model.

The positive long-run relationship between inflation and growth does not mean that inflation is good for economic growth. As mentioned in the literature review, numerous recent studies indicate that the positive relationship between the two variables has a limit. When inflation increases beyond this limit, it has a negative effect. The next section deals with the estimation of the threshold level of inflation that the Ethiopian economy can hold.

4.4 Empirical Estimation of the Threshold level of Inflation in Ethiopia

As mentioned in chapter three, Conditional Least Square (CLS) is the technique that is used to carry out the formal estimation of the threshold level of inflation. The intention of the CLS technique is to identify the level of inflation that maximizes R^2 or the one that minimizes the residual sum of squares (RSS) among the different ascending values assigned as a threshold.

The variables employed in the threshold estimation are transformed in the form of growth rate such as GDP growth rate, investment growth, population growth and the rate of inflation. In addition to this the Hodrick – Prescott method of data smoothening is used. The Hodrick – Prescott filter is a smoothening method widely used in macro-econometric analysis to obtain a smooth estimate of the long-run trend of a series.

Equation (3) that is re-written below is estimated and the maximum value of R^2 is assessed to identify the optimal level of inflation.

$$\text{Growth}_t = \beta_0 + \beta_1(\text{inf}_t) + \beta_2 * D_t(\text{Inf}_t - \Pi^*) + \beta_3(\text{pop}_t) + \beta_4(\text{inv}_t) + \beta_5(\text{open}_t) + \beta_6(\text{Drought}_t) + \varepsilon_t$$

(3)

The values of the threshold points (k) range from 2% - 15% and Table 20 below shows how the outcomes of R^2 vary as the inflation threshold assigned arbitrarily (k) increases. As clearly seen from Table 20 the value of R^2 is maximized at 10% level and hence this point is considered as the threshold level of inflation.

Table 20: CLS Estimation of the Inflation Threshold

k	Variable	Coefficient	Std. Error	t-stat	Prob.	R²
2	C	-0.010024	0.003637	-2.755953	0.0075	
	Inflation	0.523627	0.020365	25.71223	0.0000	
	D2(Inf-2)	-0.000634	0.000513	-1.235970	0.2208	
	Investment Growth	-0.009152	0.002653	-3.449979	0.0010	0.954668
	Population Growth	2.479769	0.352977	7.025299	0.0000	
	Openness	0.439265	0.066922	6.563868	0.0000	
	Drought	-0.000321	0.000684	-0.469800	0.6400	
3	C	-0.010338	0.003477	-2.973625	0.0041	
	Inflation	0.533490	0.020092	26.55284	0.0000	
	D3(Inf-3)	-0.000956	0.000535	-1.786491	0.0786	
	Investment Growth	-0.010909	0.002910	-3.748740	0.0004	0.957892
	Population Growth	2.494177	0.341782	7.297561	0.0000	
	Openness	0.453652	0.064317	7.053349	0.0000	
	Drought	-0.000228	0.000662	-0.343881	0.7320	
4	C	-0.007563	0.003502	-2.159950	0.0345	
	Inflation	0.538057	0.019462	27.64683	0.0000	
	D4(Inf-4)	-0.001576	0.000634	-2.484866	0.0155	
	Investment Growth	-0.015095	0.003098	-4.872253	0.0000	0.961691
	Population Growth	2.186573	0.342553	6.383176	0.0000	
	Openness	0.428278	0.063446	6.750319	0.0000	
	Drought	-0.000418	0.000652	-0.640235	0.5243	
5	C	-0.008818	0.003291	-2.679647	0.0094	
	Inflation	0.553977	0.019744	28.05854	0.0000	
	D5(Inf-5)	-0.001931	0.000768	-2.513755	0.0145	
	Investment Growth	-0.020252	0.003532	-5.734561	0.0000	0.963857
	Population Growth	2.272742	0.324661	7.000350	0.0000	
	Openness	0.470404	0.060308	7.800075	0.0000	
	Drought	-9.12E-05	0.000632	-0.144325	0.8857	
6	C	-0.009372	0.003288	-2.850884	0.0059	
	Inflation	0.557319	0.020202	27.58681	0.0000	
	D6(Inf-6)	-0.001298	0.000861	-1.506631	0.1369	
	Investment Growth	-0.022801	0.003938	-5.789433	0.0000	0.963846
	Population Growth	2.321259	0.324320	7.157313	0.0000	
	Openness	0.479953	0.060759	7.899344	0.0000	
	Drought	0.000246	0.000643	0.381885	0.7038	
7	C	-0.009634	0.003289	-2.929470	0.0047	
	Inflation	0.559838	0.021157	26.46120	0.0000	
	D7(Inf-7)	-0.000198	0.001049	-0.188853	0.8508	
	Investment Growth	-0.025760	0.004347	-5.926568	0.0000	0.964918
	Population Growth	2.346405	0.323569	7.251628	0.0000	
	Openness	0.481817	0.062012	7.769739	0.0000	
	Drought	0.000652	0.000653	0.997677	0.3223	
8	C	-0.008986	0.003207	-2.801763	0.0068	
	Inflation	0.561301	0.020720	27.09012	0.0000	
	D8(Inf-8)	0.001018	0.001153	0.882298	0.3811	0.967866
	Investment Growth	-0.029930	0.004670	-6.409231	0.0000	
	Population Growth	2.292075	0.315271	7.270166	0.0000	
	Openness	0.466284	0.060652	7.687902	0.0000	
	Drought	0.001150	0.000659	1.745746	0.0859	
9	C	-0.008208	0.003166	-2.592824	0.0119	
	Inflation	0.556587	0.020800	26.75860	0.0000	
	D9(Inf-9)	0.002139	0.001150	1.860266	0.0678	
	Investment Growth	-0.031624	0.004834	-6.542243	0.0000	0.970211
	Population Growth	2.234853	0.311036	7.185194	0.0000	
	Openness	0.444853	0.060400	7.365117	0.0000	
	Drought	0.001147	0.000638	1.798407	0.0771	
10	C	-0.006802	0.003111	-2.186382	0.0328	
	Inflation	0.545556	0.020654	26.41392	0.0000	
	D10(Inf-10)	0.003511	0.001139	3.082291	0.0031	
	Investment Growth	-0.031949	0.004875	-6.553585	0.0000	0.973212*
	Population Growth	2.120947	0.306239	6.925788	0.0000	
	Openness	0.407381	0.059762	6.816734	0.0000	
	Drought	0.001127	0.000611	1.844052	0.0702	

11	C	-0.009082	0.003268	-2.778800	0.0073	
	Inflation	0.566596	0.020606	27.49681	0.0000	
	D11(Inf-11)	0.002157	0.001373	1.571482	0.1215	
	Investment Growth	-0.035673	0.005288	-6.746294	0.0000	0.970105
	Population Growth	2.341907	0.326753	7.167201	0.0000	
	Openness	0.459280	0.060576	7.581920	0.0000	
	Drought	0.000984	0.000662	1.485250	0.1429	
12	C	-0.011558	0.003340	-3.460700	0.0010	
	Inflation	0.579077	0.020114	28.78915	0.0000	
	D12(Inf-12)	-0.001593	0.001892	-0.841902	0.4034	
	Investment Growth	-0.036143	0.005685	-6.357055	0.0000	0.968853
	Population Growth	2.594354	0.342301	7.579154	0.0000	
	Openness	0.504854	0.059074	8.546157	0.0000	
	Drought	0.000762	0.000717	1.061475	0.2930	
13	C	-0.011847	0.003658	-3.238398	0.0020	
	Inflation	0.580539	0.021068	27.55576	0.0000	
	D13(Inf-13)	-0.001159	0.001933	-0.599618	0.5512	
	Investment Growth	-0.037307	0.006457	-5.777711	0.0000	0.967754
	Population Growth	2.636507	0.390661	6.748841	0.0000	
	Openness	0.503752	0.060394	8.341053	0.0000	
	Drought	0.000772	0.000731	1.055103	0.2960	
14	C	-0.011602	0.003945	-2.941301	0.0048	
	Inflation	0.580026	0.021736	26.68444	0.0000	
	D14(Inf-14)	-0.000668	0.001956	-0.341360	0.7342	
	Investment Growth	-0.037450	0.006908	-5.421196	0.0000	0.967000
	Population growth	2.609872	0.432896	6.028866	0.0000	
	Openness	0.500493	0.061150	8.184634	0.0000	
	Drought	0.000791	0.000740	1.068974	0.2898	
15	C	-0.011238	0.004316	-2.603596	0.0119	
	Inflation	0.579424	0.022543	25.70354	0.0000	
	D15(Inf-15)	-0.001051	0.002070	-0.508034	0.6135	
	Investment Growth	-0.036837	0.007377	-4.993468	0.0000	0.966411
	Population Growth	2.559548	0.487658	5.248653	0.0000	
	Openness	0.499921	0.061192	8.169738	0.0000	
	Drought	0.000943	0.000784	1.202939	0.2343	

*Denotes the threshold level of inflation

From the results of Table 20, it is shown that all the explanatory variables in the growth model are significant at 10% level, i.e., when inflation is at its threshold. When inflation is at 10% the p-value of the coefficient for the rate of inflation is close to zero implying the significant relationship between inflation and economic growth at 1% level of significance. For the level of inflation that is more than 10% there is a significant negative relationship between inflation and growth. If inflation increases above the threshold level, economic growth is expected to decline roughly by 0.55% in each quarter. This value is obtained by adding up the coefficients of the inflation threshold and the inflation rate which is 0.558726. The results in Table 20 also show that 10% is the optimum level of inflation that the economy can absorb without affecting the economic growth. Among the given values of k, at

10% the value of R^2 is maximized at a point of 0.973212. The relation between the threshold k values assigned and the R-squared is given in Figure 4 below.

Figure 4: The Value of k versus R^2
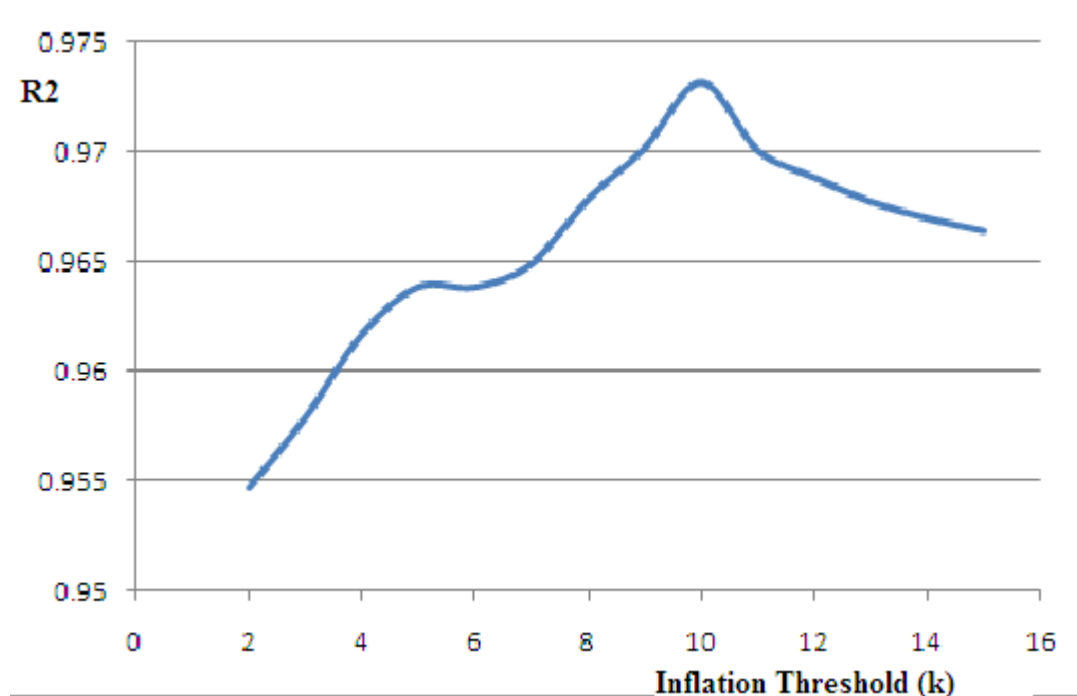
Form Figure 4 one can see that the level of R-squared increases up to the point where the assigned inflation threshold (k) reaches 5%. However, R-squared does not show a change, neither decreasing nor increasing, as inflation threshold increases from 5% to 7%. The value of R-squared then increases again from 7% until it reaches 10%. From 10% onwards the increase in the inflation threshold reduces the value of R-squared showing that the value of R-squared peaks at 10%.

At the threshold level of inflation, i.e., 10%, the estimation result for all variables is statistically significant at 1% level except for drought which is also significant at 10%. Based on the results in Table 20 and Figure 4, the level of inflation less than 10% is conducive to the economy while a level of inflation that is greater than the 10% has a negative effect on the economy.

The inflation threshold of 10% is not that high for a developing country such as Ethiopia. Most studies carried out in the estimation of the threshold level of inflation for developing countries have findings that are around 10%. Some of these studies include Khan and Senhadji (2001), Kremer, Nautz and Bick (2009), Jha and Dang (2011), Pollin and Zhu (2005), Bick (2010) and Mubarik (2005).

The results of these studies show that the threshold level of inflation for developing countries is mostly double digit, i.e., 10% or more. The findings from Khan and Senhadji (2001) shows that developing countries have a threshold level of inflation at about 11%. Kremer, Nautz and Bick (2009) found out that for developing countries an inflation rate up to 17% does not affect the growth rate of the economy. Similar to Khan and Senhadji (2001), Jha and Dang (2011) found out that 11% is a threshold level of inflation for developing countries. In a single country time series study for a developing country, Pakistan, Mubarik (2005) also reveals that 9% is the threshold level of inflation for the economy of the country. Therefore, the level of threshold 10% for Ethiopia should not be regarded as surprisingly high. Having the result of the threshold level of inflation from Table 20 the next sub-section deals with the diagnostic test for the estimation where k = 10%.

4.4.1 Diagnostic Tests

For the model where the threshold level of inflation is 10%, a diagnostic test is carried out to check whether the model has Gaussian error terms. The diagnostic tests include normality test, serial correlation test, hetroscedasticity test and Cumulative sum (CUSUM) test of recursive residuals. The Jarque-Bera normality test is used to check if the error terms are normally distributed. The Breusch-Godfrey Lagrange Multiplier (LM) serial correlation test is used to check whether the error terms are serially independent. The autoregressive conditional heteroscedasticity (ARCH) LM test is used to

check the problem of heteroscedasticity. The CUSUM test is employed to capture a non-zero mean of the residuals due to shifts in the parameters of the model. The results of these tests are summarized in Table 21.

Table 21: Diagnostic Tests for the optimal level of inflation

Test	Test Statistic	p-value	Conclusion
Normality Test (JB test)	1.420906	0.491421	Residuals Normally Distributed
Serial Correlation (LM test)	65.99591	0.1939	No serial Autocorrelation
Heteroscedasticity test (ARCH test)	1.634256	0.1560	No Heteroscedasticity
Stability (CUSUM)	Within the Bands		Stable

The Jarque-Bera normality test results shows that residuals are normally distributed based on the relative lower value of the test statistic and high probability value of the test statistic. The test statistic obtained in the Jarque-Bera test is 1.420906 and the p-value of the test statistic is 0.491421. According to the JB normality test, these values do not lead to the rejection of the null hypothesis that the residual series are normally distributed.

The Breusch-Godfrey serial correlation test result reveals that the error terms in the model are serially independent. However, at lower lags this case is not true and hence to remove the problem of autocorrelation taking higher lags is necessary. Hence, at higher lag the test statistic has a value of 65.99591 with its probability value of 0.1939 showing that the serial correlation problem is treated. The large p-value of the test statistic leads to the rejection of the null hypothesis that the error terms are serially correlated.

On the other hand, the result from the ARCH LM test shows that error terms have constant variance. This is due to the lower test statistic of the ARCH LM test that is 1.634256 and its relative higher p-value of 0.1560. From this result one can reject the null hypothesis that the error terms have non-constant variance.

Finally, the result from the cumulative sum (CUSUM) of recursive residuals shows that the structural stability of the model falls between the lines of $\pm 0.948[\sqrt{T-k} + 2(\tau - K)/\text{T-K}]$ at about 5% level of significance. Thus, CUSUM does not wander from the lines and stays within the bands at 5% level of significance implying the stability of the model.

As a conclusion, the findings of this chapter have addressed the specific objectives of the study. The findings of this chapter notify that the two macro-economic variables, i.e., inflation and economic growth have long-run relationship. This result is obtained both from the Engle-Granger co-integration approach and the Johansen's approach of co-integration. These tests also show that the two variables have positive long-run relations. This positive relationship implies that the Ethiopian macro-economic condition is similar to that of Keynesian explanation of the relationship of inflation and growth.

The short-run relationship between inflation and growth and the short-run reaction of the inflation model in the times of shock is also addressed in this chapter. Similar to the long-run relationship, in the short-run the two variables have positive relationship. However, the very high p-value for the coefficient of the real gross domestic product (RGDP) in the error correction model makes the finding insignificant both at 5% and 10% level of significance.

Both the Engle-Granger and the Johansen's approach findings of the error correction tests show that in cases of any disequilibrium in the model, the economy converges to its long-run equilibrium path.

The two approaches have also similar results in the speed of adjustment to the long-run path of the economy. According to the Engle-Granger approach it is 43% of the deviation from the equilibrium that is adjusted in each quarter. On the other hand, the Johansen's multivariate error correction model shows that it is 40% of the disequilibrium is adjusted in each quarter to the long-run path model.

Finally, in estimating the threshold level of inflation, the findings from this chapter reveal that up to 10% level, inflation does not have a significant negative impact on the growth of the economy. However, if inflation rate exceeds the 10% level then the growth of the economy will be affected negatively. Based on the results of this chapter, the next chapter provides a conclusion, policy implication and implications for further research.

Chapter Five

Conclusion and Policy Implication

5.1 Conclusion

This dissertation is motivated by the recent occurrence of roaring inflation and the rapid growth of gross domestic product (GDP) in Ethiopia. The stable macroeconomic historical condition of the country has made economic researchers and policy makers give less concern to study the relationship between inflation and economic growth. Due to this reason, even though the inflation growth literature is exhaustively assessed in international literature, a literature gap exists in Ethiopia in this area. This dissertation is thus believed to contribute to fill this gap.

The objectives of this study are to examine the relationship between inflation and economic growth in the long run and in the short run. In doing so, the long-run determinants of the recent inflation are also addressed. The study also searches for the optimum level of inflation that the economy can hold without the growth being affected negatively.

Based on these objectives, this dissertation contributes to the literature in this area by exploring the literature reviews exhaustively, identifying the gaps and by filling these gaps. It also provides policy recommendation for macro-economic policy makers and central bankers on what level should inflation be targeted in the monetary policy of the country.

The findings of this study reveal the existence of positive long-run relationship between inflation and economic growth. In this dissertation the long-run relationship is captured using Engle-Granger co-integration approach and the Johansen approach. Both of these approaches indicate the positive long-run relationship between the two macroeconomic variables, inflation and

growth. The positive long-run relationship implies a sustained rapid growth in the economy has a tendency of increasing the rate of inflation in the long-run. The finding of positive relationship between inflation and growth is similar to the Keynesian theoretical framework of the macro-economy. When Keynesian economics was popular the economy of the world in general was under reconstruction after the destruction of the Second World War. Similarly, Ethiopia is recently under construction of its economy and the positive relationship between inflation and GDP growth should not be a surprise.

Though recent global economic literature states the negative long-run relationship between inflation and growth, this does not hold for the developing country like Ethiopia. As it used to be a positive relationship during the growth process of the developed countries (i.e. after WWII until 1970's) the positive relationship among the two variables is rational in the growth process of Ethiopia. However, from the lessons learned from the world experience the positive relationship has its limits, until it reaches the natural rate of unemployment.

The findings of these studies also show that the growth of the economy explains more than the quarter of the increase in the general price level. From this one can conclude that there is a strong positive relationship between economic growth and inflation. On the other hand, inflation expectation and the real effective exchange rate also affect the rate of inflation significantly.

Since one of the aims of the study is to carry out the short-run relationship and the short-run dynamics, the results conclude that in the short-run, the relationship between the two variables is insignificant. However, regarding the dynamics the negative sign on the error correction term shows that in cases of any deviation of inflation in the short-run, it will be adjusted to its long-run equilibrium path. Concerning the speed of adjustment based on the Engle-Granger approach

43% of the deviation of inflation from its long-run path is adjusted in each quarter. On the other hand, based on the vector error correction model, it is 40% of the deviation of inflation from its long-run path that is adjusted in each quarter. There is not much difference between the two approaches of co-integration and error correction models.

Though the positive long-run relationship exists between the two macro-economic variables, high and unstable rate of inflation affects the growth process too. Due to this reason, estimating the threshold level of inflation is one of the important goals of the study. The 10% level of inflation as a threshold point is the other finding of this dissertation. Hence a level of inflation more than or less than 10% negatively affects the growth of the economy while the level of inflation at 10% keeps the growth of the economy at the optimal level. Even though this level of inflation is considered to be very high for developed countries, for a developing country such as Ethiopia 10% of inflation as a threshold point is tolerable. This result is similar to the popular study in this area, i.e., Khan and Senhadji (2001) that estimated the threshold level of inflation.

5.2 Policy Implications

This study provides an important policy recommendation for Ethiopian macro-economic policy makers and the country's central bankers. Though inflation targeting is the current fashion among monetary policy makers, developing countries such as Ethiopia should not only aim to combating inflation but also should have to consider the economic position of the country. According to the finding of this study, a 10% level of inflation is the optimal level of inflation that helps the economy to grow optimally. Hence, the central bank which is responsible for the monetary policy of the country should aim to keep inflation at 10% so that the growth of the economy is not hampered. In order to achieve this target, coordination of the fiscal and monetary

policies is necessary and thus the Ministry of Finance and Economic Development, the National Bank of Ethiopia, and the Revenue and Customs Authority must work together to achieve policy effectiveness. According to the recent five year development plan (GTP), government has a goal to keep inflation at 6%. Though this figure is a bit ambitious, it may also sacrifice economic growth at the expense of controlling inflation.

The results of the study also show that inflation expectation is the independent variable in the inflation model that largely explains the rate of inflation. Such findings signal the need for researchers and policy makers to work on inflation expectation in order to control the inflation rate. As mentioned above, the rate of inflation should be kept at 10% in order to have optimal level of economic growth and thus expectations on inflation should also be kept around the target level so that inflation rate will not rise. To keep expectations lower, official announcement of the inflation target is necessary and the government of Ethiopia has undertaken similar measures. However, from the world experience such announcements might not be enough to create credibility among the public due to the possibility of governments' temptation of inflating the economy. Therefore, in addition to the announcements, central bank independence might be required to keep inflation expectations at a lower level. Nevertheless, further researches are necessary on the costs and benefits of the central bank's independence for developing country like Ethiopia.

In general, coordination among different governmental economic policy making institutions is vital. Though it is the choice of a policy on priority among inflation and growth, whatever the government chooses the coordination among fiscal policy, monetary policy, trade policy and investment policy is essential to achieve the desired goal.

5.3 Areas for Further Research

Even though this study has tried to address different issues regarding the relationship between inflation and growth, it is obvious that all the problems of this topic area are not addressed in this paper. Thus, it is worth mentioning some of these areas that need further assessment in order to fill the gap.

The relationship between inflation and growth is not a onetime study but it is continuous and it is important to observe the dynamics in the relationship between the two macro-economic variables. By doing so, it is possible to foresee the path of the two variables in the long-run so that corrections can be made before occurrence of shock.

In further studies it is also recommended to include more explanatory variables that can explain the current inflation well. For the case of expectation this study employs the adaptive expectation approach, i.e., expectation based on past information only. In this study expectation largely explains the current inflation and it is worth including more information in the development of inflation expectation rather than depending only on the past information.

The other issue that is out of the scope of this study is the causality analysis. There exists large disagreement on whether economic growth triggers inflation or inflating money stock (an increase in money supply) causes the economic growth. This causality analysis is necessary in order to control the variable that is affecting the other.

Future studies in this area should also focus on the pros and cons of central bank independence for a growing economy within a developmental state framework such as Ethiopia. Though central bank independence is largely acceptable in global literature, there are counter arguments

that take inflation targeting and central bank independence as an obstacle for economic growth. As mentioned above, due to the stable price history of Ethiopia, this area is not studied well and I believe the above mentioned implications for further studies would help fill the gap in this area.

References

Aaron, H.,1967, 'Structuralism versus Monetarism: A note on evidence', *T and F online*, viewed 2 April 2012, from http://www.tandfonline.com/doi/abs/10.1080/00220386708421218

Abbott, A. & De Vita, G., 2011, 'Revisiting the Relationship between Inflation and Growth: A Note on the Role of Exchange Rate Regimes', *Economic Issues 16(1)*, 37 – 52.

Agung, G.N., 2009, *Time Series Data Analysis Using E-views*, John Willey & Sons (Asia) Publishers, Singapore.

Ahmed, S. and Mortaza, M. G., 2005, 'Inflation and growth in Bangladesh: 1981-2005' *Policy Analysis Unit Working Paper*, Series WP0604, 1 – 22.

Ahortor, C.R.K., & Adenutsi, D.E., 2009, 'Inflation, Capital accumulation and Economic Growth in Import Dependent Developing Economies', *The 14th annual conference on Econometric modelling for Africa,* Abuja, Nigeria, 8-10 July 2009.

Ambler, S., 2008, 'The Cost of Inflation in New Keynesian Models', *Bank of Canada*, Winter 2007-2008, 5 – 14.

Asaminew, E., 2010, 'Inflation and Growth: An estimate of the Threshold Level of Inflation for Ethiopia', *Proceeding of the Ninth International Conference on the Ethiopian Economy,* Ethiopian Economics Association, Addis Ababa, July 21 -23, 2011.

Asteriou, D. and Hall, S.G., 2007, *Applied Econometrics: A Modern Approach*, Pagrave Macmillan, New York.

Ayalew, Y., 2000, The Trade-off between Inflation and Unemployment in Ethiopia. *Proceedings of the 10th Annual Conference on the Ethiopian Economy:* Nazreth, Ethiopia, Ethiopian Economics Association. Nov. 3-5, 2000.

Baharumshah, A.Z., Hamzah, N.A. & Sarbi S.R.M., 2011, 'Inflation Uncertainty and Economic Growth: Evidence from LAD ARCH Model', *Journal of Applied Statistics 38(1)*, 195 – 206.

Ball, L., Mankiw, N.G., & Romer, D., 1988, 'The New Keynesian Economics and the Output-Inflation Trade-off', *Brookings paper on Economic Activity*, 1988(1), 1 – 90.

Barro, R.J., 1995, 'Inflation and Economic Growth', *Bank of England Quarterly Bulletin*, 166 – 176.

Baumol, W.J., 1999, 'Retrospectives Say's Law', *Journal of Economic Perspectives 13(1),* 195 – 204.

Bera, A.K. and Higgins, M.L., 1993, 'ARCH Models: Properties, Estimation and Testing', *Journal of Economic Surveys*, 7 (4), 305 – 62.

Bick, A., 2010, 'Threshold Effects of Inflation on Economic Growth in Developing Countries' in econ papers, Goethe University, Department of Economics, 1 – 8.

Bittencourt, M., 2010, 'Inflation and Economic Growth in Latin America: Some Panel Time Series Evidence' *University of Pretoria department of economics working paper series*, 2010 – 2011, 1 – 22.

Blanchard, O., & Gali, J., 2005, 'Real Wage Rigidities and the New Keynesian Model', *Federal Reserve Bank of Boston Working Paper Series No. 05-14*, 1 – 36.

Boyd, J.H. & Champ, B., 2006, 'Inflation, Banking and Economic Growth', *Federal Reserve Bank of Cleveland working paper*, May 2006, ISSN 0428-1276, 1 – 5.

Bruno, M. & Easterly, W., 1996, 'Inflation and Growth: In Search of a Stable Relationship' *Federal Reserve Bank of St. Louis,* May/June 1996, 139 – 145.

Campbell, J.Y. and Shiller, R.J., 1988, 'Interpreting Co-integrated Models', *Journal of Economic Dynamics and Control*, 12(2-3), 505-522.

Central Statistics Agency (CSA), 2008, *Annual Report 2006/07*, DDCSA, Addis Ababa.

Cheung, Y.W. and Lai, K.S., 1995, 'Lag Order and Critical Values of the Augmented Dickey Fuller Test', *Journal of Business and Economic Statistics*, 13(3), 277 – 80.

Chimobi, O.P., 2010, 'Inflation and Economic Growth in Nigeria', *Journal of Sustainable Development 3(2)*, 159–166.

Cottrell, A., 1997, 'Keynes, Richardo, Malthus and Say's Law', *History of Economic Societies meetings*, Charleston, SC, June 1997, 1 – 20.

Dalle, G., 2009, 'Challenges of Crop Cultivation in Pastoral Dry lands of Ethiopia', *Proceedings of the National Conference on Sustainable Land Management and Poverty Alleviation*, Addis Ababa, May 18 – 19, pp. 77 – 84.

Dholakia, R.H., & Sapre, A.A., 2011, 'Speed of Adjustment and Inflation – Unemployment Trade-off in Developing Countries – Case of India', *Indian Institute of Management Research and Publication*, Working paper Series no. 2011-07-11, July 2011, 2 – 30.

Dickey, D.A, and Fuller, W.A., 1979, 'Distribution of the Estimators for Autoregressive Time Series with a Unit Root', *Journal of American Statistical Association*, 74, 427 – 431.

Dickey, D.A., and Fuller, W.A., 1981, 'The Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root', *Econometrica*, 49, 1057 -1072.

Dimand, R.W., 2005, 'David Hume and Irving Fisher on the Quantity Theory of Money', *Brock University, St. Catharines, Ontario L2S 3A1, Canada,*1 – 9.

Dinsa, B. and Kifle, D.,2009, 'Use of Fertilizers and Crop Productivity in Western Oromiya', *Proceedings of the National Conference on Sustainable Land Management and Poverty Alleviation*, Addis Ababa, May 18 – 19, pp. 122 – 131.

Domar, E.D., 1946, 'Capital Expansion, Rate of Growth and Employment', *Econometrica 14(2),* 137 – 47.

Domar, E.D., 1947, 'Expansion and Employment', *The American Economic Review 37(1)*, 34-55.

Dotsey, M. & Sarte,P.D. G., 2000, 'Inflation Uncertainty and Growth in a Cash-In-Advance Economy', *Journal of Monetary Economics 45 (3)*, 631 – 655.

Engle, R.F., 1982. 'Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation'. *Econometrica*, 50, 987-1007.

Engle, R.F. & Granger, C.W.J., 1987, 'Co-Integration and Error Correction: Representation, Estimation and Testing', *Econometrica 55(2)*, 251 – 276.

Engle, R.F., Hendry, D. and Richard, J.F., 1983, 'Exogeneity', *Econometrica*, 51, 277 – 304.

Engle, R.F. and Yoo, B.S., 1987, 'Forecasting and Testing in Co-integrated Systems', *Journal of Econometrics*, 35, 143 – 159.

Erbaykal, E. & Okuyan, H.A., 2008, 'Does Inflation Depress Economic Growth? Evidence from Turkey', *International Research Journal of Finance and Economics 17 (2008),* 40 – 48.

Erchafo, G., 2001, Monetary Policy Instruments in Ethiopia, *National Bank of Ethiopia Economic Research Department*, November 2001, 2 – 17.

Fielding, D., 2008, 'Inflation Volatility and Economic Development: Evidence from Nigeria', *University of Otago Economics Discussion Papers No. 0807,* 1 – 22.

Friedman, B.M., 1968, 'The Role of Monetary Policy', *The American Economic Review, March LVIII(1)*, 1 - 17.

Friedman, B.M., 1976, 'Inflation and Unemployment', *Nobel Memorial Lecture*, 267 – 286.

Frimpong, J.M., & Oteng-Abayie, E.F. 2010, 'When is Inflation Harmful? Estimating the Threshold Effect for Ghana', *American Journal of Economics and Business Administration 2(3)*, 232 – 239.

Geda, A., 2005. 'Macroeconomic Performance in Post-Reform Ethiopia', *Journal of Northeast African Studies*, 8(1), 159-185.

Geda, A. & Tafere, K., 2008, 'The Galloping Inflation in Ethiopia: A Cautionary Tale for Aspiring 'Developmental States' in Africa', *Alemayehu Academic Researches web*, viewed 3 April 2012, from

http://www.alemayehu.com/AA%20Recent%20Publication/The%20Galloping%20Inflation%20and%20Financing%20Development%20in%20Ethiopia_sept2008.pdf.

Gillman, M. & Harris, M.N., 2010, 'The Effect of Inflation and Growth: Evidence from a Panel of Transition Countries', *Economics of Transition 18(4)*, 697 – 714.

Gokal, V. & Hanif, S., 2004, 'Relationship between inflation and economic growth', *Economics Department: Reserve Bank of Fiji*, working paper 2004/4, 1 – 24.

Granger, C.W.J., 1981, 'Some Properties of Time Series Data and their Use in Econometric Model Specification', *Journal of Econometrics*, Vol. 16, 121 – 130.

Gujarati, D.N., 2003, *Basic Econometrics*, McGraw Hill, New York.
Hansen, B.E., 1996, 'Inference when a Nuisance Parameter is not Identified Under the Null Hypothesis', *Econometrica*, 64, 413 – 430.

Hansen, B.E., 1999, 'Testing for Linearity', *Journal of Economic Surveys*, 13(5), 551 – 76.

Harrod, R.F., 1938, 'An Essay in Dynamic Theory', *History of Political Economy 28 (2)*, 253 – 280.

Hasanov, F., 2011, 'Relationship between Inflation and Economic Growth in Azerbaijani Economy: Is there any Threshold Effect?', *Institute for Scientific Research on Economic Reforms MPRA no. 33494*, 2-10.

Hodge, D., 2005, 'Inflation and Growth in South Africa', *Cambridge Journal of Economics 36(2)*, 163 – 180.

Hodrick, R. J. and Prescott, E. C., 1997, Post-war U.S. business cycles: an empirical investigation, *Journal of Money, Credit, and Banking*, vol.29, 1 - 16.

Hussain, M., 2005, 'Inflation and Growth: Estimation of Threshold point for Pakistan', *Economic Policy Department: State Bank of Pakistan*, 2 – 10.

Iqbal, N. & Nawaz, S, 2009, 'Investment, Inflation and Economic Growth Nexus', *The Pakistan Development Review 48(4)*, 863 – 874.

Ismail, A., Zaman, K., Atif, R.M., Jadoon, A. & Seemab, R., 2010, 'The Role of Exports, Inflation and Investment on Economic Growth in Pakistan (1980 – 2009)', *International Journal of Economic Research 1(1),* 1-9.

Jarque, C. M., and Bera, A. K., 1980, 'Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals', *Economics Letters*, 6, 255-259.

Jarque, C. M.,and Bera, A. K., 1987, 'A Test for Normality of Observations and Regression Residuals', *International Statistical Review*, 55(2), 163-172.

Jha, R. & Dang, T., 2011, 'Inflation Variability and the Relationship between Economic Growth', *Australian National University ASARC working paper 2011/08*, 1 – 19.

Johansen, S., 1988, 'Statistical Analysis of Co-integration Vectors', *Journal of Economic Dynamics and Control*, 12(2), 231–254.

Johansen, S., 1991, 'Estimation and Hypothesis Testing of Co-integration Vectors in Gaussian Vector Autoregressive Models', *Econometrica,* 59, 1551 – 1580.

Johansen, S. & Juselius, K., 1990, 'Maximum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money', *Oxford Bulletin of Economics and Statistics 52(2)*, 169 – 210.

Khan, M.S., & Senhadji, A.S., 2001, 'Threshold Effects in the Relationship between Inflation and Economic Growth' *IMF Staff Papers 48(1)*, 1-21.

Koop, G., 2009, *Analysis of Economics Data*, John Willy & Sons Ltd, Chichester.

Krause, M.U., & Lubik, T.A., 2003, 'The (Ir)relevance of Real Wage Rigidities in the New Keynesian Model with Search Frictions', *Johns Hopkins University working paper no. 2003/504*, 1 – 43.

Kremer, S., Bick, A. & Nautz, D., 2009, 'Inflation and Growth: New Evidence from a Panel Threshold Analysis', *Department of Money and Macroeconomics: Goethe University Frankfurt*, 1 – 23.

Leeson, R., 1994, 'Inflation, Disinflation and Natural Rate of Unemployment: A Dynamic Framework for Policy Analysis' *The Australian Economy in 1990's*, 125 – 175.

Leeson, R., 1997, 'The Phillips Controversy: A Further Reply to Chapple', *History of Economics Review 29(7)*, 97 – 106.

Lin J.L. and Tsay R.S., 1996, 'Co-integration constraint and Forecasting: An empirical examination', *Journal of Applied Econometrics*, 11(5), 519 – 538.

Lisman, J.and Sandee J. (1964), 'Derivation of Quarterly Figures from Annual Data', *Journal of Applied Statistics*, 13, 87 – 90.

Lucas, R.E., Jr., 1973, 'Some International Evidence on Output-Inflation Tradeoffs', *The American Economic Review 63(3)*, 326 – 334.

Lucas, R.E., Jr., 1988, 'On the Mechanics of Economic Development', *Journal of Monetary Economics, 22(1988)*, 3 – 42.

Lucas, R.E., Jr., 1996, 'Monetary Neutrality', *Nobel Prize Lecture*, 246 – 266.

Lucas, R.E., Jr., & Rapping, L.A., 1969, 'Real Wages, Employment and Inflation', *Journal of Political Economy 77(5)*, 721 – 754.

Lupu, D.V., 2012, 'The Correlation between Inflation and Economic Growth in Romania', *Lucrări Ştiinţifice Vol 5, Seria Zootenhie*, 359 – 363.

Malla, S., 1997, 'Inflation and Economic Growth: Evidence from a Growth Equation', University of Hawaii, Working Paper *Hawaii. Edu web*, viewed 28 March 2012, from http://sunilmalla.com/research/Papers/Inflation_econ_growth_1997.pdf.

Mallick, H., 2008, 'Inflation and Growth Dynamics: the Indian Experience', *Journal of Economic Policy Reform 11(3)*, 163 – 172.

Mallik, G., & Chowdhury, A., 2001, 'Inflation and Economic Growth: Evidence from Four South Asian Countries', *Asia-Pacific Development Journal 8(1)*, 123 – 135.

Michael, Y., 2008, *'The Relationship between Inflation and Unemployment in Ethiopia'*. M.A. dissertation, Department of Economics. Addis Ababa University.

Ministry of Finance and Economic Development (MoFED), 2000, Annual Report 1999/2000, Addis Ababa, Ethiopia.

Ministry of Finance and Economic Development (MoFED), 2010, Growth and Transformation Plan 2011 – 2015, Addis Ababa, Ethiopia.

Ministry of Finance and Economic Development (MoFED), 2011, Annual Report 2010/11, Addis Ababa, Ethiopia.

Minney T. 2010. 'A rising Giant'. *New African*. February 2010. 67-8

Mubarik, Y.A., 2005, 'Inflation and Growth: An Estimate of the Threshold Level of Inflation in Pakistan', *SBP working paper series No. 08*, 2-12.

Munir, Q., Mansur, K., & Furuoka, F., 2009, 'Inflation and Economic Growth in Malaysia: A Threshold Regression Approach', *ASEAN Economic Bulletin 26 (2),* 180 – 93.

National Bank of Ethiopia (NBE), 2009, Annual Report 2008/09, Addis Ababa, Ethiopia.

Ng, S. and Perron, P., (2001), 'Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power', *Econometrica*, 69 (6), 1519-1554.

Ozdemir, Z.A., 2010, 'Dynamics of Inflation, Output Growth, and their Uncertainty in the UK: An Empirical Analysis', *The Manchester School 78(6)*, 511 – 537.

Palenzuela, D.R., Mendez, G.C. and Garcia, J.A., 2003, 'Relevant Economic Issues Concerning the Optimal Rate of Inflation', *ECB Working Paper Series No. 278*, 4 – 41.

Pankhurst, R., 1963b, 'The Ethiopian Monetary and Banking Innovations in the Nineteenth and Early Twentieth Centuries' *Journal of Ethiopian Studies*, 1(2), 64 – 120.

Pentecost, E.J., 2000, *Macroeconomics: an open economy approach*, 1st Ed., Macmillan Press Ltd., New York.

Pesaran, M.H., Shin, Y. & Smith, R.J., 2001, 'Bounds Testing Approaches to the Analysis of Level Relationships', *Journal of Applied Econometrics 16(3)*, 289 – 326.
Phillips, P. C. B., 1987, 'Time Series Regression with a Unit Root', *Econometrica,* 55(2), 277 –301.

Phillips, P. C. B. and Perron, P., 1988, 'Testing for a Unit Root in Time Series Regression', *Biometrika,* 75(2), 335–346.

Pollin, R., & Zhu, A., 2005, 'Inflation and Economic Growth: A Cross-Country Non-Linear Analysis', *Political Economy Research Institute: working paper series no. 109*, 1 – 23.

Ramalho da Silva, D.F., 2011, 'Friedman, Phelps, Lucas and the Natural Rate of Unemployment', *Paper prepared for the 12th annual Summer Institute for the Preservation of the History of Economic Thought at the University of Richmond,* 1 – 44.

Ramsey, J.B., 1969, 'Tests for Specification Errors in Classical Linear Least-Squares Regression Analysis', *Journal of Royal Statistical Society*, 31(2), 350 – 71.

Ramsey J.B. and Alexander A., 1982, 'The Econometric Approach to Business Cycle Analysis Reconsidered', *Journal of Macroeconomics*, 6(3), 347 – 55.

Romer, P.M., 1994, 'The Origins of Endogenous Growth', *Journal of Economic Perspectives*, 8(1), 3 – 22.

Salian, P.V., & Gopakumar, K., 2012, 'Inflation and Economic Growth in India – An Empirical Analysis', *IGDIR Delhi*, 1 – 28.

Salvatore, D., (2004), *International Economics*, John Willey & Sons, New Jersey.

Seleteng, M., n.d., 'Inflation and Economic Growth: An estimate of an optimal level of inflation in Lesotho', *Central Bank of Lesotho Research Department*, Working Paper Series, 2-12.

Serranito, F., 2003, 'Openness, Growth and Convergence Clubs: A Threshold Regression Approach', Université de Paris Nord, *CEPN, CNRS UMR*, 7115.

Sergii, P., 2009, 'Inflation and Economic Growth: The Non-Linear Relationship, Evidence from CIS Countries' M.A.Dissertation, Kyiv School of Economics. Kiev, Ukraine.

Singh, K., & Kalirajan, K., 2003, 'The Inflation – Growth Nexus in India: An Empirical Analysis', *Journal of Policy Modelling 23(2003)*, 377 – 396.

Smal,M.M., 1998, 'The Cost of Inflation', *SARB Quarterly Bulletin*, September, 34 – 4.

Snowdon, B. & Vane, H.R., 2005, *Modern Macroeconomics: Its Origins, Development and Current state*, Edward Elgar, Cheltenham, U.K.

Solow, R.M., 1956, 'A Contribution to the Theory of Economic Growth', *Quarterly Journal of Economics 70 (1),* 65 – 94.

Studenmund A.H. 2011, *Using Econometrics: A Practical Guide*, Pearson, USA, Boston.

Teshome, A. 2011, 'Sources of Inflation and Economic Growth in Ethiopia: Descriptive Analysis', *aiga forum web*, viewed 3 April 2012, from
http://www.aigaforum.com/articles/Inflation_and_Growth_Ethiopia_Part1.pdf.

Toda, H.Y, & Yamamoto, T., 1995, 'Statistical Inference in Vector Auto regressions with Possibly Integrated Process', *Journal of Econometrics 66(2)*, 225 – 250.

Urbain, J.P., 1992, 'On Weak Exogeneity in Error Correction Models', *Oxford Bulletin of Economics and Statistics*, 54(2), 187 – 207.

Utkulu U., 1997, 'How to Estimate Long-run Relationships in Economics: An Overview of Recent Approaches', *DEÜ IIBF Dergisi*, 12(2), 39 – 48.

Vaona, A., 2011, 'Inflation and Growth in Long Run: A New Keynesian Theory and Further Semi parametric Evidence', *Macroeconomic Dynamics* 16 (2012), 94 – 132.

Wolde-Rufael Y., 2008, Budget Deficits, Money and Inflation: The case of Ethiopia, *Journal of Developing Areas*, London Borough of Camden, 183 – 199.

Wooldridge J.M., 2002, *Introductory Econometrics a Modern Approach*, South-Western College, Cincinnati, OH.

Wooldridge J.M. 2009. *Econometrics*, Cengage Learning, New Delhi.

Xiaojing, Z., 2008, 'How Should China Handle Trade-offs between Growth and Inflation?'*, China Economist*, May 2008, 76 – 85.

Yap, J.T., 1996, 'Inflation and Economic Growth in Philippines', *Phillipine Institute for Development Studies Discussion Paper Series No. 96-11*, 1 – 26.