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MODELING INFLATION VOLATILITY AND ITS EFFECT ON ECONOMIC GROWTH IN ETHIOPIA

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ABSTRACT

Modeling Inflation Volatility and Its Effect on Economic Growth in Ethiopia

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Inflation volatility is a serious problem in the conduct of monetary policy. This is because it makes economic planning difficult, affects investment decision and hence growth. This study is aimed at modeling inflation volatility and analyzes its effect on economic growth in Ethiopia. The study uses quarterly data on Consumer Price Index (CPI) and Gross Domestic Product (GDP) for the period 1991/92-2010/11. To model inflation volatility as time varying process an extended form of GARCH (Generalized Autoregressive Conditional Heterosedasticity) model i.e. Threshold GARCH is used. The study finds strong evidence for the existence of Freidman-Ball hypothesis. TGARCH model is used to allow for asymmetric effect of positive and negative inflationary shocks and the result indicates strong asymmetric effect of inflationary shocks on inflation uncertainty. Cointegrated VAR model and granger causality test are also used to see the relationship between inflation, inflation uncertainty and growth. From the cointegrated VAR model the growth rate of GDP affects inflation positively in the long run and negatively in the short run. The granger causality result indicates that inflation granger causes inflation uncertainty positively and inflation uncertainty granger causes output growth negatively. To prevent the negative consequences of inflation including uncertainty problem National Bank of Ethiopia (NBE) should restore public confidence via credible policy instruments. Furthermore determining the threshold level of inflation-growth relationship is important to know the type of relationship that exists between growth and inflation.

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Table of Contents

List of Tables

List of Figures

List of Appendices

Acronyms and Abbreviations

AD-AS	Aggregate Demand-Aggregate Supply
ADF	Augmented Dickey Fuller
AIC	Akake's Information Criteria
ARCH-M	Autoregressive Conditional Heteroskedasticity-in-Mean
CPI	Consumer Price Index
CSA	Central Statistics Authority
CVAR	Cointegrated Vector Autoregressive
DF	Dickey Fuller
ECM	Error Correction Model
EDRI	Ethiopian Development Research Institute
EEA	Ethiopian Economics Association
FPE	Final Prediction Error
G-7	Group Seven Countries
GARCH	Generalized Autoregressive Conditional Hetroskedasticity
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
HQ	Hannan-Quinn Criteria
IFPRI	International Food Policy Research Institute
IFS	International Financial Statistics
IMF	International Monetary Fund

KPSS	Kwiatkowski Phillips, Schmidt and Shin
LM	Lagrangia Multiplier
MDGs	Millennium Development Goals
MoFED	Ministry of Finance and Economic Development
MPK	Marginal Productivity of Capital
NAIRU	Non-Accelerated Inflation Rate of Unemployment
NBE	National Bank of Ethiopia
NIC	News Impact Curve
OLS	Ordinary Least Square
OMO	Open Market Operation
PASDEP	A Plan for Accelerated and Sustainable Development to End Poverty
PP	Philip Perron
PPI	Producer Price Index
SAP	Structural Adjustment Program
SIC	Schwarz Information Criteria
TGARCH	Threshold Generalized Autoregressive Conditional Heteroskedasticity
UECCC-GARCH	Unrestricted Extended Constant Conditional Correlation-Generalized Autoregressive Conditional Heteroskedasticity
UK	United Kingdom
US	United State
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
WB	World Bank

I. INTRODUCTION

1.1 Background of the Study

Currently the aim of any developing country is to achieve sustainable economic development which demands achieving continuous economic growth. One of the preconditions for economic growth is macroeconomic stability.

The concept of macroeconomic stability has undergone through considerable changes. The period after World War II was dominated by the Keynesian thinking and for them macroeconomic stability meant a mix of external and internal balance, which in turn implied in the second case, full employment and stable economic growth accompanied by low inflation. In the mid seventies western countries shifted towards monetarist economic policy and inflation control become the most important goal of economic policy. Later the coming of new classical economists leads to the abandonment of monetarism in the early eighties. The new classical economists advocate the idea that the economy is always operating at full employment level and any form of expansionary policies will only generate inflation. (Saad, 2007)

Besides the different thinking among different school of thoughts about macroeconomic stability the major indicators of macroeconomic stability are inflation, unemployment rate, balance of payment and output growth. A distortion in any of these variables leads to macroeconomic instability. This paper focuses on the two indicators of macroeconomic stability i.e. inflation and output.

Inflation is one of the macroeconomic outcome variables and according to Mankiew (2006) "it is simply defined as an increase in the average price and the rate at which money is exchanged for a good or a service." Since early 1700 to 1930's unemployment was the main concern of economists. But, during the 1930's unexpectedly inflation has become a problem with the same intensity as that of unemployment in the earlier years. Thus since 1930's the problem of inflation attracted the attention of economists and policy makers.

There is a long history documenting a positive relationship between the level and variance of inflation. Friedman hypothesis (1977) explains that "a rise in the average rate of inflation leads to more uncertainty about the future rate of inflation, it distorts the effectiveness of the price mechanism in allocating resources effectively and thus it creates economic inefficiency and a lower growth rate of output." On the other hand, Cukierman and Meltzer hypothesis (1986) argument implies a positive casual effect from inflation uncertainty to inflation which is the reverse of Friedman hypothesis. One way or the other the two hypotheses demonstrate the fact that there is relationship between inflation and inflation uncertainty. In its simplest form, inflation uncertainty means unpredictability of the level of inflation.

Ethiopia, with a population of about 82 million, is the second-most populous country in Sub-Saharan Africa. One of the world's oldest civilizations, Ethiopia is also one of the world's poorest countries. At US$390, Ethiopia's per capita income was much lower than the Sub-Saharan African average of US$1,176 in FY 2010. (Robles, 2012)

The country has excreted its effort since 1992 to cope up with the world economy by introducing various trade liberalization and other related reforms. The first phase reform, the liberalization policy regime, undertaken during 1992/93-1994/95 included devaluation of birr, introduction of new interest rate structure, public expenditure rationalization, market liberalization, trade and price deregulation. In the second phase (1994/95-1996/1997), focus was given to the creation of fertile environment for labor-intensive growth, restricting government roles to selected economic activities, and enhancing private sector activity and investment (MoFED, 1998). In the third phase, the government has made a commitment to reduce poverty by engaging in a broad based economic growth within a stable macroeconomic environment.

The basic framework of the economy has been shifted towards pro-poor growth strategy beginning from 2000. "Pro-poor strategies require the public sector to induce, regulate and sustain the process of growth, target resources into priority sectors and those areas that can bring direct benefit to the poor and secure macroeconomic stability, including low inflation and high and stable level of employment" (Saad, 2005). Some of the steps taken from this time onwards include: A Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) (2005/06-2009/10) was launched and in 2010 Growth and Transformation Plan (GTP) was designed with the objectives: maintain at least an average real GDP growth rate of 11%, meet the Millennium Development goals, and achieve a structural change within the economy. (MoFED, 2010)

Different organizations such as World Bank Group in 2011 reported Ethiopia as one of the fastest growing economies in Africa but, they also pointed out that balance of payment and high inflation are the major macroeconomic problems in the country. For so

long, Ethiopia has been a low inflation country in Sub-Saharan-Africa. This is attributed to the fact of having strong currency, prudent monetary and fiscal policies (1960's - 1973), general price control (1974-1992) and implementation of economic reform and stabilization programs (1992-2004). (NBE, 2005)

In Ethiopian history adequate rainfall and good harvest are associated with low food and CPI inflation. This link seems to have been lost in 2004/05-2007/08 period since food inflation continued to accelerate despite good weather and agricultural harvest. Annual food inflation measured in simple growth rates, rose from 7.7% in 2004/05 to 14.0% in 2005/06 and it further accelerate to 18.8% in 2006/07(NBE, 2005/06). Though there was a slight decline in the level of inflation rate in the year 2009, it soared up further to a record level of 39.2% by the end of 2011(own computation based on CSA data).

In an effort to control inflation and the rising cost of living, the government has been taking various measures, such as imposing tight cash controls on government expenditure, temporarily introducing price caps on selected goods, increasing the salary of civil servants by 35-39 percent so as to reduce problems related to the cost of living and bank credit caps (EEA, 2011). Beside all these efforts inflation is continues to be the major threat of macroeconomic stability. So, controlling inflation and maintaining macroeconomic stability is not a matter of choice for Ethiopia, it must maintain higher growth with stability to achieve its long term needs. As a result, the primary purpose of this study is to model inflation volatility and analyze its effect on economic growth in Ethiopia beginning from the liberalization period 1991/92.

1.2 Statement of the Problem

One of the most difficult issues that monetary authorities in many developing economies have to deal with is the management of a stable price environment. This involves managing inflation and avoiding uncertainties associated with it. Countries with high average inflation also tend to have inflation rates that change greatly from year to year. Volatility in inflation rate has strong implication on macroeconomic stability. The Noble Laureate Engle (1983) argued "When inflation is unpredictable, risk averse economic agents will incur loss, even if prices and quantities are perfectly flexible in all markets. Inflation is a measure of the relative price of goods today and goods tomorrow; thus, uncertainty in tomorrow's price impairs the efficiency of today's allocation decisions"

Inflation uncertainty is considered as one of the major costs of inflation since it not only distorts decisions regarding future saving and investment due to lower predictability of the real value of future nominal payments, but it also extends the adverse affects of these distortions to the efficiency of resource allocation and the level of real activity (Fischer, 1981; Golob 1993 and Holland 1993).

Until recently, inflation in Ethiopia had been low relative to other sub-Saharan African countries with historic level of 21% in 1991- 1992, owing mainly to sever drought and political instability. Furthermore, inflation in Ethiopia was structural by nature; the rate of inflation has been low when the performance of the agricultural sector, the mainstay of the economy, is good and it was high during drought and famine periods and where there was war. However, the recent inflationary spiral has been unusual, in the sense that it has been steadily soaring and creeping up despite good harvest of agricultural produces.

During the 1997/98-2006/07 period, the average annual rate of food price inflation was 7.4% while non-food inflation stood at 4%. However, over the period 2002/03-2006/07 food inflation more than doubled (15.2%) and non-food inflation averaged 6.4%. (Alemayehu and Kibrome, 2008). There was however a slight decline in the general inflation rate in the year 2004 due to the recovery of agricultural production and general economic growth (Tehome, 2011). Though, the general inflation rate declined and even became negative in 2009 it accelerated in the year 2010. It was around 7.6 in January 2010 which further increased to 17.7% in January, 2011 and at the end of this year it has reached a record level of 39.2%, food inflation being 50.3% while non food inflation was 24.3%. (own computations using CSA data)

The inflation series in Ethiopia therefore, shows highly volatile characteristics and this plays a central role in determining inflation performance. Inflation volatility is in general considered as welfare decreasing because it impedes the allocative role of markets and deters agents from entering long-term contracts for the exchange of goods and services. In an open economy, it also increases the risk of capital flight, which is detrimental to domestic investment. A lack of price stability exerts harmful effects on the economy not only through changes in the price level but also through increased price level uncertainty. Thus, inflation volatility can impede growth even if inflation on average remains restrained. It is also mentioned in the GTP document how macroeconomic instability in general and inflation in particular could be a sever challenge for realizing the plan (IMF report, 2011).

The government has made different attempts to curb this problem and reduce inflation to single digit. Irrespective of the efforts made, however, the inflation rate is steadily

soaring. Furthermore having a volatile price has strong impact on different investment projects.

Ever since the emergence of inflation more focus has been given to the inflation rate, not to volatility of the series. But what makes matters even worst is its volatility now it has reached to a level those policy makers can hardly predict. Therefore, if these problems are not solved, the consequence is not only confined into a macro-economic sphere and a short-term period, rather, it will have persistent and adverse effect on sustainable development and poverty reduction activities, leaving the country highly dependent on foreign aid. It will also aggravate the problems that many families who are not currently secured in food are at constant risk of falling into extreme food poverty (MOFED, 2005). It will also accentuate the financial gap that is required to achieve MDG targets (Teferi, 2008). These will heavily cripple the country's endeavor to meet GTP by 2015 and join middle-income group by 2025. Therefore all the above facts are the motive to investigate this issue.

Many studies related to inflation had been done in Ethiopia notably, a study by Alemayehu and Kibrom (2008), Kibrom (2008), Loening et.al. (2009) and Teshome (2011) but the way they address or the methodology they use is more or less similar. In addition, most of them give emphasis to the inflation rate and its determinants not on analyzing its volatility or its effect on growth. Therefore, this paper is expected to add value on existing works by employing a different methodology that is TGARCH, which is a powerful method to address volatility issues.

1.3 Objectives of the Study

The overall objective of this paper is to examine the volatility of the inflation process and its implication on economic performance and in particular economic growth with the following specific objectives:

- To explore volatility clustering process
- To find out the responsible factors of volatility and its effects on economic performance
- To establish relationship between volatility, economic growth and inflation
- To find out whether volatility is a prerequisite for or is a consequence of economic growth

1.4 Scope of the Study

The aim of this study is confined to modeling inflation volatility and analyzes its effect on economic growth in Ethiopia. The study uses quarterly data of CPI and GDP for the period 1991/92-2010/11. This period was chosen because it is the time where liberalization started and more volatility on the inflation series is observed.

1.5 Significance of the Study

This research focuses on one of the highly controversial issues in the heart of economics. Though much study has been done in the topic being discussed, there is widespread difference among scholars on account of their differences in assumptions, theories and methodologies. This paper would thus be important on a number of its assumptions and analytic modeling style. This paper will be useful for Ethiopia in two important ways.

First, it will highlight whether the current macroeconomic stability policy taken by the country is worthy in reducing inflation. Second, the paper will highlight alternative stability options that create a fertile ground for the accelerated growth and sustainable development.

1.6 Organization of the Study

The remaining sections are sub divided into four sections. The next section deals with the review of theoretical and empirical literature that is relevant to the study. Section three presents some background information on the Ethiopian monetary policy and macroeconomic performance and section four deals with econometrics model specification and estimation. The last section deals with conclusion and policy recommendations based on major findings obtained from the analysis.

II. LITERATURE REVIEW

2.1 THEORETICAL LITERATURE REVIEW

2.1.1 Concept and Measurement of Inflation

Different economists define inflation in various ways. Milton Friedman writes "By inflation I shall mean a steady and sustained rise in price." Whereas, Samuelson puts it as "Inflation occurs when the general level of prices and costs is rising." Mankiew, define inflation as an increase in the average price and the rate at which money is exchanged for a good or a service.

In general, inflation can be defined as a **sustained or continuous** rise in the **general price** level or a sustained or continuous fall in the value of money. There are key terms in the definition of inflation. First, inflation refers to the movement in the general level of price not the changes in one price relative to other prices. Second, the prices are those of goods and services not asset. The third and most important thing is the rise in price has to be continuous over a long period of time. (Labonte, 2011)

Inflation measurement is the process through which changes in the prices of individual goods and services are combined to yield a measure of general price change (Lebow and Rudd, 2006). The common measures of inflation used to detect the extent of inflationary pressure include: Consumer Price Index (CPI), Producer Price Index (PPI) and GDP-deflator. CPI is expressed as the ratio of average prices currently paid by consumers to the average prices paid in a reference or base period. It takes the change in the price of consumer goods and services. On the other hand, PPI are used to estimate prices received

by domestic producers of goods at various levels of processing. It takes the change in the price of raw materials used by producers. The last one i.e. GDP deflator is the ratio of nominal and real GDP. CPI measures the change in the price of consumer goods and services assuming fixed basket of commodity and it also includes the change in the price of imported goods and services. But one of the major weakness of CPI is it doesn't include the change in the price of raw materials that are used by the producer. PPI address this problem but it only includes the price of raw materials. Whereas GDP-deflator takes only locally produced goods and services. Most studies use CPI to measure inflation because it represents the majority of economic actors i.e. consumers. (Mankiew, 2006)

2.1.2 Volatility: Measures and Empirics

In economics, in particular in the context of inflation, volatility refers to the degree to which inflation itself fluctuate with which there are clearly some periods of small fluctuations and periods of large fluctuations. This phenomenon is known as volatility clustering.

Volatility clustering is a property of most heterosedastic processes used in finance and economics as noted by Mandelbort (1963) that "large changes tend to be followed by large changes of either sign and small changes tend to be followed by small changes". In a nutshell, volatility in economics refers to a variable conditional variance of fluctuation (error terms) that measure uncertainty given a model and information set with which its unconditional variance is constant. Hence time varying heteroscedasticity occurred resulting in persistent volatility as it is not dying through time for a long period of time.

Some of the characteristics of volatility are that it is not directly observable, there exists volatility clusters (volatility may be high for certain time period and low for other periods), it evolves overtime in a continuous manner and it doesn't diverge to infinity.

Early approaches proxies inflation uncertainty by the moving standard deviation or variance of the inflation series, these studies measured inflation variability not uncertainty.

There are two broad classes of techniques available to measure uncertainty. These are ex-post versus ex-ante approaches. The first approach constructs uncertainty based on the historical data of the process that generates the random variables of concern. This group of methods includes the measures: nominal statistical variance, variance of the unpredictable part of a stochastic process, the conditional variance estimated from the GARCH type model. The ex-ante method mainly refers to the variance derived from survey data. (Olayinka and Hassan, 2010)

Engle (1982) introduced the ARCH methodology, a powerful method to address volatility issues. He used ARCH methodology to model U.K inflation for the period 1958-1977 using quarterly data. His model specification was as follows

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \alpha_2 \pi_{t-4} + \alpha_3 \pi_{t-5} + \alpha_4 r_{t-1} + e_t \quad \text{.....(2.1)}$$

$$h_t = \beta_o + \beta_1 (\gamma_0 e^2{}_{t-1} + \gamma_1 e^2{}_{t-2} + \gamma_3 e^2{}_{t-3} + \gamma_4 e^2{}_{t-4}) \quad \text{.....(2.2)}$$

Where 2.1 is the mean equation and 2.2 is the conditional variance equation. π_t is the inflation rate which is the difference of the log price index, r_{t-1} is the lagged value of real wage and h_t is a time varying conditional variance . The nature of the model is such that

increase in the previous period's real wage increases current inflation rate. Lagged inflation rates at t-4 and t-5 are intended to capture seasonal factors. In testing for ARCH errors, the Lagrange multiplier test is used. In his analysis ARCH (1) errors was not significant whereas, the test for ARCH (4) effect found to be significant. The rationale for choosing two-parameter variance function in equation 2.2 was to ensure the non negativity and stationarity constraint that may not be satisfied using an unrestricted estimating equation. The necessary and sufficient conditions for the two constraints (i.e. non negativity and stationarity) to be satisfied are $\beta_0 > 0$ and $0 < \beta_1 < 1$ (Enders, 1995). Three key properties of ARCH process are volatility clustering, fat tailed unconditional distribution and reduction of those fat tails under temporal aggregation (Francis X, 2004).

Bollerslev's (1986) develop the GARCH methodology which allows the measurement of inflation uncertainty by the conditional variance of the inflation series. GARCH is a method for extracting volatility and capture risk in each period more sensitively than the simple rolling standard deviation, which gives equal weight to correlated shocks and single large outliers. (Adamgbe, 2004)

According to Bollerslev's, ARCH procedure is useful in modeling different economic phenomena. But it uses an arbitrary linear declining lag structure in the conditional variance equation since estimating a totally free lag distribution often lead to the violation of the non-negativity constraints. Bollerslev tries to overcome the non-negativity constraint by introducing the lagged value of the variance in the conditional variance equation. The generalized ARCH (p,q) model i.e. GARCH (p,q) allows for both autoregressive and moving average components in the heteroskedastic variance. Where, p indicates the order of ARCH process and q the order of GARCH process. Bollerslev

estimated the volatility of inflation process in US for the period 1948-1983 using quarterly data and his estimation was as follows:

GARCH (1, 1)

$$\pi_t = \mu_0 + \mu_1\pi_{t-1} + \mu_2\pi_{t-2} + \mu_3\pi_{t-3} + \mu_4\pi_{t-4} + e_t \quad \text{.....2.3}$$

$$h_t = \eta_o + \eta_1 e^2_{t-1} + \eta_2 h_{t-1} \quad \text{.....2.4}$$

Where 2.3 is the mean equation and 2.4 is the conditional variance equation (Enders, 1995)

2.1.3 The Theoretical Relationship between Growth and Inflation

There are different economic theories to ascertain consensus on the inflation-growth relationship. Classical economics uses supply side theories, which emphasized the need for incentives to save and invest if the nation economy is to grow. Whereas, Keynesian theory provides AD-AS framework to link inflation and growth. Monetarism on the other hand emphasized on the critical role of monetary growth in determining inflation. Other theories such as neo classical and endogenous growth theories suggest that inflation affects growth through its impact on investment and capital accumulation.

A. Classical Growth Theory

The founder of this growth theory was Adam Smith. Smith argued that growth was self reinforcing and exhibited increasing return to scale. The classical growth theory viewed saving as a creator of investment and hence growth. The link between the change in price level (inflation) and its "tax" effect on profit and output were not specifically articulated in this growth theory. But the relationship between the two variables is implicitly

suggested to be negative as indicated by the reduction in firms profit level through higher wage costs (Gokal and Hanif, 2004)

B. Keynesian Theory

According to this theory, in the short run, the aggregate supply curve (AS) is upward sloping rather than vertical. Had the AS curve been vertical, changes on the demand side of the economy affects only prices but since it is upward sloping, changes in aggregate demand (AD) affects both price and output (Dornbusch et.al, 1996). Here, there are many factors that affect the inflation rate and the level of output in the short run. These include change in expectations, labor force, price of other factors of production, monetary policy and fiscal policy. When moving from short run to the hypothetical long run, the above listed factors and their shocks on the steady state of the economy is assumed to balance out. The dynamic adjustment of the short run aggregate demand and aggregate supply curve yields an adjustment path which exhibits an initial positive relationship between inflation and growth, but later its effect turns out to be negative. Under this model there is a short run tradeoff between output and the change in inflation but no permanent tradeoff between them. (Gokal and Hanif, 2004)

C. Monetarist Theory

Milton Friedman, who coined the term "Monetarism", mentioned several key long run properties of the economy including the quantity theory of money and the neutrality of money. The first theory linked inflation and growth by equating the total amount of spending in the economy to the total amount of money in existence. The second theory i.e. neutrality of money took place when the equilibrium values of real variables

including the level of GDP are independent of the level of money supply in the long run. If the neutrality of money holds then inflation will be harmless. In general monetarist suggest that in the long run prices are mainly affected by the growth rate of money, while having no real effect on growth and if the money supply growth is higher than the economic growth, then inflation will occur (Grauwe and Polan, 2005).

D. Neo-Classical Theory

The earliest neo classical theory was postulated by Solow (1956) and Swan (1958). Mundell (1963) was the first to articulate a mechanism relating inflation and output growth separate from the excess demand for commodities. According to his explanation an increase in inflation or inflation expectations immediately reduces people's wealth by making the rate of return on individuals real money balance to fall. A fall in real money balance will have an effect on growth through its effect on saving and interest rate. (Seleteng, ,2005)

Tobin (1965) is another neo classical economist who developed further Mundell's model in making money as a store of value in the economy. Individuals in this model substitute current consumption for future consumption by either holding money or acquiring capital. According to this model, when inflation increases the return to money falls this induce people to substitute money (which has low return) with capital. This shift results in a higher steady state of capital stock which increases the level of output. However, the effect on output growth is temporary. The impact of inflation on growth can be classified as a "lazy dog effect" where it induces greater capital accumulation and higher growth only until the return on capital falls.

Sidrauski (1967) proposed that an increase in the inflation rate doesn't affect the steady state capital stock. As a result, neither output nor economic growth is affected. In contrast Stockman (1981) developed a model in which an increase in the inflation rate results in a lower steady state level of output and a decline in people welfare. He considered money as complimentary to capital. According to his explanation, inflation erodes the purchasing power of money balance; people reduce their purchasing of both consumption and capital goods which leads the steady state level of output to fall.

In general the theoretical view of neoclassical school can yield different results with regard to inflation-growth relationship. An increase in inflation can result in higher output (Tobin effect) or lower output (Stockman effect) or no change in output (Sidrauski).

E. Neo- Keynesian

It emerged from the ideas of Keynesianism and one of the major developments of neo Keynesian was the concept of 'potential output' or natural rate of output. This is the level of output when the economy is operating at optimal level of production, given the institutional and natural constraints. This level of output also corresponds to the natural rate of unemployment or non-accelerating Inflation rate of unemployment (NAIRU)[1]. According to this theory, inflation depends on the level of actual output (GDP) and the natural rate of unemployment. First, if GDP exceeds its potential and unemployment is below the natural rate of unemployment, inflation will increase as suppliers increase their

[1] It is the unemployment rate at which the inflation rate is neither rising nor falling

price and built in inflation[2] worsen. Second, if the GDP falls below its potential level and unemployment is above the natural rate of unemployment, inflation will decelerate as suppliers reduce price as there will be excess capacity and this undermine built in inflation. The final case is when GDP is equal to its potential and unemployment rate is equal to NAIRU, then the inflation rate will not change as long as there is no supply shocks (Gokal and Hanif, 2004).

F. Endogenous Growth Theory

This growth theory describes economic growth which is generated by factors generated within the production process. In the endogenous growth theory, the growth rate depends on one variable; the rate of return of capital. Variables like inflation reduce the rate of return of capital which in turn reduces capital accumulation and growth. In the neo classical model discussed previously the return on capital declines as more capital is accumulated. While in the endogenous growth models per capita output continues to increase because the return on capital doesn't fall below a positive lower bound. Another form of capital i.e. human capital was later included in the endogenous model. The effect of inflation on the two forms of capital was negative. An inflation tax on capital income directly reduces the growth rate while a tax on human capital could cause labor to leisure substitution which lowers the rate of return on human capital and can also lower growth rate. (Gokal and Hanif, 2004)

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[2] Built-in inflation is often linked to the price/wage spiral because it involves workers trying to keep their wages up with prices and then employers passing higher costs on to consumers as higher prices as part of a vicious circle.

2.1.4 The Link between Inflation, Inflation Uncertainty and Growth

In its simplest form, inflation uncertainty means unpredictability of the level of inflation. In the 1970s, most studies defined inflation uncertainty as simply the variance of observed inflation. An obvious criticism of this approach is that an increase in the variance of inflation does not imply a corresponding rise in inflation uncertainty, if available information allows agents to predict some of the increased volatility. However, recent studies measured inflation uncertainty using proxies obtained from either forecasters' estimates or models of inflation. (IMF, 2010)

Though knowing the exact relationship between inflation, inflation uncertainty and growth is a controversial issue some of the hypotheses in the area are presented as follows:

Friedman hypothesis (1977) argues that a rise in the average rate of inflation leads to more uncertainty about the future rate of inflation. Furthermore, inflation uncertainty distorts the effectiveness of the price mechanism in allocating resources effectively and thus it creates economic inefficiency and a lower growth rate of output. When the level of inflation is high, policy makers will be reluctant to disinflate because of the recessionary effect of contractionary monetary policy. This makes future monetary policy unpredictable hence uncertainty about the future level of inflation rises. In addition, inflation uncertainty by affecting interest rates, also impacts on the intertemporal allocation of resources. Therefore, an empirical study that test for the real effect of inflation should control for the impact of inflation uncertainty on output.

Cukierman and Meltzer hypothesis (1986) employed a Barro and Gordon (1983) setup, where agents face uncertainty about the rate of monetary growth and therefore inflation. In the presence of this uncertainty, the policy maker applies expansionary monetary policy in order to surprise the agents and enjoy output gains. This argument implies a positive casual effect from inflation uncertainty to inflation and has been dubbed as the Cukierman-Meltzer hypothesis by Grier and Perry (1998).

Dotsey and Sare (2000) showed that more inflation uncertainty can have a positive output effect. According to the authors, an increase in the variability of monetary growth and therefore inflation makes the return to money balance more uncertain and leads to a fall in the demand for real money balance and consumption. Hence, agents increase precautionary saving and the pool of funds available to finance investment increase. This leads to an increase in the level of output.

Holland (1995) explained that the monetary authorities when faced with more inflation uncertainty in the economy will contract the growth rate of money supply and hence reduce inflation and the associated inflation uncertainty in order to counteract the negative welfare effect of inflation uncertainty on the economy. So, if inflation causes inflation uncertainty there is also a feedback effect from inflation uncertainty to inflation because the stabilization effort of monetary authorities. This is the so called 'Stabilized Fed hypothesis' and postulates a negative effect of inflation uncertainty on inflation.

Ball (1992) analyzed an asymmetric information game where the public face uncertainty regarding the type of policy maker in office. Two types of policy makers are considered: a weak type that is unwilling to disinflate and a tough type that bears the cost of

disinflation. The policy makers alternate stochastically in office. When current inflation is high, the public faces increasing uncertainty about future inflation as it is not known which policy maker will be in office the next period and consequently what the response to the high inflation rate will be (i.e. what the money supply growth will be). Such an uncertainty doesn't arise in the presence of low inflation rate. It's also possible that more inflation will lead to lower level of inflation uncertainty. On the other hand, Pougerami and Maskus (1987) explained that in the presence of rising inflation agents may invest more resources in forecasting inflation, thus reducing uncertainty about inflation.

2.2 EMPIRICAL LITERATURE REVIEW

2.2.1 Cross Country Literatures

There are many studies done on the effect of inflation volatility on output but the results are not consistent. Certain studies support a negative association between them Brunner (1993) Ungar and Zilberfarb (1993) argued that increased output growth could lead to higher inflation but lower inflation uncertainty. On the other hand, Stockman (1981) showed that anticipated inflation reduces the demand for real balance, implying that the demand for capital and output growth decrease. This section of the literature review presents some empirical findings on modeling inflation volatility and its relationship with inflation and growth.

Ruth Judson and Athanaios Orphanides (1996) using panel data for the period 1959-1992 indicate that first; inflation volatility is robustly and significantly negatively correlated with income growth across level of inflation, time and type of country. Second, the level of inflation is significantly negatively correlated with growth but apparently only for

inflation levels higher than 10% per year. Third, the level of the volatility of inflation appears to have independently significant influence on growth. They concluded their work by arguing that high inflation is detrimental for growth and volatile inflation is associated with lower growth at all levels of inflation.

Rizvi and Naqvi (2009) tried to model the inflation process by taking a sample of ten Asian countries. They use quarterly data of inflation from 1987Q1-2008Q4 and apply symmetric and asymmetric GARCH specification. Their result shows that the leverage parameter obtained from TGARCH (Threshold Generalized Autoregressive Conditional Heteroscedasticity) has the expected sign and is significant for almost all countries suggesting strong asymmetry in inflation volatility.

Hakan Berument et.al (2001) using Turkish data for the period 1986-2000 applied asymmetric GARCH (exponential GARCH) method to model inflation uncertainty. Their results indicate that in Turkey the effect on inflation uncertainty of positive shocks to inflation are greater than that of negative shocks to inflation. Furthermore, when monthly dummies are used in modeling both inflation and inflation uncertainty the effect of lagged inflation on inflation uncertainty disappears which indicates that there is no significant effect of lagged inflation on inflation uncertainty.

Conrad and Karanasos (2008) employ the UECCC-GARCH (Unrestricted Extended Constant Conditional Correlation- GARCH) model to investigate the inflation-growth uncertainty link using US monthly data for the period 1960: 01-2007: 12. The main advantage of this new specification is that it allows for volatility feedback of either sign i.e. positive or negative. They reached at two major findings. First, real volatility affects

nominal uncertainty negatively, as predicted by Friedman (1997). Second, there exist strong evidence supporting the Logue and Sweeney (1981) theory that inflation uncertainty has a positive impact on the volatility of growth.

Bruno and Easterly (1996) suggested that the power of growth-inflation relationship in the empirical long run growth literature seems to be coming from the short run rather than the long run. They found a negative short run relationship between inflation and growth. Recent empirical studies suggest that for industrial countries the threshold level of inflation above which inflation significantly slows growth is estimated at 1-3%.

Faria and Carneiro (2001) tried to establish a relationship between inflation and growth using monthly data for the period Jan 1980- July 1995 for the Brazilian economy. The authors used a bivariate time series model based on Blancharad and Quay (1989). This methodology allows one to assess the effects of temporary and permanent shocks in a bivariate VAR model. Their first finding indicates a zero long run response of output to a permanent inflationary shock supporting Sidrauski's (1967) super neutrality of money in the long run. However, in the short run inflation has negative impact on growth.

Empirical evidence by Nicholas Apergis (2003) using a panel data for G-7 countries indicate that inflation uncertainty causes a negative output growth implying the acceptance of Friedman hypothesis. The results are similar to those reached by Grier and Perry (2000). Output growth seems to cause inflation uncertainty in a positive manner through a short-run Philips effect, implying again the Friedman's hypothesis.

Different empirical works have been conducted to analyze the welfare effect of inflation uncertainty. The empirical work of Fountas and Karanasos (2007) on G-7 countries found

strong evidence about Friedman's hypothesis i.e. (increasing uncertainty about inflation distorts the effectiveness of the price mechanism in allocating resources efficiently, thus leading to negative output effects) for Japan and there is weak evidence for Canada and UK. Hence, inflation uncertainty is quite costly in terms output for Japan and somewhat costly for Canada and UK.

Grier and Perry (2000) use monthly data for 1948Q7-1996Q12 for the US and test the effect of inflation uncertainty on output. Their result confirms the fact that inflation uncertainty reduces output growth.

Judson and Orphandies (1999), using cross-country panel data from 1959 to 1992 for 119 countries, found that both inflation and inflation uncertainty lower growth. On the other hand, Herrero and Vilarrubia (2005) offer support to an inverted U-shaped relationship between real volatility and growth. Using a set of more than 100 countries during the period 1978-2002, they find evidence that a moderate degree of volatility is growth improving while high volatility is detrimental for growth.

Chang and He (2010) examined the effect of inflation uncertainty on output growth as a function of the rate of inflation. They employ a bivariate Markov regime switching model for the US economy for the period 1960Q1-2003Q3 and demonstrate that nominal uncertainty inhibits growth in both low and high inflation regimes.

Erbaykal and Okuyan (2008) examined the relationship between inflation and economic growth in Turkey using data covering the period 1987:1-2006:2. The existence of a long term relationship between these two variables was examined using "Bound Test" developed by Pesaran et al. (2001), and the existence of a cointegration relationship

between the two series was detected following the test result. Whereas no statistically significant long term relationship was found but, there was a negative and statistically significant short term relationship. The causality relationship between the two series was examined in the framework of the causality test developed by Toda Yamamoto (1995). Whereas no causality relationship was found from economic growth to inflation, a causality relationship was found from inflation to economic growth.

Chimobi (2010) tried to see the relationship between inflation and economic growth in Nigeria for the period 1970-2005. Consumer Price Index (CPI) and Gross Domestic Product (GDP) were taken as a proxy for inflation and economic growth, respectively. To ascertain the relationship between the two variables Johansson's co integration test was carried out. But the result obtained from this estimate fails to find cointegration relationship or long run relationship during the investigated period.

2.2.2 Studies in Ethiopia

Though studies that relate volatility of inflation and economic growth in Ethiopia are scanty, there are some works done on the source of inflation and its effect on economic growth.

An empirical investigation by Teshome (2011) on the source of inflation and economic growth in Ethiopia tries to come up with some results using descriptive analysis. According to the author, before 2004 Ethiopian market condition was characterized by demand deficiency. However starting from 2004 onwards, demand continues to increase at an increasing rate leaving aggregate supply behind. This lead to excess demand and he

concluded that the Ethiopian inflation is a demand pull, the one arising from excess demand.

A study by Alemayehu and Kibrom, (2008) tried to identify factors responsible for the soaring inflation in Ethiopia for the period 1994/95-2007/08 by applying VAR methodology. According to them, the most important determinants of inflation in the long run are mainly domestic monetary development while cost push factors are the forces behind short run inflation. They conclude their work by recommending the use of conservative monetary and fiscal policy to lower the inflation rate and increasing the credibility of monetary policy to solve problems with expectation. They also mentioned that announcing targets on important macroeconomic variables and adhering to the target can be another solution.

Loening *et.al.* (2009) made an investigation on the behavior of Ethiopian inflation for the period 1999-2008 using monthly data. They used error correction model to identify the factors affecting overall inflation and its major components i.e. cereals price, food price and non-food prices. Their finding showed that, in the long run, domestic food and non food prices are determined by exchange rate and international food and goods prices. Whereas in the short to medium run, agricultural supply shocks and inflation inertia strongly affect domestic inflation, causing large deviations from long run price trends. Finally, they suggest that there is a need for exchange rate and monetary policies to take in to account the cereal sector as food staple growth is among the key determinants of inflation.

Andinet (2008) showed the welfare impact of inflation on the urban population. According to his explanation the primary victims of inflation particularly, food price inflation are the urban poor and wage earners. This is indicated by an increase in the Gini coefficient in urban areas from 0.34 in 1995/96 to about 0.43 in 2004/05 whereas it remains unchanged for the case of rural population. He also substantiates his argument by measuring the price elasticity of major cereals like teff and wheat whose elasticity lies below one, which confirms the fact that they are necessary items. In the case of Ethiopia, 63% of daily calorie requirement is contributed by cereals consumption and a rise in the price of these items leads to starvation and malnutrition. He concluded his work by recommending setting of regular wage indexation as a way out of the problem.

Abdualaziz's (2008) empirical investigation entitled "The Short run and Long run Dynamics of Money Supply, Output and Price level in Ethiopia" investigated the long run neutrality of money. The analysis was made for the period 1964-2005 using quarterly data. The author used Co integrated Vector Autoregressive (CVAR) model to assess the short run and long run dynamics. The CVAR approach suggests long run path of output has been independent of the monetary shocks. But money stock is found to have a significant effect on long run aggregate price level.

As can be seen from above, most of the literature related with inflation tries to see the sources of inflation. They neither dealt with its uncertainty and volatility nor with its effect on economic growth. It is to this end that this study finds it worthwhile investigating the effects that inflation uncertainty would have on economic growth in Ethiopia.

III. Overview of Ethiopian Monetary Policy and Macroeconomic Performance

3.1 Framework of Ethiopian Monetary Policy

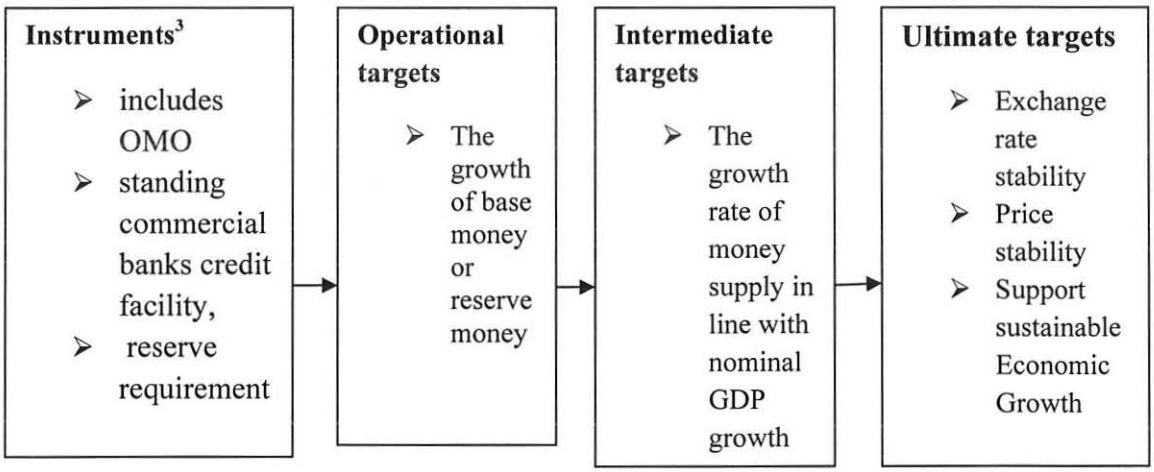
Monetary policy refers to the government regulation of the money supply and the level of interest rate. It is executed by the central bank, either in its capacity as a regulator of the financial sector or through its participation in OMO (Open Market Operation) and government deficit financing. Monetary policy is important because it influences the level of output, employment and the rate of economic growth. (Saad , 2007)

In Ethiopia, the National Bank of Ethiopia (NBE) as the central bank of the country is given the responsibility of formulating and conducting monetary policy. According to proclamation number 591/2008 the main purpose of NBE is to maintain stable rate of price and exchange, to foster a healthy financial system and undertake other related activities conducive to rapid economic development. Some of the specific objectives of NBE includes; maintaining single core digit inflation and keeping the exchange rate of birr close to the equilibrium exchange rate.

The NBE has also its own ultimate or final target, intermediate target and operating target. The final targets of monetary policy in Ethiopia are to maintain price and exchange rate stability and support sustainable economic growth. Whereas, intermediate targets includes those variables that affect the ultimate objectives of monetary policy but are not under the direct control of NBE. Most commonly used intermediate targets include monetary aggregates such as money supply or some credit aggregates and

exchange rate. The current target is to ensure that the money supply growth is in line with nominal GDP growth rate (NBE, 2009). The use of monetary aggregates as an intermediate targets is due to the assumption that there is a predictable relationship between money supply and inflation, which is the final objectives of monetary policy. While using exchange rate as intermediate targets, the bank pegs the nominal exchange rate to the currency of a country with low inflation. The advantage of an exchange rate target is that it provides a clear and easily monitored anchor for price expectation; however, this kind of targeting severely limits the independence of monetary policy as the pursuit of other objectives using monetary policy would be restricted, and furthermore, it requires maintaining fiscal discipline. (EEA, 2011)

Figure-3.1 Framework of Ethiopian Monetary Policy



Source: NBE report (2009)

[3] Reserve requirement is the most important policy instrument used and in addition Treasury bill and credit facilities are also used as an instrument. However, OMO is not currently in use.

On the other hand operating targets are variables that are under the control of the NBE. The operating targets of monetary policy include reserve money targets and short term interest rate targeting. As IMF (2005) cited in EEA (2011) in underdeveloped financial markets setting a reserve money targets may be preferable option as linkage between short term rates and monetary aggregates and inflation is not clearly understood.

"The operational target is an economic variable that the central bank wants to influence, largely on a day-to-day basis, through its monetary policy instruments. They can be used to link instruments of monetary policy to intermediate targets set by the central bank and represent the first impulse in the transmission process of monetary policy"(NBE, 2009:3) The growth of base money/reserve money[4] is being used as operational target of the National Bank of Ethiopia.

3.1.1 Monetary Policy Instruments

On broad bases, we can classify monetary policy instruments as direct and indirect. A direct monetary policy instrument involves giving instructions to commercial banks on their deposit and lending activities. Most of the time they are effective but their drawbacks are they create distortion in the economy, financial repression and financial disintermediation. Whereas, an indirect monetary instruments involves the uses market based instruments to affect commercial banks liquidity. Some of the direct monetary policy instruments include direct lending, administratively set interest rate and bank-by-bank credit ceiling. Whereas, indirect monetary policy instruments include reserve requirements, OMO (Open Market Operation), central bank standing deposit and lending

[4]. Reserve money (Base money) is defined as the sum of currency in circulation and deposits of commercial banks at NBE

facilities (EEA, 2011). These instruments are helpful to inject or absorb liquidity in the financial system.

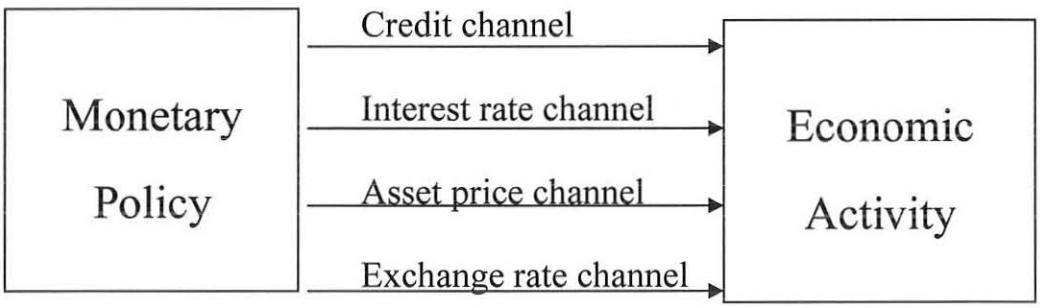
Reserve requirement is a major policy instrument used by NBE. The bank imposes reserve requirement on commercial banks. This instrument is effective in curtailing banks' lending activity. The reserve requirement was 5% before 2007 but later it was raised to 10% during this year and latter to 15% in April 2008. The NBE also imposes liquidity requirement ratio and the prevailing liquidity ratio is 25% (Ibid: 168-178).

The NBE can't use OMO (Open Market Operation) as there is no secondary market in the country. The Treasury bill is the only active primary market in the country and also used by NBE as a monetary policy instrument. Government offers 28 days, 91 days and 182 day bills. In general, some of the instruments used and to be used by NBE specifically includes OMO, standing commercial banks credit facility, reserve requirement, use of selected credit control when necessary, and moral Suasion (NBE, 2009).

3.1.2 Transmission Mechanism of Monetary Policy

Another aspect of monetary policy is the transmission mechanism which refers to the process that links monetary policy actions to the ultimate objectives of monetary policy.

Figure-3.2 Transmission Mechanisms of Monetary Policy



Source: EEA (2011)

The transmission channels in which monetary policy can affect real economic activity includes the credit channel, the interest rate channel, the exchange rate channel and the asset price channel.

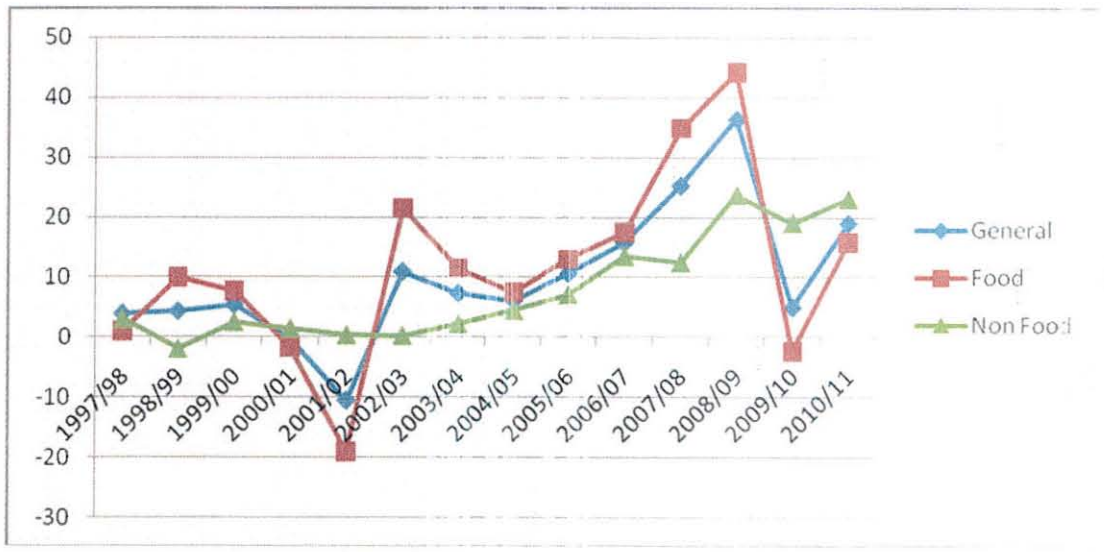
In the case of the interest rate channel an increase in money supply lowers the real interest rate, which in turn stimulates investment and therefore GDP (Christensen, 2011). The asset price channel also requires the existence of secondary market for equities and real estates. In the case of Ethiopia there exists no secondary market as a result this channel is not currently in use. The exchange rate channel affects economic activity through its effect on interest rate. When money supply increases nominal interest rate decreases and this in turn implies a decrease in real interest rate. When this takes place the dollar denominated assets are less attractive which leads to a decline in the demand

the dollar denominated assets are less attractive which leads to a decline in the demand for dollars or depreciation. It is known from theory that depreciation makes domestic goods cheaper and increase net export which is positively correlated with GDP (Akila, 2005). Finally the credit channel works through banks lending activity to the private sector which affects investment and hence growth. In the case of Ethiopia the interest channel, the exchange rate channel and the credit channel are used. However, underdevelopment of financial market has got serious effect on the effectiveness of these transmission channels.

3.2 Price Development

Price development in most cases is used as a proxy for macroeconomic stability. In a situation where the general price level is continuously rising it is very difficult to maintain macroeconomic stability.

Figure 3.3 Annual Inflation Rate: (1997/98-2010/11)



Source: ***Constructed based on data obtained from CSA***

In the early 1990's Ethiopia was characterized as a low inflation country. High level of inflation was recorded in 1991/92 which was around 21%. This high rate of inflation was observed because of severe drought and instability. For the remaining years the inflation rate was low and even negative for some years. For instance the inflation rate was 2.2% in 1996/97 and -0.1% in 1997/98. In the year 2001/02 the country experience a deflation of -7.2% due to a decline in food price associated with bumper agricultural production following the good weather condition (NBE, 2004/05). The fall in the price of agricultural prices had adverse impact on farmer's incentives to produce more crops. However, credit availability and government involvement in purchasing some agricultural surplus at pre set higher prices helped farmers to curb the problem of seasonal fall in agricultural prices during this time. (EEA, 2011)

The decline in price in 2002 peaked up to 15.1% in 2002/03. The inflation rate further increase and reached a record level of 18.6 in October 2003. Though there was a slight decline in 2003/04 it continues to rise again in 2004/05. In 2005/06 general inflation reached a record level of 12.3%, food inflation 14.0% and core inflation as proxied by non food price 8.0% from their previous level of 6.8%, 7.7% and 5.2% in 2004/05. The increase in core inflation was basically due to an increase in the house rent, price of construction materials, water, fuel etc. In 2006/07 all the three indicators of inflation i.e. general, food and core inflation continued to increase.

However, in 2007/08 though the year-on-year[5] basis annualized inflation and food inflation increases core inflation showed a slight decline from 15.2 % (in 2006/07) to

[5] Annualized means 12 month average of CPI

about 12.5 % (in 2007/08). This might be due to a drop in the rate of inflation in house rent, construction materials, portable water and fuel, electric power, communication which jointly constitutes 55.6% of non-food inflation. The annualized headline inflation at the end of 2009/10 was 2.8% which was 33.6% point lower than 2008/09. This was largely because of the slowdown in the prices of food items. During the same year annualized food inflation dropped to -5.4% due to a significant decline in the price of cereals, bread and prepared food, potatoes, pulses and oil and fat (NBE, 2008/09).

Furthermore the action taken by the NBE in 2009/10 to exercise tight monetary policy through instruments particularly direct credit ceiling and reserve requirement also contributed in reducing the inflation rate during this year. The national bank devalued the birr against US dollar by about 17%, the government has increased the salary of civil servants by more than 1/3, the government also imposed price cap on basic commodities which was believed to have been distortionary as the slight decline in inflation rate increase again as can be seen from a month to month general inflation in May 2011 to 34.7%. (EEA, 2011)

3.3 Trends in Monetary Aggregates and Inflation

The relationship between growth and money was not a concern before 1990s in Ethiopia. This is due to the fact that first, large portion of the economy is non-monetized and second output and growth has been largely dedicated by natural factors such as rainfall. However, following the Structural Adjustment Policy (SAP) of early 1990's any surge in money supply was viewed to simultaneously trigger inflation. EEA (2011)

The table below indicates the growth rate of broad money and its components for the period 2000/01-2009/10.

Table-3.1 Growth Rates in Broad Money and its Components (2000/01-2009/10)

	2000/01-2004/05	2005/06-2009/10	2005/06	2006/07	2007/08	2008/09	2009/10
Net foreign assets	32.1	19.1	-12.7	10.2	-12.5	70.4	40.4
Domestic credit	10.5	21.3	22.3	25.5	29.3	12.0	17.6
Claims on government	9.4	10.1	16.6	20.1	9.0	0.7	4.2
Claims on non government*	13.3	30.9	28.9	31.1	48.8	19.9	25.6
Other items(net)	16.9	16.1	7.6	23.3	26.5	9.5	13.4
Broad Money	**13.2**	**21.0**	**15.3**	**22.2**	**20.4**	**22.8**	**24.3**
Narrow money	11.6	19.6	11.8	24.4	19.4	21.9	20.6
Currency in circulation	14.2	19.2	13.9	20.0	28.8	11.6	21.6
Demand deposits	9.5	20.3	10.0	28.4	11.2	32.2	19.8
Quasi money	15.2	22.5	19.3	19.8	21.4	23.8	28.2

*it includes public enterprises.

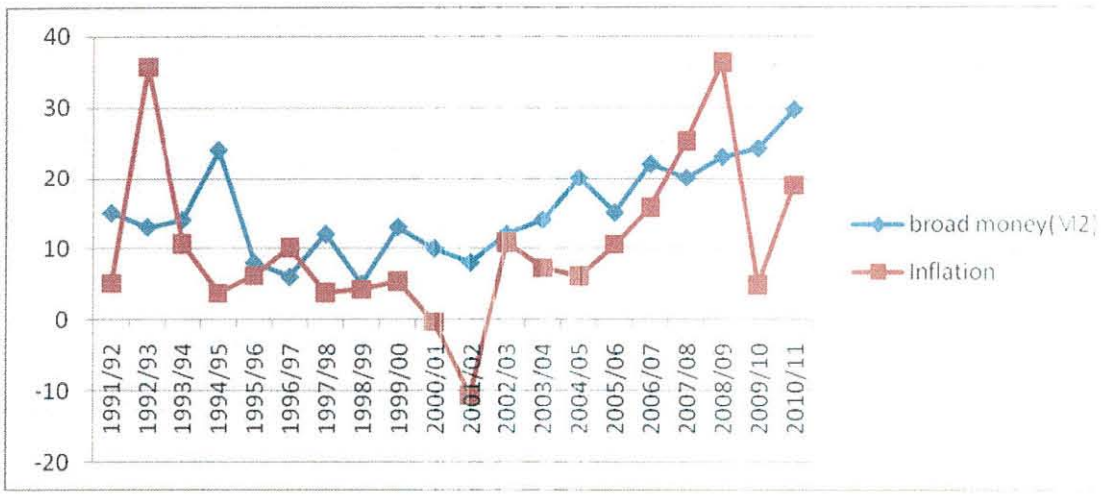
Source: EEA/EEPRI computations using data from NBE.

From the above table we can see that domestic liquidity as measured by broad money (M2) relatively show high growth rate in the year 2009/10. The growth in net foreign asset and domestic credit contributed to the highest growth rate recorded. It can also be seen that credit given to the government is declining and offset by credit to the non-

government (the private sector). The decrease in government borrowing from banks is expected to reduce inflationary pressure.

The lowest growth rate in broad money was recorded during the period 2000/01-2004/05 and the highest in 2009/10 as mentioned above. During the fiscal year 2009/10 the level of quasimoney, that comprises savings and time deposits, reached a recorded level of 28.2%. This may be associated with improved financial intermediation as banks started extending their branches. The growth rate of broad money also increases from 24.3% in 2009/10 to 29.65% in 2010/11.

Figure- 3.4 Trends in Inflation and Broad Money (1991/92-2010/11)



Source: Constructed based on data from NBE and CSA

As can be seen from the graph the trend of broad money and inflation tends to flow in a similar manner. The trend in broad money though indicates a fluctuating trend; it shows a continuous increment after the period 2001/02. Whereas, the trend in inflation beside having a fluctuating trend and being volatile, it's generally increasing. The year 2008/09 marked as a year in which both inflation and broad money shows high growth rate. In the year 2009/10 the rate of inflation slowed down due to measures taken by the NBE.

However it further swung up in 2010/11 due to the distortionary effect of the measures taken in 2009/10. The money supply also grew from 24% to 29%.NBE (2009/10)

3.4 Economic Growth

One of the final targets of the National Bank of Ethiopia is securing sustainable economic growth. The economy of the country was growing on average by 2.7% for the period 1960/61-1991/92. However from this time onwards the growth rate is increasing despite having a fluctuating trend. The growth performance of the economy is attributed to its components i.e. agriculture, industry and service sector. Agriculture includes crop, livestock and hunting, forestry and fishing. Industry includes mining and quarries, manufacturing, electricity, gas and water. The service sector includes trade, hotels and restaurants, transport and communication, public administration and defense, education, health and social works and related. (Catherine Dom, 2009)

Table-3.2 Growth Rates of GDP

Period	Agriculture	Industry	Service	GDP	Percapita GDP
1960/61-2009/10	1.87	3.83	4.91	2.96	0.04
1960/61-1973/74	2.10	7.04	7.47	3.60	1.33
1974/75-1990/91	0.06	3.60	3.41	1.75	-0.07
1991/92-2009/10	4.14	7.16	8.42	6.09	3.28
1991/92-1999/00	2.11	6.38	7.99	4.59	1.78
2000/01-2004/05	5.55	8.20	6.70	6.22	3.42
2005/06-2009/10	8.37	10.01	14.33	11.01	8.21
2008/09	6.36	9.67	13.97	10.05	7.25
2009/10	7.63	10.58	13.04	10.41	7.61

Source: EEA/EEPRI computations using data from MoFED.

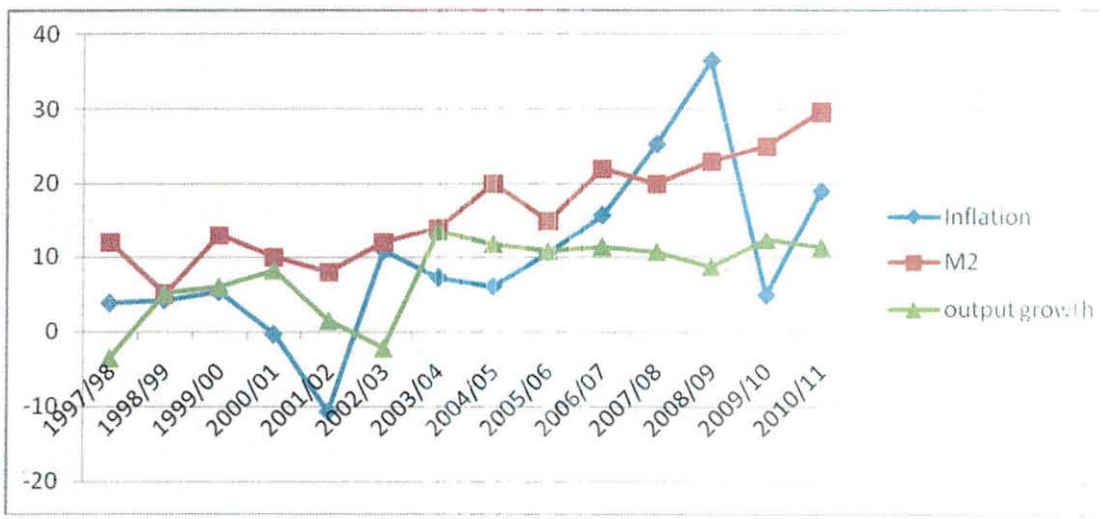
The above table indicates that the highest growth rate in the agriculture sector is observed within the period 2005/06-2009/10. This performance is also reflected in the highest growth rate of the whole economy which is around 11%. The growth rate in the industry and service sector are also increasing besides having a fluctuating trend. The year 2005/06-2009/10 marked as a year where we observed the highest growth rate of the agriculture, the service sector and also to some extent the industrial sector. The highest growth rate of the economy in this year which is 11% may be associated (attributed) to the increase in the growth rate of its components mainly the service sector. The period has also marked a shift to dominance in the overall economy from agriculture to the service sector. The most important and growing activities were public sector, financial sector and wholesale and retail sector activities (NBE 2009/10).

When we see the growth rate in the component of GDP the service sector is taking the lead in recent years. It emerged as the dominant sector of the economy in terms of share of GDP and growth in value added. The share of agriculture in GDP declined from 51% in 2000/01 to 44.6% in 2007/08, before declining further to 43% in 2008/09. On the other hand, we see the performance of the industrial sector, which exhibited a marginal increase in its share of GDP from 12.1% in 2000/01 to 13% in 2007/08 and 2008/09, registered real growth of 9.9% in 2008/09, down marginally from the 10% growth in 2007/08. The 2008/09 expansion in the industrial sector was driven mainly by the growth in construction (11.7%) and manufacturing (9.4%). (NBE, 2008/09)

3.5 Trends in Growth Rate of Broad Money, Inflation and Output Growth

This section of the discussion tries to see the relationship between broad money, inflation and output growth using a graphical illustration.

Fig 3.5 Trends in the growth rate of Broad money, Inflation and Output growth (1997/98-2010/11)



Source: Constructed based on NBE and CSA data

The above graph indicates that the three variables i.e. inflation, broad money (M2) and output growth generally have an increasing trend. The growth rate of output on average was around 3.5% before 2002/03. For the same year the average growth rate for inflation and broad money was 0.54% and 9.6% respectively. However, by the year 2002/03 the growth performance falls below zero and inflation roses from a record level of -10.6% to

greater intensity. The money supply (M2) also grew from 8% to about 12%. The possible explanation for poor growth performance and high level of inflation in this year is associated with the drought that severely hits the country in 2002/03.

From the year 2003/04 on wards the growth rate of the economy is highly increasing and so does the inflation. Customarily, a decline in growth is used to be associated with an increase in inflation, however; this links seems to have been lost from the year 2003/04 on wards. The only link to have been maintained is the direct relationship between money supply and inflation.

IV. METHODOLOGY

4.1 Data Source and Description

Quarterly time series data on Gross Domestic Product (GDP) and inflation, the latter being measured by CPI is used. The data which ranges from 1991/92Q1-2010/11Q4 is collected from CSA (Central Statistical Authority), NBE (National Bank of Ethiopia) and IFS (International Financial Statistics). Annual GDP data is decomposed based on country specific interpolation method to generate quarterly GDP data. The year 1991 is chosen as the liberalization era started from this year plus it is advisable to trace back to know the exact period where the volatility process has started or emerged.

GDP interpolation method- In the case of Ethiopia there is no quarterly GDP data available officially. However there are different interpolation methods to get quarterly data. Chow and Lin (1971) developed a method for the decomposition of annual GDP data using related variable series. Though this approach seems feasible it has got some limitation. Firstly, it can't handle non-stationary characteristics of the data and the second and the most important limitation is the difficulty in the selection of predictor variables which is ad-hoc and based totally on data availability than on theory, especially for developing countries. The other approach for the decomposition of annual data was developed by Lisman and Sande (1971). The major limitation of this approach is that it assumes the same value for each quarter within a year so it doesn't show intra year dynamics. Yemiserach (2005) generate quarterly GDP data using the approach developed by Goldstein and Khan (1976). This approach uses Simpson's parabolic rule which tries to generate quarterly figures by dividing a year interval into equal sub-intervals. Though

this approach is simple it's not theoretically feasible and country specific. The approach used in this paper is the one by Haile Kibret (2001). He tried to study the behavior of seasonality function of each sector in its contribution to annual GDP based on seasonality adjustment coefficients. The detail methodology can be seen in the appendix six. The major limitation of this approach is that it uses constant coefficients, ignores private sectors contribution to industry and share to other sub-service sector is equally divided in to four quarter.

Inflation and Inflation uncertainty- Inflation is computed by taking the percentage change of CPI data. Inflation uncertainty, which is another variable used in the analysis, is derived from GARCH (Generalized Autoregressive Conditional Heterosedasticity) estimate using the actual inflation data. The detail about the estimation technique of inflation uncertainty will be discussed in the next segment of the paper.

4.2 Descriptive Statistics

Analyzing the descriptive statistics of variables to be used in the analysis is important to know the characteristics of the data and to make a better interpretation. The descriptive statistics of the two major variables used in the study are shown below where INF (Inflation) and RGDPG (Growth rate of Real GDP). Economic growth rates are calculated from the difference of logs of real gross domestic product. Likewise, inflation rates are calculated from the difference of logs of CPI.

Table 4.1 Descriptive Statistics

Descriptive statistics	INF	RGDPG
Mean	9.5721	0.0152
Median	8.0677	-0.025
Maximum	61.8565	1.059
Minimum	-11.9277	-0.490
Standard deviation	12.9614	0.21
Skewness	1.43766	1.433
Kurtosis	6.14423	8.10
Jarque bera	60.5122	114.4
Probability	0.0000	0.0000
Observations	80	80

The trend of inflation in Ethiopia indicates some volatile characteristic inside the investigation period. This is also highly evident from the fact in Table 4.1 the inflation rates have a high standard deviation nearly equal to its mean value. In Table 4.1, we observe that the mean and median of inflation is 9.57 and 8.06, respectively. Skewness is a measure of asymmetry of the distribution of the series around its mean, and the skewness of a symmetric distribution, such as the normal distribution, would be zero. Descriptive statistics reveal that quarterly inflation data are biased to the right and has a right tail. This is also true in the case of real GDP series. On the other hand, kurtosis measures the peakedness or flatness of the distribution of the series, and the kurtosis of the normal distribution is 3. If the kurtosis exceeds 3, the distribution would be peaked relative to the normal. An excess kurtosis can easily be noticed in both the inflation and GDP series. Jarque-Bera is a test statistic for testing whether the series is normally distributed under the null hypothesis. The test statistic measures the weighted average of

the squared differences of the skewness and kurtosis of the series with those from the normal distribution. In this case, a significant departure from normality due to the excess kurtosis is also found in the variables under investigation.

4.3 Analytical Approach and Estimation Techniques

In economic research involving time series data, before any kind of statistical estimation takes place the data of all variable in the model have to be tested for their stationarity (Gujerati, 1995). If the variables in regression are established to be stationary it means that the assumptions of the classical regression model hold. When non-stationary variables with different order of integration are used in regression, they result in spurious regression, which means in regressing a non stationary time-series variables on another time series variable one often obtains a very high R^2 although there is no meaningful relationship between them.

4.3.1 Stationarity Test

A stochastic process[6] is said to be stationary if its mean and variance are constant over time and the value of the covariance depends on the distance between two time periods not on the actual time at which the covariance is computed. This type of a stochastic process is called weak stationarity. On the other hand a stochastic process is said to be strictly stationary if the joint probability distribution is independent of time. This implies that the distribution of Y_1 is the same as Y_t and so on (Verbeek, 2004:258).

[6] A stochastic process refers to a collection of random variables ordered in time

There are various statistical tests for the detection of non stationarity or unit root problem. These includes Dickey-Fuller (DF) test, Augmented Dickey Fuller (ADF) test, Phillip-Perron(PP) test etc. The DF test can be estimated in three ways

$$\Delta y_t = \delta y_{t-1} + u_t \ldots\ldots 4.1$$

$$\Delta y_t = \beta_1 + \delta y_{t-1} + u_t \ldots\ldots 4.2$$

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + u_t \ldots\ldots 4.3$$

Where, t is the time trend, 4.1 represent a random walk, 4.2 represent a random walk with drift and 4.3 represent a random walk with drift and time trend. In each of the three cases, the null hypothesis is $\delta=0$ i.e. there is a unit root or non stationarity against the alternative $\delta<0$ i.e the time series is stationary. The critical values to test the hypothesis $\delta=0$ is τ(tau) statistic was developed by Dickey and Fuller in 1979. An important assumption of the DF test is that the error terms u_t are independently and identically distributed.

The ADF test adjust the DF test to take care of possible serial correlation in the error terms by adding the lagged difference terms of the dependent variable. The ADF test avoids the problem of DF because it corrects for serial correlation; by adding lagged difference terms *(Greene, 2003: 643)*.The ADF test can be represented as;

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \sum_{h=1}^{m} \alpha \Delta y_{t-h} + u_t \ldots\ldots 4.4$$

Where U_t is a pure white noise error term and $\Delta Y_{t-1}= (Y_{t-1}-Y_{t-2})$, $\Delta Y_{t-2}= (Y_{t-2}-Y_{t-3})$ etc. ADF test uses the same null hypothesis and the same asymptotic critical value as that of DF test (Gujarati, 2004: 815-819)

The Dickey-Fuller tests assume that the errors are statistically independent and have a constant variance. However, Phillip and Perron (1998) developed a generalization of the Dickey-Fuller procedure that allows for fairly mild assumption concerning the distribution of the errors (Enders, 1995:239). The PP test uses non parametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms. The PP test has an advantage over the ADF test as it gives robust estimates when the series has serial correlation and time-dependent heteroscedasticity and there is a structural break (Mallik and Chaudhury, 2001).

All the three tests discussed so far used to test the null hypothesis of non-sationarity against the alternative of stationary. However Kwiatkowski, Philiphs, Schmidt and Shin in 1992 developed a test called KPSS test. The KPSS test is different from other class of tests in that it reverses the null and the alternative hypotheses and is named as a test of stationarity rather than unit root test. In this study both ADF and PP tests are used to detect non-stationarity problem and KPSS test is also used to cross check the result of ADF and PP test.

Table 4.2 Stationarity Test Result

Variables	ADF Test		PP Test	
	Without Trend	With Trend	Without Trend	With Trend
INF	-4.37	-5.11	-3.15	-3.46
RGDPG	-8.89	-8.82	-8.80	-8.73

Mackinnon (1996) one side p-value critical value -3.52 and -2.90 on model W/o Trend (Without trend) and -4.088 and -3.472 on model with trend for 1%, 5% critical value.

As can be seen from the tabulated value the two variables are stationary in level or I (0) process. This is due to their construction. Inflation is derived by taking the logarithmic difference of CPI data and CPI data is I (1) data meaning it will be stationary when we difference it once. And the logarithmic first difference of CPI gives as Inflation data as a result it is stationary. Whereas, RGDPG which is the growth rate of GDP is also stationary as it is also growth rate.

4.3.2 Estimation Technique

4.3.2.1 Generalized Autoregressive (GARCH) and Threshold Generalized Autoregressive (TGARCH) Models

The basic notion of the least square model assumes that the expected value of all error terms when squared is the same at any given point. This assumption is called homoskedacticity and it is this assumption that focuses on ARCH/GARCH models. In a data where the variance of the error terms is not equal i.e. the error terms may reasonably expected to be larger for some points or ranges of the data for the others are said to suffer from heteroskedasticity. In the presence of this problem, the regression coefficients for an ordinary least square regression are still unbiased but the standard errors and confidence interval will be too narrow, giving false predictions. Ordinary Least Square (OLS) assumes heteroskedasticity as a problem to be corrected whereas; ARCH/GARCH models treat heteroskedasticity as a variance to be modeled. As a result ARCH/GARCH model not only overcome the deficiency of OLS but also help to compute prediction for the variances of the error terms. They are commonly used in financial applications to measure the risk associated with the return of different assets. (Engle, 2001:157-159)

ARCH models and its generalized form GARCH model were introduced by Engle (1982) and Bollerslev's(1986) respectively to address volatility issues. The appeal of using ARCH/GARCH models is that it captures volatility clustering and powerful as compared to the traditional method which proxies' inflation uncertainty by the moving standard deviation which measured inflation variability not uncertainty. A Lagrange multiplier test can be used to test for the presence of ARCH effects. First we estimate the mean equation (e.g. regression of the variable on a constant and possibly other variable). Save the estimated residuals and obtain their squares $\hat{\varepsilon}_t^2$. Then Regress $\hat{\varepsilon}_t^2$ on $\hat{\varepsilon}_{t-1}^2,....,\hat{\varepsilon}_{t-q}^2$ and save R^2 value. Next under the under the null hypothesis of "no ARCH (q) effects"

$$(T-q)R^2 \sim \chi_q^2 \quad \text{.....4.5}$$

Finally we reject the null hypothesis of "No ARCH effects" if the calculated statistic is greater than the tabulated chi-squared value or accept otherwise (Enders, 1995:148-149). If we get evidence for the existence of ARCH effect we can model it either using ARCH or GARCH estimation. However, the major drawback of typical ARCH/GARCH model is that it assumes symmetric response of conditional variance to positive and negative shocks. To overcome this problem this paper uses the extended version of GARCH model i.e. TGARCH (Threshold Generalized Autoregressive Conditional Heterosedasticity) model developed by Glosten et al. (1993) and Zakoian(1994). The model specification is a follows:

$T-GARCH(1,1)$

$$\pi_t = \phi_0 + \sum_{i=1}^{p} \alpha_i \pi_{t-1} + \varepsilon_t \quad \text{.....(4.6)}$$

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-1}^2 + \sum_{j=1}^{r} \gamma d_{t-j} \varepsilon_{t-j}^2 + \sum_{k=1}^{q} \beta_k h_{t-1} \quad \text{.....(4.7)}$$

$$d_t = \begin{cases} 1 & \varepsilon_{t-1} > 0 \quad (\textit{good news}) \\ 0 & \varepsilon_{t-1} < 0 \quad (\textit{bad news}) \end{cases} \qquad \alpha_0 > 0, \alpha_1 > 0, \beta \geq 0 \; \textit{and} \; \alpha_1 + \gamma \geq 0$$

Where ε denotes the innovation in the mean for the specific stochastic process of Π (t) representing inflation and h is a time varying positive and measurable function of information set at time t-1 information set, the coefficient γ captures any asymmetric effects. It is called the leverage term. Positive inflationary shock has an impact of α_i while negative inflationary shock has an impact of $\alpha_i + \gamma_i$ .If γ is significant and positive bad news (negative inflationary shock) increase volatility in the inflation series. To determine the appropriate lag length in the mean equation the usual VAR length criteria i.e. the Schwarz Information Criteria (SIC), the Final Prediction Error (FPE), Hannan-Quinn Criteria (HQ) and Akake's Information Criteria (AIC) are used.

4.3.2.2. Cointegrated Vector Autoregressive Model (CVAR)

The VAR model is a multivariate time series specification developed as a generalization of the univariate autoregressive (AR) model. It was initially proposed by Sims (1980) to avoid the 'incredible identification restrictions' of (large scale) structural econometric models and it has since become an important tool in empirical macro econometrics. A VAR model can be specified as

$$Z_t = \alpha_0 + \sum_{i=1}^{k} A_i Z_t + u_t \; \text{... ... ...(3)}$$

WhereZ_t ~I (1) and u_t ~ IN (0, Σ) where, Σ is the contemporaneous covariance matrix.

In the above equation, Z_t is an (nx1) matrix containing endogenous variables in the system and A_i is an (nxn) matrix of parameters. The system is in reduced form with each variable in Z_t regressed on only lagged values of both itself and all the other variables in the system (Enders, 1995). As such, error correction representation of a standard VAR is given as follows:

$$\Delta Z_t = \alpha_0 + \sum_{i=1}^{k-1} \Gamma_i \Delta Z_{t-i} + \Pi Z_{t-1} + u_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where Z_t~I (1) and u_t ~ IN (0, Σ)

From the above specification, Δ is the first difference operator, Γ_i is a (n x n) coefficient matrix and $\Pi_i$is a (n x n) matrix whose rank determines the number of cointegrating relationships among the variables. In this way we can represent both short run and long run relationship with parameters Γ_i and Π respectively. If Π is of full rank, that is, r = n, this suggests that the variables are level stationary. In such case, estimating the level VAR and the VECM with unrestricted OLS will give identical results (Davidson and Mackinnon, 1999: 630). If r = 0, this means that there are no cointegrating vectors. However, if Π has a reduced rank r ≤ (n - 1), then it can be decomposed to the following form, Π =αβ' where α represents the speed of adjustment to disequilibrium which is n x r matrices while β is a matrix of long-run coefficients such that the term $\beta' y_{t-k}$ is included in the ECM represents up to (n-1) cointegration relationships in multivariate model which ensures that y_t converges to their long run steady-state solution. (Enders, 1995)

When we have I (1) variables there are statistical techniques to be used to check the existence of cointegrating relationship. These include Engle-granger two step estimation and the Johansson procedure. But the variables used for investigation in this study are found to be stationary as can be seen from the ADF statistics in table 4.2 hence they are automatically cointegrated. Therefore, the above two estimation techniques will not be presented here. Along with the formulated VAR model granger causality tests and Variance decomposition analysis is also used to see the relationship between the variables clearly.

4.4 Empirical Result and Analysis

In this section empirical results obtained using the above listed estimation techniques will be discussed. The first part of the discussion deals with modeling inflation volatility using ARCH and its extended forms TGARCH. The second section establishes the relationship between inflation, inflation uncertainty and output growth using granger causality test. The last section of the analysis uses CVAR model to analyze the long run relationship and the short run dynamics of inflation and the growth rate of GDP.

4.4.1 Modeling Inflation Volatility

The first task in modeling the volatility of inflation is appropriately specifying the mean equation. There are certain economic and financial variables believed as important determinants of inflation in Ethiopia. However, in this study inflation will be modeled dynamically through an autoregressive process. The reason for including an autoregressive term is because inflation, like many other economic variables, has shown strong inertia in various studies. "There may be many reasons for this inertia, such as the

inability of market agents to interpret and respond in a timely manner after the arrival of a particular announcement or news, or the probability of uncertainty linked to that news, or the overreaction of market participants following herd behavior. In case of the presence of strong inflationary inertia, as is evident from many studies, we expect the autoregressive term to be positive and highly significant" (Rizvi, 2008).

Various lag length criteria is considered to choose the appropriate lag length for the autoregressive process in the mean equation. These criteria include the Schwarz Information Criteria (SIC), the Final Prediction Error (FPE), Hannan-Quinn Criteria (HQ) and Akake's Information Criteria (AIC). But in different literature it was argued that the last criteria i.e. AIC doesn't yield a good estimate as compared to the remaining criteria. Khim and Tai (2005) tried to see the effect of different lag length selection criteria in the presence of ARCH error. Their result revealed that SIC, FPE and HQC (but not AIC) perform considerably well in estimating the true AR lag length in all simulated series. In this paper AR (1) is chosen based on the above criteria. Measures are taken to ensure that the sum of these simulated autoregressive parameters is less than unity in magnitude ($| a1 | < 1$) so as to avoid non-stationary AR process. To check the presence of serial correlation in the residuals of AR model Breusch-Godfrey test is used and then introduced appropriate AR or MA terms for errors, as indicated by the correlogram, to eliminate serial correlation.

$$\pi_t = \underset{(0.932)}{1.42} + \underset{(0.059)}{0.838\pi_{t-1}} \quad \text{.....(4.10)}$$

Where π_t denotes inflation and π_{t-1} is the one period lagged value of inflation. From the above mean equation lagged value of the inflation is highly significant at 1% critical

value demonstrating the fact that there is high inflation inertia effect in the economy. It is usually interpreted as measuring the effect of indexation or inflation expectation. This finding is in line with Loening (2007) who suggested expectations can explain a large fraction of inflation dynamics in Ethiopia for 2000-2006. The squared residual obtained from the above regression has got an ARCH (1) effect as can be seen from the Lagrange Multiplier test (LM). The LM test was done by regressing the squared residual on its lagged value and save the R^2 value. Under the null hypothesis we have "no ARCH (q) effects".

$$(T-q)R^2 \sim \chi_q^2 \quad \text{.....(4.11)}$$

Where (T-q) refers to the degrees of freedom and it follows a chi-square distribution. In this case the estimated value is (0.10609) (78) = 8.27 and chi-square value is > chi2 (2) at 5%= 5.991. So, we are going to reject the null hypothesis of no ARCH (1) effect. This means that the inflation series exhibit volatility. The next step is modelling ARCH (1) process for inflation data.

Dependent Variable: RESID2(residual square)
Method: Least Squares
Included observations: 78 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAG1*	0.527898	0.102051	5.172875	0.0000

R-squared	0.106092	Mean dependent var	44.11068
Adjusted R-squared	0.106092	S.D. dependent var	98.16158
S.E. of regression	92.80854	Akaike info criterion	11.91169
Sum squared resid	663233.7	Schwarz criterion	11.94191
Log likelihood	-463.5560	Hannan-Quinn criter.	11.92379
Durbin-Watson stat	1.825048		

Where LAG1* is one period lagged value of the squared residual.

4.4.1.1 Modeling ARCH (1) Process and GARCH

Prior to the ARCH model introduced by Engle (1982), the most common way to forecast volatility was to determine the standard deviation using a fixed number of the most recent observations. As we know that the variance is not constant, i.e. homoskedastic, but rather a heteroskedastic process, it is unattractive to apply equal weights considering we know recent events are more relevant. Moreover, it is not beneficial to assume zero weights for observations prior to the fixed timeframe. The ARCH model overcomes these assumptions by letting the weights be parameters to be estimated thereby determining the most appropriate weights to forecast the variance (Lamark et.al, 2005)

Dependent Variable: INF
Method: ML - ARCH (Marquardt) - Normal distribution
Included observations: 79 after adjustments
Convergence achieved after 19 iterations
Presample variance: backcast (parameter = 0.7)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.545696	0.787119	1.963738	0.0496
INF1	0.711886	0.039636	17.96054	0.0000
	Variance Equation			
C	15.49273	5.319806	2.912273	0.0036
RESID(-1)^2	0.778815	0.284841	2.734208	0.0063

R-squared	0.697672	Mean dependent var	9.191245
Adjusted R-squared	0.693745	S.D. dependent var	12.58550
S.E. of regression	6.964850	Akaike info criterion	6.384698
Sum squared resid	3735.204	Schwarz criterion	6.504670
Log likelihood	-248.1956	Hannan-Quinn criter.	6.432763
Durbin-Watson stat	0.794866		

The estimated ARCH (1) model can be written as:

Mean Equation

$$\hat{\pi}_t = 1.545 + 0.711\pi_{t-1} \quad \text{.....(4.12)}$$

Variance Equation

$$\hat{h}_t = 15.49 + 0.78\hat{\varepsilon}^2_{t-1} \quad \text{.....(4.13)}$$

Where $\hat{h}_t$ is the conditional variance of the inflation series and $\hat{\varepsilon}_{t-1}^2$ is past value of the squared residual or a shock or may be news. The one-step ahead forecasts of inflation volatility, at forecast origin t can be expressed as

$$\hat{\pi}_{t+1} = 1.545 + 0.711\pi_t$$
$$\hat{h}_{t+1} = 15.49 + 0.78\hat{\varepsilon}_t^2$$
where
$$\hat{\varepsilon}_t^2 = (\pi_t - \hat{\pi}_t)^2 = (\pi_t - 1.545 - 0.711\pi_{t-1})^2$$

In this way we can determine the forecast n-periods ahead. Even though the ARCH model was useful at the time, it has its shortcomings. For instance, we do not know how many lags, *p,* we should apply for the best results and the potential number of lags required to capture all of the dependence in the conditional variance could be very large thus making the model not very parsimonious and also ARCH imposes restriction on the conditional variance equation to prevent getting negative result in the conditional variance (Enders, 1995).

To overcome this limitation of ARCH model GARCH model was developed by Bollerslev's(1986). GARCH is more economical than ARCH as it has only three parameters and allows an infinite number of past squared errors to influence the current conditional variance (Brooks, 2002). The GARCH model allows the conditional variance to be dependent upon previous own lags. In effect we can forecast the next period's variance, examples of which will be shown through the

- Weighted average of the long run average variance (mean),
- The variance predicted for this period (GARCH) and,

- Information about volatility during the previous period which is the most recent
- Squared residual (ARCH).

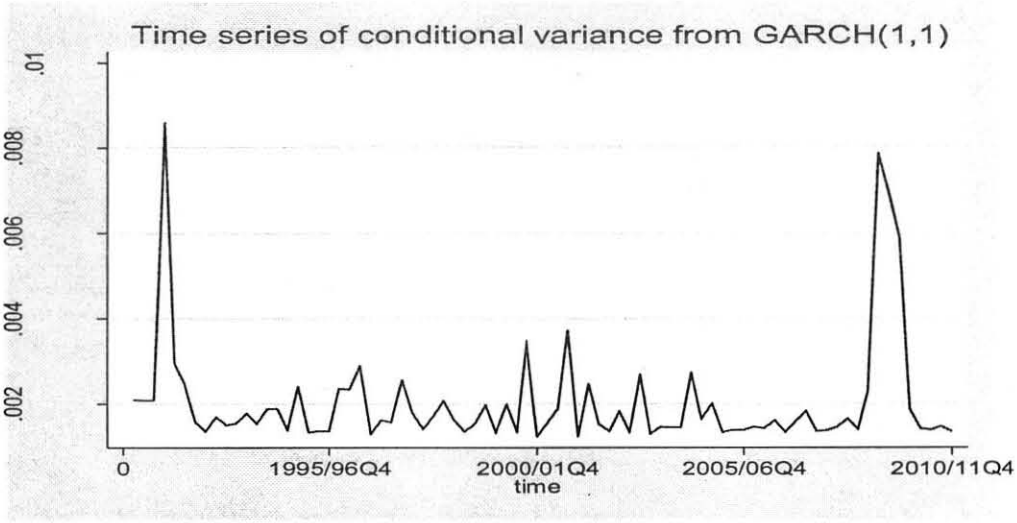
The GARCH (1, 1) model is given by

$$\pi_t = \beta_o + \beta_1 \pi_{t-1} \quad \text{.....(4.14)}$$

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \quad \text{.....(4.15)}$$

If we estimate the GARCH (1, 1) using the above same procedure and sketch the result in graphical form we will get the following result.

Figure 4.1 Time Series plot of GARCH (1, 1)



The graph shows that high level of inflation uncertainty or volatility was observed with in the period 1991/92 and 2005/06-2010/11 and these periods are characterized by high inflation rate. The major cause for high volatile inflation in the year 1991/92 is due to lack of political stability and peace. In this year the inflation rate was 21%. The period 2005/06-2010/11 is also characterized by high rate of inflation with an average growth

rate of 19%. The figure indicates that periods of high inflation are also characterized by periods of high uncertainty or volatility.

4.4.1.2 Threshold GARCH

Though the above GARCH graph clearly shows the conditional variance over time it assumes symmetric response of inflation uncertainty to positive and negative inflationary shock. However, it has been argued that the behavior of inflation volatility is asymmetric rather than symmetric. According to Brunner and Hess (1993) and Joyce (1995), a positive inflation shock is more likely to increase inflation uncertainty via the monetary policy mechanism, as compared to a negative inflation shock of equal size. This paper tries to tackle the major drawback of GARCH model (i.e. symmetric response) by employing the extended version of GARCH model i.e. TGARCH (Threshold Generalized Autoregressive Conditional Heterosedasticity) model developed by Glosten et al. (1993) and Zakoian(1994). The model specification is a follows:

$$T-GARCH(1,1)$$

$$\pi_t = \phi_0 + \sum_{i=1}^{p} \alpha_i \pi_{t-1} + \varepsilon_t \quad \text{.....(4.16)}$$

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-1}^2 + \sum_{j=1}^{r} \gamma d_{t-j} \varepsilon_{t-j}^2 + \sum_{k=1}^{q} \beta_k h_{t-1} \quad \text{.....(4.17)}$$

$$d_t = \begin{cases} 1 & \varepsilon_{t-1} > 0 \quad (\textit{good news}) \\ 0 & \varepsilon_{t-1} < 0 \quad (\textit{bad news}) \end{cases} \quad \alpha_0 > 0, \alpha_1 > 0, \beta \geq 0 \, and \, \alpha_1 + \gamma \geq 0$$

If ε denotes the innovation in the mean for the specific stochastic process of Π (t) representing inflation and h is a time varying positive and measurable function of information set at time t-1 information set, the coefficient γ captures any asymmetric

effects. It is called the leverage term. Positive inflationary shock has an impact of α_i while negative inflationary shock has an impact of $\alpha_i + \gamma_i$ .If γ is significant and positive bad news (negative inflationary shock) increase volatility in the inflation series. The estimated TGARCH model is presented as follows:

Dependent Variable: INF
Method: ML - ARCH (Marquardt) - Normal distribution
Included observations: 79 after adjustments
Convergence achieved after 35 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.099018	0.742754	1.479652	0.1390
INF1	0.887571	0.073778	12.03036	0.0000
	Variance Equation			
C	6.054228	3.172622	1.908273	0.0564
RESID(-1)^2	0.731471	0.335259	2.181811	0.0291
RESID(-1)^2*(RESID(-1)<0)	-0.760140	0.309192	-2.458475	0.0140
GARCH(-1)	0.549662	0.202447	2.715098	0.0066
R-squared	0.718752	Mean dependent var		9.191245
Adjusted R-squared	0.715100	S.D. dependent var		12.58550
S.E. of regression	6.717640	Akaike info criterion		6.335329
Sum squared resid	3474.755	Schwarz criterion		6.515287
Log likelihood	-244.2455	Hannan-Quinn criter.		6.407426
Durbin-Watson stat	0.960634			

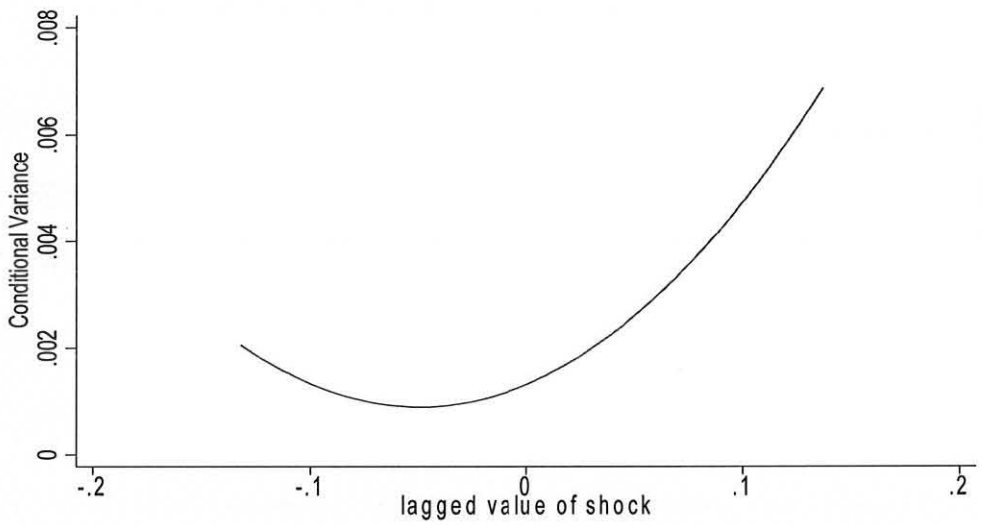
$$\hat{h}_t = 6.05 + 0.734\hat{\varepsilon}^2_{t-1} - 0.76d_{t-1}\hat{\varepsilon}^2_{t-1} + 0.549\hat{h}_{t-1} \quad \text{.....(4..18)}$$

The asymmetry parameter is different from zero supporting the fact that there is asymmetric effect of news on volatility. The asymmetry term is negative which indicates positive inflationary shocks create more volatility in the inflation series as compared to negative inflationary shocks. From the result, positive inflationary shocks increase

volatility by a factor of 0.73. According to Brunner and Hess (1993) and Joyce (1995), a positive inflation shock is more likely to increase inflation uncertainty via the monetary policy mechanism, as compared to a negative inflation shock of equal size.

Engle and Ng (1993), and Pagan and Schwert (1990) proposed the analysis of volatility models based on News Impact Curves (NIC). This curve shows the response in inflation volatility to positive and negative idiosyncratic shocks and applicable after the estimation of TGARCH model.

Figure 4.2 News Impact Curve



The GARCH (1, 1) graph in the previous section only shows the conditional variance over time irrespective of positive or negative inflationary shocks and it's less powerful for policy recommendation purpose. However, the above news impact curve indicates that positive inflationary shocks cause more volatility or increase the conditional variance of the inflation series. This means that factors that affect inflation or that increase inflation are also responsible for the increment in inflation uncertainty or volatility. This hyperbolic sign integral shape of news impact curve is also important for monetary

authorities and highlights the importance of inflation stabilization programs or inflation targeting policies, which reduces the next period volatility (Jonhson, 2002).

4.4.2 The Relationship between Inflation, Inflation Uncertainty and Growth

To test for the relationship between inflation uncertainty and indicators of macroeconomic performance, such as inflation and output growth, one can use a simultaneous or a two-step approach. Under the simultaneous approach, an ARCH-in-mean (ARCH-M) model is estimated with the conditional variance equation incorporating lags of the series, thus allowing simultaneous estimation and testing of the bidirectional causality between the series and the associated uncertainty. Under the two-step approach, estimates of the conditional variance are obtained from the estimation of an ARCH model and then these estimates are used in running Granger-causality tests to examine the causality between macroeconomic performance and uncertainty. In this study the second approach is used. In this case the granger causality answers the questions "Does increase in inflation volatility increase GDP? Or an increase in GDP increases inflation volatility? Or does increase in inflation increase inflation volatility?"

$$\pi_t = \sum_{i=1}^{n} \alpha_i y_{t-i} + \sum_{j=1}^{n} \beta_j \pi_{t-j} + \sum_{k=1}^{n} \theta_k h_{t-k} + u_{1t} \quad \text{.....(4.19)}$$

$$y_t = \sum_{i=1}^{n} \lambda_i y_{t-i} + \sum_{j=1}^{n} \delta_j \pi_{t-j} + \sum_{k=1}^{n} \omega_k h_{t-k} + u_{2,t} \quad \text{.....(4.20)}$$

$$h_t = \sum_{i=1}^{n} \eta_i y_{t-i} + \sum_{j=1}^{n} \mu_j \pi_{t-j} + \sum_{k=1}^{n} \gamma_k h_{t-k} + u_{3t} \quad \text{.....(4.21)}$$

Where π_t, y_t and h_t are inflation, economic growth and inflation uncertainty respectively. The Granger-Causality will be used to test the following hypothesis discussed in the literature review section.

Testable hypothesis – Theories	Expected sign of the effect
1) Inflation Granger-Causes inflation uncertainty	
➢ Friedman hypothesis(1977) and Ball(1992)	+
➢ Pourgerami and Maskus(1987),Ungar and Zilberfarb	-
2) Inflation uncertainty Granger-Causes output growth	
➢ Friedman(1977)	-
➢ Dotsey and Sarte(2000)	+
3) Inflation uncertainty Granger-Causes inflation	
➢ Cukierman and Meltzer (1986)	+
➢ Holland(1995)	-

Following Nas and Perry (2000) since Granger causality tests initially indicate the temporal ordering or precedence relationship between each variable but do not reveal the sign of this relationship, we also give below the sign of the sum of the coefficients taken from each Granger equation to determine whether the Granger causality, if estimated, is in the positive or negative way. For the causality tests, various lag lengths are considered to see whether the estimation results are sensitive to the a priori lag selection.

Table 4.3 Granger Causality Test for Inflation, Inflation uncertainty and Output Growth

No of lags	Ho: Inflation doesn't granger causes inflation uncertainty	
Two lags	2.31(+)**	Friedman hypothesis(1977) and Ball(1992)
Four lags	2.50(+)**	
Six lags	2.95(+)**	
Eight lags	3.13(+)**	
Ten lags	1.82(+)**	
	Ho: Inflation uncertainty doesn't granger causes inflation	
Two lags	No sig. relationship	Holland(1995)
Four lags	-0.02(-)**	
Six lags	No sig. relationship	
Eight lags	-0.02(-)*	
Ten lags	No sig. relationship	
	Ho: Inflation uncertainty doesn't granger causes real output growth	
Two lags	-0.0033(-)*	Friedman(1977)
Four lags	No sig relationship	
Six lags	No sig relationship	
Eight lags	No sig. relationship	
Ten lags	-0.0037(-)*	

The asterisks ** and * indicate significance at the 1% and 5% levels, respectively. The signs (+) and (-) are used for the process by which the sum of the coefficients of Granger equation yields a positive or negative sign, respectively.

The granger causality test in the first case gives support to the Freidman-Ball hypothesis. Friedman (1977) was the first to suggest that higher average inflation could result in higher inflation uncertainty. This idea was developed by Ball (1992) in the context of a model in which higher inflation leads to increasing uncertainty over the monetary policy stance. According to his explanation when inflation increases the public become more

uncertain about commercial banks attitude towards inflation. This is because of the tradeoff between unemployment and inflation. Some central banks pursue to have high inflation as long as unemployment declines and others may take measures to reduce the inflation. Mladenovic (2009), Henry Ma (1998) and Rizvi and Naqui (2009) also get the same finding for the case of Serbia, Colombia and Pakistan, respectively.

The hypothesis inflation uncertainty doesn't granger causes inflation is also rejected at 1% level of significance. The sign of the sum of the coefficients in this case turns out to be negative contradicting to what Cukeirman-Meltzer hypothesis. Holland (1995) explained that an increase in inflation uncertainty can be viewed by policy makers as costly, so induce them to fight inflation to reduce inflation uncertainty. Increased inflation first raises inflation uncertainty, which creates real economic costs, and then leads to monetary tightening and stabilization to lower subsequent inflation. But the effect of inflation uncertainty in reducing inflation tends to decline when we increase the lag length and become almost insignificant when the time horizon increases. Nas and Perry in 2000 also get the same finding for Turkey for the period 1960-1998.

Concerning the relationship between inflation uncertainty and output growth, the granger causality test indicates that the hypothesis inflation uncertainty does not granger causes output growth is rejected at 5% level of significance. The direction of the effect found to be negative at lag 2 and 12. This finding is in line with Friedman (1971) hypothesis. His hypothesis has got two parts. The first one shows that an increase in inflation may induce an erratic policy response by the monetary authority and therefore leads to more uncertainty about the future rate of inflation. This hypothesis is the one discussed in support of the first granger causality result. The second part of Friedman argument says

increasing uncertainty about inflation distorts the effectiveness of price mechanism in allocating resources efficiently, thus leading to negative output effect.

There are two possible channels through which inflation uncertainty can affect growth negatively. The first is through the investment channel. We can use short run Philips curve[7] to demonstrate the transmission mechanism. From the theory of short run Philips curve higher inflation uncertainty leads to higher unemployment uncertainty which in turn implies greater uncertainty about the future Marginal Product of Capital (MPK). The uncertainty associated with MPK leads to lower level of investment. According to the general growth accounting framework[8], a decline in investment keeping other factors constant leads to a decline in the growth rate of GDP. The Keynesian model also indicates that the decrease in investment implies a decrease in demand hence a decline in output growth. This finding is line with Neanidis and Savva (2010) finding for the case of G-7 countries.

[7] $U_t = U_n - \beta(P_t - E(P_t))$, where U_t is the unemployment rate at time t, U_n is the natural rate of unemployment, $E(P_t)$ is the expectation of inflation and P_t is the rate of inflation at time t.

[8] Growth accounting framework is given by $\dot{Y}=E_kK_t + E_LL+E_AA$, where E_kK_t is the contribution of capital to growth, E_LL is the contribution of labor to growth and E_AA is the contribution of technology to growth.

4.4.3 Cointegrated Vector Autoregressive Model for Inflation and Growth rate

The relationship between inflation and growth are controversial issues in macroeconomics. The structuralist believes that inflation is essential for economic growth whereas, the monetarist see inflation as detrimental to economic growth. This segment of the discussion tries to see the relationship between economic growth and inflation in Ethiopia using Cointegrated Vector Autoregressive (VAR) analysis.

First attempt was made to see the relationship between inflation and GDP using lncpi and lnrgdp as a proxy for inflation and RGDP respectively. But the Johansson procedure fails to get any co integration relationship between the two as a result, the study establish relationship between inflation (the growth rate of cpi) and growth rate of RGDP. The VAR model can be written as;

$$GRGDP = \alpha + \beta_i \sum_{i=1}^{k} GRGDP_{t-i} + \gamma_i \sum_{i=1}^{k} INF_{t-i} + \mu_i \quad \text{.....(4.22)}$$

$$INF_t = \delta + \beta_j \sum_{j=1}^{k} INF_{t-j} + \gamma_j \sum_{i=1}^{k} GRGDP_{t-j} + \mu_j \quad \text{.....(4.23)}$$

Where GDGDP is the growth rate of GDP and INF is the growth rate of CPI. The first task before going to the VAR estimation is to check the stationarity characteristic of the data. The stationarity characteristic of the data is checked by using ADF and PP test as shown in table 4.2. Both variables are stationary or I (0) process. If two variables are stationary at level then they are automatically cointegrated and there exist a long-run

relationship between them (Datta and Kumar, 2011). Therefore, in this case inflation rate and growth rate are automatically cointegrated and have long run relationship.

Appropriate lag length for the VAR estimation is chosen based on SC (Schwarz Information Criteria), HQ (Hannan-Quinn Information criteria) and LR (Likelihood Ratio test)[9]. The above criteria chooses lag 2 to be an appropriate lag length for the VAR estimation. From the VAR estimation we have two cointegrating vectors or in other words two long run relationships. The possible argument for having two cointegrating vector is that an I (0) variable in a cointegrated VAR model will appear as a co integrating vector on its own (Reade, 2011). Since we already have stationary variables there is no need to discuss about the λ_{max} and trace statistics of the Johansson test. The main interest of the paper is to see the long run cointegrating relationship and short run dynamics. From the above computation we have the following equation.

Normalizing the coefficient of GRGDP we get the first co integration equation

1 Cointegrating Equation(s): Log likelihood 169.6264

Normalized cointegrating coefficients (standard error in parentheses)

GRGDP	INF
1.000000	-0.679116
	(0.34156)

Adjustment coefficients (standard error in parentheses)

D(GRGDP)	1.510871
	(0.22205)
D(INF)	-0.106776
	(0.05383)

GRGDP – 0.67INF = ECM1.....(4.24)

[9] The lag length selection criteria and various VAR diagnostic tests are presented in the Appendix 1 - 3.

From the result we have positive relationship between growth rate of GDP and inflation. In technical terms, in the long run a 1% change in inflation increases the growth rate by 0.67% at 5% critical value.

Normalizing the coefficient of INF we get the second co integration equation

1 Cointegrating Equation(s): Log likelihood 169.6264

Normalized cointegrating coefficients (standard error in parentheses)

INF	GRGDP
1.000000	-1.472502
	(0.21094)

Adjustment coefficients (standard error in parentheses)

D(INF)	-0.072513
	(0.03655)
D(GRGDP)	1.026056
	(0.15080)

INF – 1.47GRGDP = ECM2.....(4.25)

In this case too we have a positive long run relationship between inflation and the growth rate of GDP. A 1% increase in GDP growth leads to a 1.47% increase in the inflation rate. The elasticity is also high meaning that inflation is more sensitive to the change in growth rate. In this case the t- value is also highly significant at 1% as compared to the result obtained from the first cointegrating result. This indicates that the boom in aggregate demand causes inflationary pressure in the long run in Ethiopia. The implication is that attempts to achieve faster economic growth may overheat the economy to the extent that the inflation rate becomes unstable. Mallik and Chawdhury (2001) also found a positive long run relationship between growth rate of GDP and inflation for four south Asian countries namely, India, Pakistan, Bangladesh and Srilanka.

Since we ascertain the existence of cointegrating relationship the next step is to estimate the Vector Error Correction model (VEC). The VEC Modeling provides important

information on the short-run relationship between any two cointegrated variables. The focus of the VEC Model analysis is the one period lagged error terms from the previously estimated co integrating equations. These lagged terms provide an explanation of the short-run deviations from the long-run equilibrium. The VEC model can be written as

$$DGRGDP = \alpha + \rho Z_{t-1} + \beta_i \sum_{i=1}^{k} DGRGDP_{t-i} + \gamma_i \sum_{i=1}^{k} DINF_{t-i} + \mu_{1i} \quad \text{.....(4.26)}$$

$$DINF_t = \delta + \phi X_{t-1} + \beta_j \sum_{j=1}^{k} DINF_{t-j} + \gamma_j \sum_{i=1}^{k} DGRGDP_{t-j} + \mu_{2i} \quad \text{.....(4.27)}$$

The model is cast in terms of rates of change of these two variables. Note that the sum of DINF measure accumulated change in the rate of inflation not CPI. The innovations, μ_t= (μ_{1i}, μ_{2i}) is assumed to have mean zero, contemporaneous covariance matrix E [$\mu_t \mu'_t$] =Ω and to be strictly non autocorrelated. From the above two VEC models the second one is taken for the estimation of error correction model. This is due to the fact that the first one doesn't yield any significant relationship in the VEC model.

Table 4.4 Error correction Model; Dependent variable DINF

Variable	Coefficient	S.E	T-stat
DINF(-1)	-0.178	0.1081	-1.64
DINF(-2)	-0.287	0.1075	-2.678
DRGDP(-1)	-0.1213	0.03658	-3.316
DRGDP(-2)	-0.086	0.02751	-3.144
C	-0.0008	0.0047	-0.170
ECM(-1)	-0.0725	0.036	-1.95

In the short run the growth in GDP affects inflation negatively. The results show the existence of a significant feedback relationship between inflation and economic growth. In the context of Ethiopia, the growth of economy in the short run has a temporary impact to reduce inflation. This means that those factors that tend to increase GDP growth have also a tendency to reduce the inflation rate in the short run. The error correction term obtained from VEC model is negative and statistically significant at 5%. The speed of adjustment to restore long run equilibrium is quite low, which is 7.2% per quarter. This means the speed of adjustment will be around 28.8% annually and it will take almost 3 and half years to completely recover from a single shock and restore long run equilibrium. To check if there is a casualty relationship between growth rate and inflation, granger causality test is used and the result is presented below.

Pairwise Granger Causality Tests
Date: 05/20/12 Time: 13:46
Sample: 1 80
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
GRGDP does not Granger Cause INF	78	6.20469	0.0032
INF does not Granger Cause GRGDP		2.60664	0.0806

The above granger causality result indicates that we reject the hypothesis GRGDP does not granger causes INF at 1% critical value. This indicates that there is causality relationship running from growth to inflation. To see the sign of causality we are going to add lagged values of the causing variable i.e. GRGDP in the inflation equation. In this case the sum of the coefficient turns out to be negative meaning increase in the growth rate of GDP decrease inflation. This is consistent with the short run finding. To substantiate the results obtained in the VEC model and in the granger causality let's

check variance decomposition Result. Impulse response function is not presented here but interested readers can see appendix 4.

Table -4.5 Results of Variance Decomposition of Inflation and Growth

Variance Decomposition of growth rate of GDP				Variance Decomposition of Inflation		
period	S.E	GRGDP	INF	S.E	GRGDP	INF
1	0.169730	100.0000	0.000000	0.041594	1.032825	98.96717
2	0.175592	93.45215	6.547847	0.049007	9.669769	90.33023
3	0.204660	95.14584	4.854159	0.049032	9.757625	90.24238
4	0.208377	91.80313	8.196867	0.050001	13.07441	86.92559
5	0.219417	92.60014	7.399863	0.050056	13.15327	86.84673
6	0.220793	91.47916	8.520838	0.050393	14.30777	85.69223
7	0.225319	91.81642	8.183581	0.050443	14.30546	85.69454
8	0.225879	91.38501	8.614993	0.050587	14.78630	85.21370
9	0.227762	91.52688	8.473118	0.050606	14.78162	85.21838
10	0.228006	91.34673	8.653274	0.050668	14.98853	85.01147

Cholesky[10] Ordering RGDPG INF

The variance decompositions were estimated using the causal ordering GDGDP causes inflation as indicated by the granger causality test. This analysis is used to supplement the Granger Causality test results to examine the out of sample causality. These results show how much an economic growth's own shock is explained by movements in its own variance and the other variable and how much inflation shock is explained by its own shock and GRGDP shock. In the first period around 99% of the forecast variance of inflation is due to its own innovations and the remaining 1% is due to innovations in GDP growth. The result indicates that more than 14% variability of inflation is accounted by growth innovations over the 10 quarter horizon. It supports our Granger causal result that says growth causes inflation. On the other hand, all the forecast variance of GDP growth in the first period is due to its own innovations. Though the share of inflation in

[10] Cholesky Ordering imposes an ordering of the variables in the VAR and attributes all the effect of any common component to the variable that comes first in the VAR system.

explaining the forecast error variance of growth increases as the time horizon increases its effect is not as such significant as compared to the contribution of growth shocks in explaining the variance of inflation.

V. CONCLUSSION AND RECOMMENDATION

5.1 Conclusion

Macroeconomic performance is measured on how some indicators like output and inflation behaves through time. Countries design different monetary and fiscal policies that can help them to secure sound macroeconomic framework. This study focuses on the monetary aspect leaving aside the fiscal policy part. In a general terms the objective of monetary policy are inflation and output stabilization. Monetary policy's best contribution to sustained growth is to foster price stability. However, an exogenous shock to the economy that generates uncertainty about inflation rate and output growth rate tend to cause deviation of these variables from the desired value and hence necessitates some policy response (Fountas et.al, 2009). Therefore the objective of this paper is to model uncertainty associated with inflation and ascertain the relationship between inflation, growth and inflation uncertainty.

The analysis began with a descriptive analysis. This part of the discussion shows the macroeconomic framework of the country and the trend analysis of the variables used in the study. In this regard, the paper assesses the monetary policy performance conducted by the NBE with a due emphasis on major instruments, the operating targets, intermediate targets and ultimate targets of monetary policy. The study also identifies major transmission mechanisms in which monetary policy affects economic activity. The descriptive analysis also indicates the trend of inflation, growth and money supply. As can be seen from the trend analysis the study identifies the period between 2002/03-2009/10 as a period where high and volatile level of inflation is recorded. In addition,

inflation rate tends to be high when the growth performance of the economy is weak and it falls when the country recorded high growth rate. However, this link seems to have been lost since 2003/04 on wards as both are continuously increasing. Since undertaking a descriptive analysis cannot help to fully address the objectives of the study, the study uses time series econometric analysis to complement the descriptive one.

In the first part, inflation uncertainty is estimated using the well known GARCH methodology and its extensive form TGARCH. The result indicates that high level of inflation is associated with high level of inflation uncertainty which go in line with Freidman-Ball hypothesis. Furthermore, the TGARCH estimates confirm the fact that there is asymmetric effect of inflation uncertainty i.e. positive shocks tend to increase inflation uncertainty by large amount as compared to negative shocks of equal magnitude. To establish the link between inflation, inflation uncertainty and growth, CVAR model and granger causality tests is used. The CVAR is helpful in establishing long run and short run relationship between growth and inflation

Generally, the major findings of the study on the basis of the above time series econometric analysis includes

- High level of inflation is associated with high level of inflation uncertainty within the investigation period and the causality is running from inflation to inflation uncertainty. In addition, positive inflationary shocks increase inflation uncertainty more than negative inflationary shocks of equal magnitude.
- Inflation uncertainty affects growth negatively though after long time lag due to some rigidity in the economy and there is strong evidence for the existence of inflation inertia effect within the investigation period.

- In the long run there is a significant positive relationship between inflation and growth where as in the short run there is a significant negative relationship between the two variables.
- When a shock happens that makes the inflation level to deviate from its long run equilibrium value, it takes three and half years to return back (restore long run equilibrium) and the speed adjustment is quite low.
- From the granger causality test made the direction of causality is running only from growth to inflation and the sign of the effect is negative, which is the same as the short run finding.

In general based on the above main findings the study makes the following conclusions. First inflation in Ethiopia is highly volatile within the investigation period and its effect on growth through the uncertainty channel is significant. This is to mean that inflation is highly associated with high level of inflation uncertainty and the high level of uncertainty is also found to have a significant negative effect on growth.

From the estimated CVAR model the short run result indicates that an increase in growth reduces inflation in the short run. In contrast, in the long run increase in growth rate of GDP increase inflation. When we see the speed of adjustment in which inflation adjust to its long run equilibrium value after a single shock its quite low. Only 28.8% of the shock can be recovered per year. This is attributed to the fact that the instruments used by NBE as well as the transmission channels are not effective in reducing inflation. The major reason for the ineffectiveness of the transmission channels is due to underdeveloped financial system.

5.2 Recommendation

Based on the analysis made and the major findings obtained the study tries to forward the following policy recommendations;

The sensitivity of inflation to changes in the growth rate is larger than that of growth to changes in inflation rate as can be seen from the elasticity estimate in the long run equation. This has an important policy implication i.e. finding a growth rate that is consistent with stable inflation rate is sounder rather than always focusing to beat inflation first. This implies that finding the threshold level of growth-inflation relationship is important.

The other major policy implication is NBE should build credibility and public confidence to control the stochastic movement of prices and volatility, which highly damaging the expectation of private investors, which are assumed to be the engine for growth. In addition, to tackle the problem of uncertainty different arguments were proposed by different economists. For instance Milton Friedman argued that price indexation can solve the problem of inflation uncertainty. According to his argument price should indexed in consistent manner with which even the wage contract should move along with it to neutralize the effect of inflation uncertainty. On the other hand others think of price indexation as inflationary. This study doesn't recommend price indexation as a solution to the problem at hand rather as an area of further investigation.

Furthermore, Underdeveloped Financial Markets make the instruments as well as the transmission channels less effective. So more attention has to be paid to develop our

financial market and more research needs to be done to identify the constraint and challenges of financial market development in Ethiopia.

Finally, though the study achieved the objectives mentioned lack of quarterly data on many important macroeconomic variables act as a limitation of the study.

REFERENCES

Abdulaziz Bahiru (2008).The Short and Long run Dynamics of Money Supply, Output and Price level in Ethiopia. Ethiopian Development Research Institute, Addis Ababa

Adamgbe, E. (2004). Price volatility, expectations and monetary policy in Nigeria, *CBN Economic and Financial Review* (4) 12-27.

Alemayehu Geda and Kibrom Tafere (2008), The Galloping Inflation in Ethiopia: A Cautionary Tale for Aspiring 'Developmental States' in Africa, Department of Economics, AAU.

Akila,W. (1998).The Performance of Simple Monetary Policy Rules in a Large Open Economy. Stanford University.

Andinet Woldemichael (2008) .Report on The Ethiopian Economy : Food Price Inflation and the Urban Poor in Ethiopia. Ethiopian Economic Association

Apergis, N. (2003).Inflation, Output Growth, Volatility and Causality Evidence from Panel data and the G-7 Countries.

Ball, L. (1992). Why Does Higher Inflation Raise Inflation Uncertainty? *Journal of Monetary Economics,* 29(4):371-78.

Barnichion, R. and Shanaka J.Peiris (2008).source of inflation in sub-saharan Africa. *Journal of African Economies* vol. 17(5):729-746, USA.

Brooks, C. (2002). *Introductory Econometrics for Finance*. Cambridge University Press.

Brunner, A., and G. Hess,(1993). Are Higher Levels of Inflation Less Predictable? A State- Dependent Conditional Heteroskedasticity Approach. *Journal of Business & Economic Statistics*, 11(4):187-197.

Bruno, M., and Easterly, W. (1995). Inflation Crises and Long-Run Growth. NBER Working Paper No. 5209.

Bullard, J. and Keating J. W. (1995). The Long-Run Relationship between Inflation and Output in Postwar Economies. *Journal of Monetary Economics*, Vol. 36, 477-96.

Catherin, D. (2009). Midterm Evaluation of the EFA Fast Track Initative Country Desk Study: Ethiopia.Cambridge Education and Oxford Policy Management.

Chang, K-L., He, C-W. (2010). Does the magnitude of the effect of inflation Uncertainty on output growth depends on the level of inflation? Manchester School 78(2), 126-148.

Chimobi, P. (2010). Inflation and Economic Growth in Nigeria. *journal of sustainable development* Vol.3(2):159-166

Christensen, B. (2011). Have Monetary Transmission Mechanisms in Africa Changed? BIS Papers chapters, volume 56, page 37-61 Banks for International Settlements.

Conrad, C. and Karanasos, M. (2008). Modelling Volatility spillover between the variabilities of US inflation and output: the UECCC GARCH model. Discussion paper series no 473, West London, UK

Cukierman, A. and Meltzer, A. (1986). 'A theory of ambiguity, credibility, and inflation under discretion and asymmetric information', *Econometrica*, Vol. 54, pp. 1099–1128.

Datta, K. and Kumar, C.(2011). Relationship between Inflation and Economic Growth in Malaysia - An Econometric Review, IACSIT Press, Singapore

Dornbusch, R., S. Fischer and C. Kearney. (1996). *Macroeconomics*. The Mc-Graw-Hill Companies, Inc., Sydney

Dotsey, M. and Sarte, P. (2000) .Inflation Uncertainty and Growth in a cash-in-advance Economy. *Journal of Monetary Economics* 45, 631-655.

Enders, W. (1995).*Applied Econometric Time Series*. Iowa State University. John Willey and Sons inc.

Engle, R.F.(1982). Autoregressive Conditional Heterosedasticity with estimates of the Variance of the U.K.inflation. *Econometrica*, 50,987-1008

Engle, R. and Schwert, G. (1990).Alternative Models for Stock Volatility. *Journal of Econometrics,* 45:267-290

Erbaykal, E. and Okuyan, H.A. (2008). Does Inflation Depress Economic Growth? Evidence from Turkey. *International Research Journal of Finance and Economics*, Issue 17, no. 1450-2887

Ethiopian Economics Association. (2011). Report on the Ethiopian Economy. AddisAbaba, Ethiopia

Faria, J. R. and F. G. Carneiro. (2001). Does High Inflation Affect Growth in the Long and Short-Run? *Journal of Applied Economics* 4(1).

Fischer, S. (1981). Towards an understanding of the costs of inflation: II Carnegie-Rochester Conference Series on Public Policy, Elsevier, vol. 15(1):5-41

Fountas, S. and Karansaso, M. (2007).Inflation, output growth, nominal and real Uncertainty: Emperical evidence for G-7. *Journal of international money and finance* 26(229-250), UK

Fransis, X. (2004).The noble memorial prize for Robert F.Engle. *Scandinavian Journal of Economics* 106(165-185) University of Pennsylvania, Philadelphia, USA

Friedman, M. (1977).Nobel Lecture: Inflation and Unemployment. *Journal of Political Economy*, 85(3):451-72.

Glosten,, L. and Runkle,D. (1993). On the relation between the expected value and the volatility of the nominal excess return on stocks. *Journal of Finance,* 48: 1779-1801.

Gokal,V. and Hanif,S. (2004).Relationship between Inflation and Economic Growth. Working paper, Reserve Bank of Fiji

Goldstein, M. and Khan, M.S. (1976) .Large versus small price changes and the demand for imports, IMF Staff Papers, 23, 200-225.

Golob, J. (1993).Inflation, Inflation uncertainty and relative price variability: a survey Federal Reserve Bank of Kansas City Working Paper No 93-15.

Grauwe, P. and Polan, M. (2005). Is Inflation Always and Everywhere a Monetary Phenomenon? *Scandinavian Journal of Economics* 107(2) 239-259

Greene, W. (2003), *Econometric Analysis*, Fifth Edition. Prentice Hall, USA.

Grier, K. and Mark J.(2000).The Effect of Real and Nominal Uncertainty on Inflation and Output growth: some GARCH-M Evidence. *Journal of Applied Econometrics* 15:45-58, John Wiley and Sons, Ltd, USA.

Gujarati, D. (2004). *Basic Econometrics*, Fourth Edition. McGraw-Hill Companies.

Haile Kibret (2001).Monetary Policy and the Monetary Approach to Balance of Payment in Ethiopia. MSc Thesis, Addis Ababa University

Hakan,M., Yaclin,Y. and Yildirim,J.(2011).The Inflation and Inflation Uncertainty Relationship for Turkey: A Dynamic Framework.Springer-Verlag

Henery, M.(1998).Inflation, Uncertainty and Growth in Colombia. IMF Working Paper No. 98/161

Herrero, G. and Vilarrubia, J.(2005). The Laffer curve of macroeconomic volatility and growth: Can it be explained by the different nature of crises? Working Paper.

Holland, A. (1995).Inflation and Uncertainty: Tests for Temporal Ordering. *Journal of Money, Credit, and Banking*, 27(3):827-37.

IMF Report. (2011).World Economic and financial surveys: regional economic outlook, Sub-Saharan Africa. Ethiopia

Joyce, M, (1995).Modeling UK inflation uncertainty: the impact of news and the relationship with inflation, Bank of England Working Paper.

Judson, R. and Orphanides, O (1999). Inflation, volatility and growth. International Finance 2, 117-138.

Kibrom Tafere. (2008). The Sources of the Recent Inflationary Experience in Ethiopia. MSc Thesis. Addis Ababa University

Labonte, M. (2011). Inflation: Causes, Costs and Current Status. Congressional Research Service, USA

Lebow, E. and Rudd, B. (2006). Inflation Measurement. Finance and Economics Discussion Series Divisions of Research & Statistics and Monetary Affairs Federal Reserve Board, Washington, D.C.

Lisman, J.and Sandee, J,(1964). Derivation of quarterly figures from annual data. Applied Statistics vol. 13 (2): 87-90.

Loening,L. Durevall,D. and Yohannes Ayalew Birru.(2009). Inflation Dynamics and Food Price in an Agricultural Economy : The Case of Ethiopia. Working Paper No 347, University of Gothenburg.

Logue, D. and Sweeney, R. (1981). Inflation and real growth: some empirical results. *Journal of Money, Credit, and Banking 13*, 497-501.

Madelbort, B.(1963) .The Variance of certain Speculative Prices. *Journal of .Business* 36:394-419, Harvard University.

Mallik, G., Chowdhury, A.(2001) Inflation and economic growth: evidence from foursouth Asian countries. *Asia-Pasific Development Journal,* 8 (1): 123-135

Mankiw, N. G.(2006). *Principles of Macroeconomics*. (4th ed.) New York: Worth Publishers.

Mladenovic Z. (2009).Relationship between Inflation and Inflation Uncertainty: The Case of Serbia. *Yougoslav Journal of Operations Research* 19(1):171-183

Ministry of Finance and Economic Development (1998). Ethiopia: sustainable Development and Poverty Reduction Paper. Addis Ababa, Ethiopia.

Ministry of Finance and Economic Development (2010).Growth and Transformation Plan for the period 2010/2011-2014/2015.Addis Ababa, Ethiopia

National Bank Annual and Quarterly reports various issues (1991/92-2007/08), Ethiopia.

National Bank of Ethiopia. (2009). Monetary Policy Framework. Economic Research and Monetary Policy Process, Addis Ababa

Nas F. and Perry J (2000).Inflation and Output growth in Turkey, 1963-1999.University of Michigan-Fliny

Neanidis,C. and S. Savva,S.(2010). Macroeconomic Uncertainty, Inflation and Growth: Regime-Dependent Effects in the G7. Centre for Growth and Business Cycle Research, Economic Studies, University of Manchester, Manchester, M13 9PL, UK

Okun A. (1971). The mirage of steady inflation. Brookings Papers on Economic Activity 485–498.

Olayinka, K.and Yusuf, H. (2010).Inflation volatility and economic growth in Nigeria: a preliminary investigation. *Journal of Economic Theory* 4(2):44-49

Phillips, P.C.B. and P. Perron, (1988). Testing for a unit root in time series regression *Biometrika,* vol. 75, pp. 335-346.

Razzak, W. (2002).Monetary policy and forecasting inflation with and without the output gap Discussion paper series, Newzealand.

Reade, J. (2011). Modeling Monetary and Fisical Policy in the US: A Cointegration Approach. University of Birmingham

Rizvi, A. and Bushra Naqvi, B. (2010). Asymmetric Behavior of Inflation Uncertainty and Friedman-Ball Hypothesis: Evidence from Pakistan *The Lahore Journal of Economics 15(2): 1-33*

Robles, L. (2012). Ethiopia: Strengthening the Nutrition Information and Early Warning System. Rapid Social Response Story Series No 11

Saad, F. (2004). Pro-poor fiscal and monetary policies. University of London

Sen, K and Chong,L. (2005).Autoregressive Lag Length Selection Criteria in the Presence of ARCH Errors. Economics Bulletin, 3(19): 1−5

Seleteng,M. (2005). Inflation and Economic Growth: An estimate of an optimal level of inflation in Lesotho, Lesotho

Sidrauski, M., (1967).Rational choices and patterns of growth in a monetary economy. *American Economic Review* 57, 534-544.

Stockman, A. (1981).Anticipated inflation and the capital stock in a cash in-advance Economy. *Journal of Monetary Economics*, Elsevier, vol. 8(3): 387-393.

Teferi Mequaninte (2008).Financing Millennium Development Goal. Belgium university of Antwerp

Teshome.A (2011) Source of Inflation and Economic Growth in Ethiopia: Descriptive Analysis, Ethiopian Civil Service University

Tobin, J. (1965). Money and Economic Growth. *Econometrica,* Vol.33, pp. 671-684.

Totonchi, J. (2011) .Macroeconomic Theories of Inflation. International Conference on Economic and Finance Research, IACSIT press, Singapore.

Ungar, M. and Zilberfarb, B. (1993). Inflation and Its Unpredictability: Theory and Empirical Evidence. *Journal of Money, Credit, and Banking* 25, 709-720.

Yimeserach Aklilu (2005).The Behavior of Money supply in Ethiopia. MSc Thesis, Addis Ababa University.

Zakoian,, J.(1994). Threshold heteroskedastic models. *Journal of Economic Dynamics and Control*, 18: 931-955.

APPENDICES

Appendix 1: VAR Lag length Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: GRGDP INF
Exogenous variables: C
Date: 05/15/12 Time: 12:37
Sample: 1 80
Included observations: 76

Lag	LogL	LR	FPE	AIC	SC	HQ
0	136.3919	NA	9.98e-05	-3.536629	-3.475294	-3.512116
1	154.5208	34.82668	6.88e-05	-3.908443	-3.724438	-3.834906
2	172.5917	33.76398*	4.74e-05*	-4.278729	-3.972054*	-4.156167*
3	176.7478	7.546535	4.75e-05	-4.282836*	-3.853491	-4.111249
4	178.1635	2.496068	5.08e-05	-4.214828	-3.662812	-3.994216

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

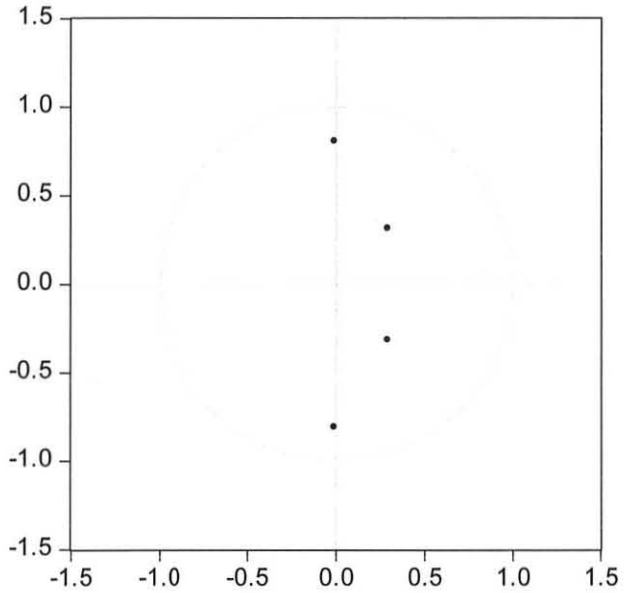
Appendix 2: Roots of Polynomial Characteristics

Roots of Characteristic Polynomial
Endogenous variables: GRGDP INF
Exogenous variables: C
Lag specification: 1 2
Date: 05/15/12 Time: 12:37

Root	Modulus
-0.011106 - 0.807587i	0.807663
-0.011106 + 0.807587i	0.807663
0.289700 - 0.314742i	0.427772
0.289700 + 0.314742i	0.427772

No root lies outside the unit circle.
VAR satisfies the stability condition.

Inverse Roots of AR Characteristic Polynomial



Appendix -3 Test for Serial correlation and Heteroskedasticity

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 05/15/12 Time: 12:38
Sample: 1 80
Included observations: 78

Lags	LM-Stat	Prob
1	6.240525	0.1819
2	1.967567	0.7417
3	1.100568	0.8942
4	3.413711	0.4911
5	4.750440	0.3139
6	6.939296	0.1391
7	1.850667	0.7632
8	1.953214	0.7444
9	5.651555	0.2267
10	3.240715	0.5184
11	5.761720	0.2177
12	1.684663	0.7935

Probs from chi-square with 4 df.

VAR Residual Heteroskedasticity Tests: Includes Cross Terms
Date: 05/15/12 Time: 12:39
Sample: 1 80
Included observations: 78

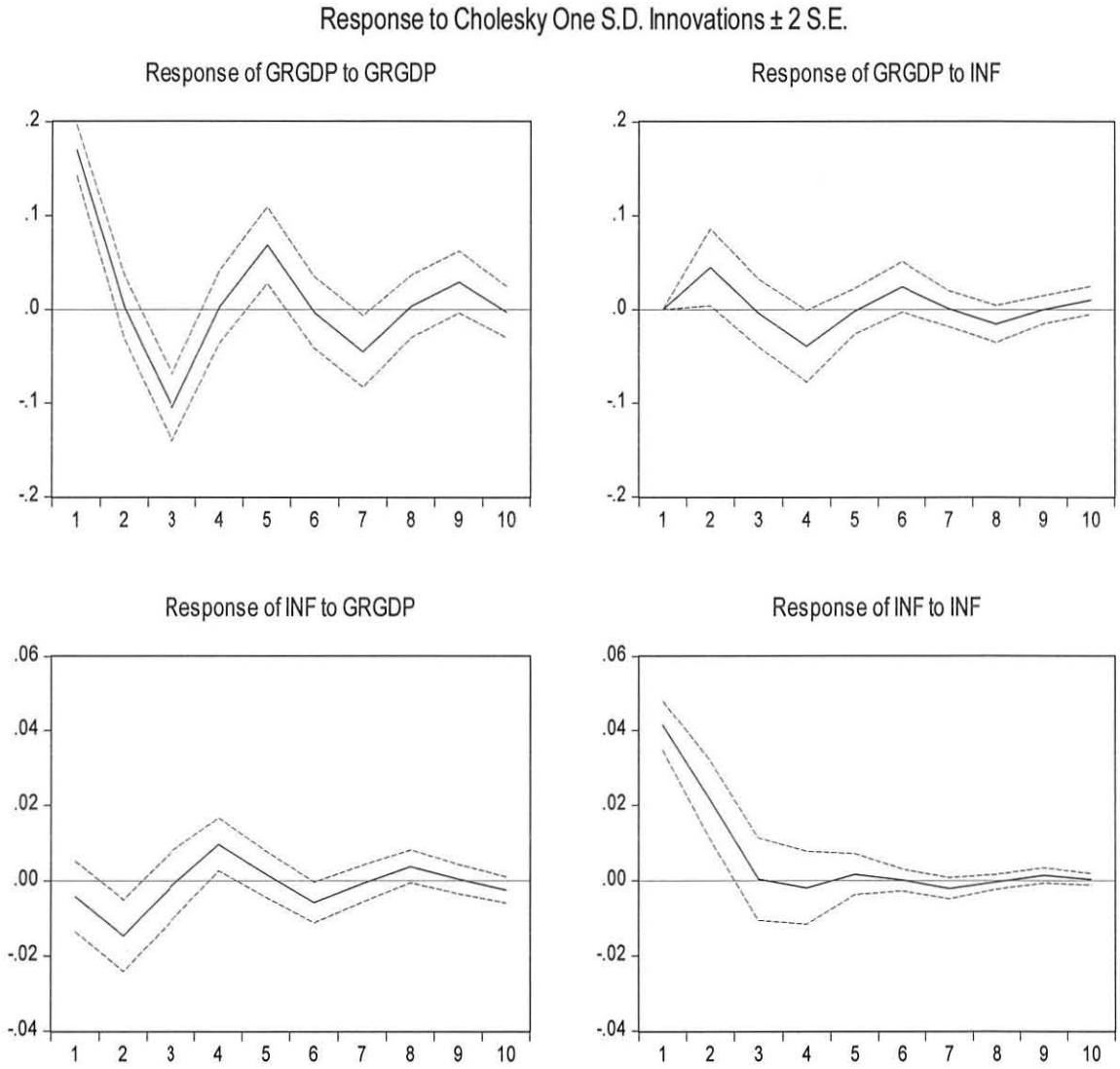
Joint test:

Chi-sq	df	Prob.
52.52607	42	0.1280

Individual components:

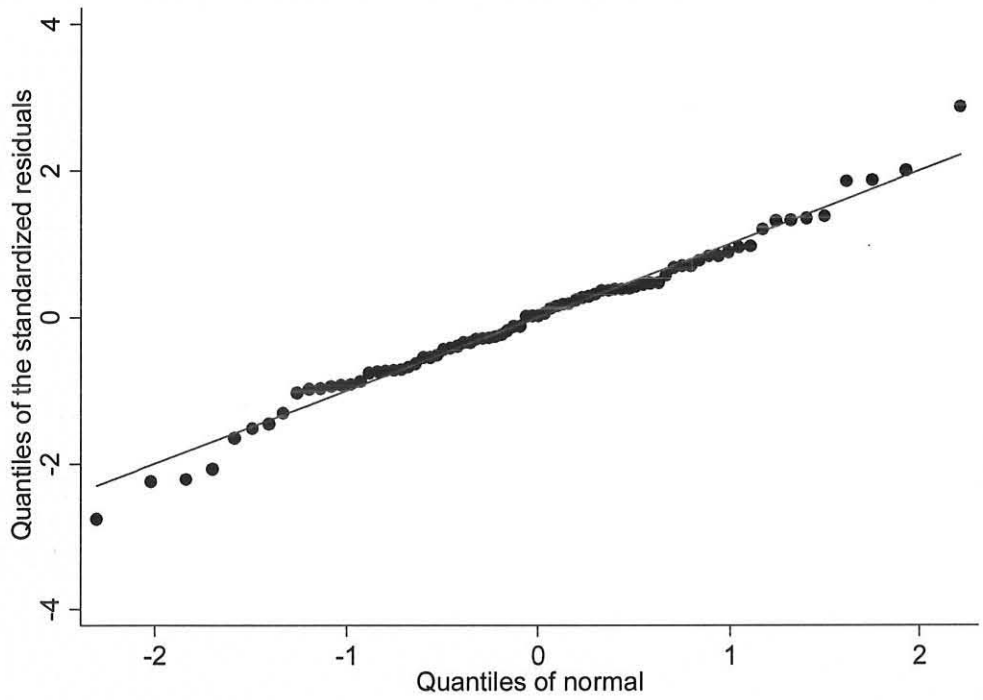
Dependent	R-squared	F(14,63)	Prob.	Chi-sq(14)	Prob.
res1*res1	0.187267	1.036875	0.4304	14.60684	0.4055
res2*res2	0.249830	1.498642	0.1379	19.48676	0.1472
res2*res1	0.146165	0.770338	0.6960	11.40085	0.6543

Appendix 4 Impulse Response Function



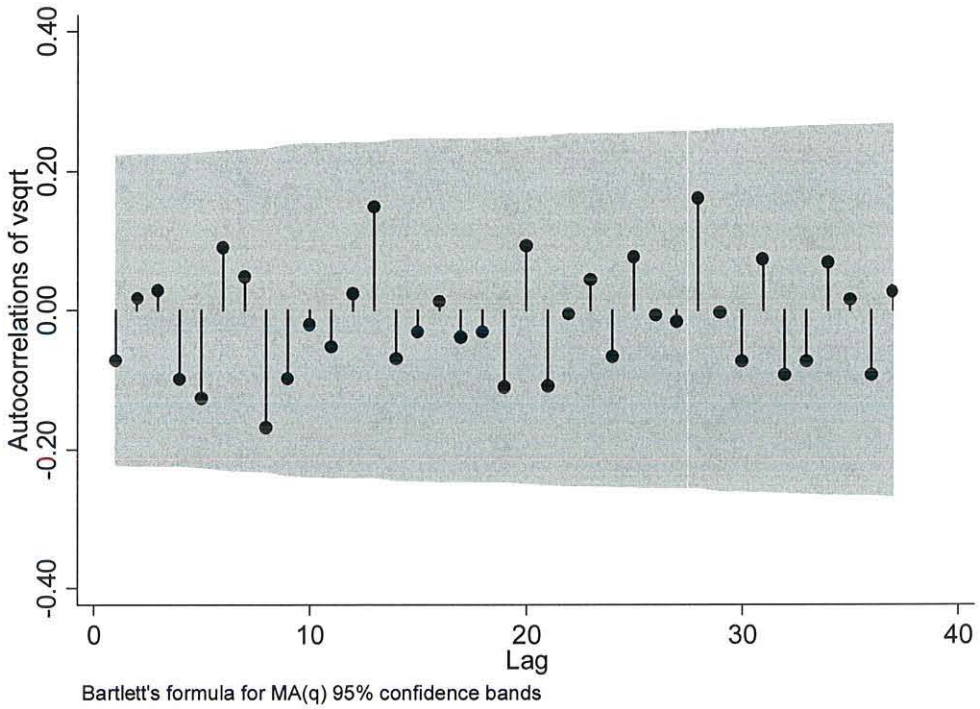
Appendix 5 - GARCH diagnosis Tests

Graph of Normality of the Standardized Residuals



The standardized Residuals are normally distributed except few deviation at the tails

Adequacy of the Variance Equation



The standardized square residual is a white noise suggesting that the variance equation is adequate.

Annex Six : -Generation of quarterly GDP from Annual GDP

(Directly Taken from Haile Kibret-NBE paper of "BOP and monetary policy")

Agricultural GDP

Ethiopian GDP is highly affected by seasonality of agricultural harvest. This is mainly due to the fact that agriculture is rain fed. The structure of agriculture harvest is divided in to main harvest, which account about 95% of the total agriculture GDP, and the belg harvest that accounts for the balance. According to information obtained from CSA, anything harvested between September & January is classified as main harvest; And the rest are belg harvested. Moreover, a survey by CSA has also suggested that about 80 % of agricultural GDP are cereals. Studying the behavior of quarterly contribution of the Agricultural sector to the total GDP is computed based on the amount of labor exerted to each activity in the production of cereals for which date is available. The data and the computed coefficient are presented below:

Labor requirement for different activities for selected cereals (in man-days)

	Barley	Wheat	Teff	Maize	Sorghum	Average	Cash
1st ploughing	4	4	5	7	5	5	0.075
2nd ploughing	4	4	5	7	5	5	0.075
3rd ploughing	3	3	5	3	-	3	0.045
Planting, sowing and covering	4	4	6	8	4	5	0.075
1st weeding	15	11	22	20	24	18	0.268
2nd weeding	-	-	-	24	7	6	0.089
Harvesting	13	19	18	9	9	13	0.194
Threshing, Windowing (shelling)	7	10	17	19	9	12	0.179
Total	50	54	78	88	63	67	1.00

Source: - CSA, Development Bank of Ethiopia, and ministry of Agriculture

The allocation of each economy to each activities and the derivation of the coefficients are performed as follows. These coefficients give the quarterly weight of agriculture output. July, August & Sep (Q1) = Sowing and first weeding; Oct, Nov, Dec (Q2) = 2nd weeding & harvesting; Jan, Feb, Mar (Q3) = threshing; April, May, Jun (Q4) = plaughing (1st, 2nd, 3rd).For each quarter the coefficient are: Q1 = 0.075 +0.268 = 0.343, Q2 = 0.089 + 0.194 = 0.283, Q3 = 0.179, Q4 = 0.075 + 0.075 + 0.045 = 0.195. Since the belg season (small rain season) is very small, about 5% relative to the main season, it is ignored.

Service GDP

The services sectors is taken to be represented by the distribution sub-sector and the quarterly seasonal adjustment coefficients are calculated for this sector based on loan disbursement from the banking system. The distributive sub-sector includes trade, hotels & restaurants & transportation & communication. The distributive sub-sectors accounts for about 75% of the total service sector's GDP. It is also believed that the distributive sub-service sectors activity uses bank credit in the form of OD facility & term loans, the time series quarterly disbursement of bank loan to the distributive service sector is available from NBE bulletin & data. For other service, however, the annual data is equally divided in to the 4th quarter because this sub- sector is beloved to be less seasonal sensitivity. The average quarterly disbursed as well as the corresponding ratios are provided in the following table:

Distribution Service	Q1	Ratio	Q2	Ratio	Q3	Ratio	Q4	Ratio
Domestic trade	458.00	0.164	3351.5	0.377	2705.3	0.304	1368.6	0.154
International trade	791.40	0.184	1006.4	0.234	1476.2	0.344	1019.8	0.237
Hotels and Restaurants	300.20	0.258	314.70	0.271	247.40	0.212	299.8	0.257
Transportation and communication	459.10	0.198	598.60	0.258	566.40	0.244	693.1	0.299
Average ratio		0.201		0.285		0.276		0.237
Other services	0.25	0.25		0.25		0.25		0.25

N.B:-other service: - inclusive banking, industries, administration, defense, justices, Educ, heath & like. **Source**: various issues of NBE

Industrial GDP

Regarding to industrial Sector, the coefficient for seasonality of industry in the total GDP are computed from quarterly production data compiled by MEDaC on twenty eight manufacturing public enterprises which data is available since fiscal year 1993 the coefficient are,

Total	Ratio
Q1= 1162178	0.217
Q2 =1385103	0.259
Q3= 1412160	0.265
Q4 =1388841	0.259
Total 5348282	1.00

After getting the coefficient of agriculture, industry and service sector, for each Q, we multiply the annual GDP by each coefficient to get quarterly sectoral value & then add them to generate the quarterly annual GDP.

DECLARATION

I, the undersigned, declare that this is my original work & has not been presented for a degree in any other university and that all sources of materials used for the thesis have been duly acknowledged.

The examiners' comments have been duly incorporated.

Declared by:-

Name: Eden Shiferaw_kefyalew

Signature: 

Date: June 25, 2012

Confirmed by Advisor:

Name: Fantu Guta(Phd)

Signature: 

Date: 25/06/12

Place and date of submission:

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