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AN EMPIRICAL INVESTIGATION ON THE RELATIONSHIP BETWEEN INFLATION AND ECONOMIC GROWTH IN ETHIOPIA

BY

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ACRONYMS

AD-AS	Aggregate demand –Aggregate supply
ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
CPI	Consumer Price Index
DF	Dickey Fuller
ECA	Economic Commission for Africa
ECM	Error Correction Model
GDP	Gross Domestic Product
HQ	Hannin Quin Information Criterion
IMF	International Monetary Fund
MOFED	Ministry of Finance and Economic Development
NAIRU	Non-Accelerating inflation Rate of Unemployment
NBE	National Bank of Ethiopia
OLS	Ordinary Least Square
PP	Pillips Parron Test
R&D	Research and Development
SAPs	Structural Adjustment programs
SC	Schwartz Information Criterion
UVAR	Unrestricted Vector Auto regression
VAR	Vector Auto regression
VEC	Vector Error Correction
WB	World Bank
WDI	World Development Indicator

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ABSTRACT

Generally, high and stable output growth and low inflation are the two main goals of macroeconomic policy. Therefore, it is important to investigate the existence and nature of the link between inflation and growth as a major objective of the study.

The data used are annually from 1991 to 2014 on inflation(as measured by percentage change of consumer price index) and economic growth (as measured by percentage change on annual real gross domestic product). The unit root result shows that the variables are stationary at first difference or they are I (1). The lag length using AIC, SC, HQ shows one lag.

The co integration relations were identified by applying Johansen's co integration tests. The result of Johansen test indicates the existence of one co integration relation between the variables, meaning there exist a long run relationship between economic growth and inflation in Ethiopia.

The Vector Error Correction (VEC) model of lag one with one co integration equations best fits the data. Vector error correction estimates indicate that there is no any short run relationship between economic growth and inflation. The error correction term (speed of adjustment towards equilibrium) shows that any disequilibrium will adjust back to equilibrium by about 80.3%. This shows whatever any deviation from the long run equilibrium will rapidly adjusted or returns back to its equilibrium.

The potential causal relations were examined by employing Granger's causality tests and the result showed that the causality running from economic growth to inflation, while inflation does not have predicting power about economic growth.

Keywords: Inflation, Economic Growth, Co-integration, Vector Error correction model and Granger Causality analysis

1. INTRODUCTION

1.1 Background of the Study

Ethiopia has recorded seventeen years of economic stagnation under the leadership of the Derg, a military government. For example, in 1990/91, the growth rate of the Ethiopian Gross Domestic Product (GDP) was -3.2percent, cyclical unemployment was about 12 percent, the rate of inflation was about 21 percent, and the country's budget was at a deficit of 29 percent of GDP. However its growth in the last decade, and in particular in the second half of the decade, has been appreciated by international observers, including the continental economic institutions such as the Economic Commission for Africa (ECA, 2007). The government has began to openly argue that its success is fundamentally related to its rejection of the 'neo-liberal' economic policy which is usually referred as the 'Washington Consensus' or Structural Adjustment Policies (SAPs). The government also attributes this growth success to its embrace of the idea of a 'developmental state', the latter usually referring to a policy of public sector intervention in the economy both through policy and active investment. Unfortunately this 'success' is being accompanied by an alarming level of inflation. (Tadesse, 2008; Demissie, 2008)

It is also true that Ethiopian economy has been characterized by erratic nature of output growth as the economy has been highly dependent on vagaries of nature and external shocks. Since agriculture accounted for over 50 percent of GDP for most of the recent past, whenever weather conditions turned to be unfavorable, agricultural production contracted and GDP followed suit. With this systematic relationship between GDP (output) and rainfall there followed a systematic price trend. Prices followed the inverse of output growth trend. During years of good rainfall as output rises prices often dropped considerably. Even within any particular year prices have been lower during harvest periods (Alemayehu, 2008).

However, generally inflation in Ethiopia was not as such an issue before the year 2002/03. Before this period the government exercised tight fiscal and monetary policies which were institutional inheritance from previous regimes. However, in the post 2002/03 period inflation began to appear as a major problem following the government's move towards less conservative monetary and fiscal policy and state activism as a developmental state in the economy breaking the institutional legacy of fiscal and monetary policy conservatism. During the same period, the economy is reported to have recorded a fast growth, export receipts have increased substantially and domestic tax revenue has increased. Government expenditure has also grown considerably. There has also been fast increase in money supply mainly as a result of growth in fiscal deficits (Alemayehu Geda and kibrom, 2011).

Stated in simple words, Ethiopia at this juncture is faced with an overheating economy. With the global soaring price of oil, wheat, corn, and minerals, this condition cannot be regarded as unique to the Ethiopian situation. What makes this a special case is that Ethiopia is a low-income country. The increase in National Consumer Price Index (the main gauge of inflation) has become very detrimental to the low-income groups and retirees who live off a fixed income. The risk of inflationary pressure is reducing the purchasing power of the Ethiopian birr. It is also known that inflation leads to uncertainty about the future profitability of investment projects especially, which have long gestation period. The increased price variability may lead to an increase in cost of production and less profitability. Inflation imposes negative externalities on the economy, when it gets in the way with an economy's efficiency. Besides this, inflation may lead to uncertainty about the future profitability of different investment projects. It may also reduce the country's international competitiveness. When there is an increase in the cost structure and price level, the international competitiveness of the country also may be adversely affected by making its export prices more expensive than the prices of the competitors, and thus, adversely affect the balance of payments. The inflation undermines the confidence of domestic and foreign investors about the future course of monetary policy. Besides this, inflation also affects the accumulation of other determinants of growth like investment on growth and investment on Research and Development (R&D). Since the current inflation rate in Ethiopia was "almost 22.8 percent (WDI, 2013).

This indicates with an increasing current economic growth with an inflationary pressure. Therefore, studying the linkage between Inflation and economic growth will enable us to understand the current inflation- growth trend and relationship in Ethiopia.

1.2. Statement of the Problem

It is now widely accepted among economists, policy makers and central bankers that the main objective of macroeconomic policies is to achieve a high economic growth rate while maintaining a low inflation rate. It is also generally believed that high inflation is detrimental to medium and long-run economic growth. Not surprisingly, the existence and the nature of the relationship between inflation and economic growth have become the subject of an extensive body of theoretical and empirical studies (Temple, 2000).

Since, high and stable output growth and low inflation are the two main goals of macroeconomic policy, it is important to investigate the existence and nature of the link between inflation and growth. In this regard there have been different theories and empirical evidence. From earlier economist theories, Classical economics recalls supply-side theories, which emphasis the need for incentives to save and invest if the nation's economy is to grow, linking it to land, capital and labor. Keynesian and Neo-Keynesian theory provided a more comprehensive model for linking inflation to growth under the AD-AS framework. Monetarism updated the Quantity Theory, reemphasizing the critical role of monetary growth in determining inflation, while Neo-classical and Endogenous Growth theories sought to account for the effects of inflation on growth through its impact on investment and capital accumulation. Each has done their respective contribution to the inflation-growth relationship.

Moreover, recent macroeconomics research result shows the positive short-term relationship between the rate of increase in prices, and output. And also there has been an exploration into the nature of the long-term relationship between inflation and growth in output. Recent Developments in growth theory have resulted in both a theoretical and an empirical analysis of the effect of inflation on long-term growth. Theoretically the relationship has been located in the effect of inflation on investment. If investment is assumed to be the engine of growth in a model of endogenous growth, an adverse impact of inflation on investment implies an inverse relationship between inflation and growth. Empirical evidence supports the hypothesis of an inverse relationship between inflation and long-term growth. This is in contrast to the short-term experience, where inflation and output growth occur together.

Motivated by these controversial theoretical and empirical evidence on inflation and growth relationship, this paper try to examine the empirical relationship between inflation and economic growth of Ethiopia both in the short run and long run especially focused on establishing a casual linkage between them, that is to prove whether there is a bidirectional, unidirectional or no any relationship at all in the case of Ethiopia.

1.3. Significance of the Study

The study can serve different purposes beyond its academic goal. It is very important to macroeconomists, financial analyst, policy makers, planners and central bankers officials in understanding the responsiveness of GDP to the change in general price level and vice versa and thus come up with the relevant policies so as to keep prices at the reasonable rate that stimulate production. It is necessary to policy makers to clear doubt as many studies on the relationship between inflation and economic growth remains inconclusive, several empirical studies confirm the existence of either a positive or negative relationship between these two macroeconomic variables.

Therefore, the outcomes of the study will fill the gap in existing knowledge by analyzing the casual relationship between inflation and economic growth of the country. Moreover it helps those who are interested to undertake a study on the area.

1.4. Objective of the Study

1.4.1 Main objective

The primary objective of this study is conducting an empirical investigation on the relationship between inflation and economic growth in Ethiopia using time series data between 1991 and 2014.

1.4.2 Specific objective

To achieve this primary objective, the following **specific objectives** have been developed:

- To assess the Structure and Trends of Inflation and Growth in Ethiopian
- To determine the short-run and long-run relationship between inflation and economic growth,
- To establish the causal link between inflation and economic growth in Ethiopia,
- To suggest some policy recommendations to macroeconomic policymakers in general and Ethiopia in particular

1.5. Hypothesis of the Study

In this study the empirical relationship between inflation rate and economic growth in Ethiopia will be investigated. The testable hypotheses are that:

Null Hypothesis:

- ✓ Inflation rate and economic growth have no any significant short run and long run relationship.

Alternative Hypothesis:

- ✓ Inflation rate and economic growth have significant short run and long run bidirectional relationship

1.6. Scope of the Study

The study is focused on Ethiopia's in relationship between inflation and economic growth which is supposed to be a serious problem facing the country. The study will cover the time period from 1991 up to 2014. It investigates the short run and long run relationship. The period was chosen because it can explain the inflationary trend experienced in Ethiopia recently. . It also tries to show the trend as well as casual relationship between the two variables.

1.7. Limitation of the Study

The main limitation of the study is data fitting problem, this is due to the presences of outlier. The other problem is luck of enough time by the researcher.

The econometric result of this study is also limited by the quality of the data. This limitation arises from the problem of inconsistency of data as reported by different institutions and even by different departments in the same institution as well as poor record keeping.

1.8. Organization of the Study

The study is organized into five chapters. Following the introductory chapter, Chapter two gives a review of theoretical and empirical literature on inflation and economic growth and an overview of inflation and economic growth also assessed in this chapter, followed by Chapter three, which discusses the methodology. Chapter four deals result and discussion of results. Finally, Chapter five presents' conclusions of the study and recommendation will be forwarded.

2. LITERATURE REVIEW

2.1 Theoretical Relationship between Inflation and Economic Growth

Economic theories reach a variety of conclusions about the responsiveness of output growth to inflation. That is there is no any theoretical study that presents a clear relationship between economic growth and inflation. Theories are useful, as they account for some observed phenomenon. Historically, in the absence of what is termed 'persistent inflation', the early inflation-growth theories were built on cyclical observations. Persistent inflation is regarded as a post World War II phenomenon. Before then, bouts of inflation were followed by bouts of deflation. Having showed no upward or downward trend, inflation was said to behave like a 'lazy dog'. It stays at a particular level unless and until there is a disturbance. Thereafter, it moves to another level, at which it settles. Theory, therefore sought to account for a positive correlation between inflation and growth. That is before 1936, the economic theory was influenced by an idea which says market forces play major role in stabilizing the price of goods and services. According to this thought (classical economic thought), any surplus/deficit output reduces/increase price and maintains stable price. But this argument was criticized when the USA economy faced a great depression. Then since 1927, the country experienced higher price rise (inflation), higher unemployment rate and surplus production. In 1936, the high government involvement was suggested to adjust the market failure. One of the instruments for the involvement of government was fiscal policy that is higher government spending to increase investment and employment opportunity. This argument believes that inflation and economic growth have positive relationships. The higher government spending in various activities stimulates higher consumption or investment spending which attracts higher price for goods and services in the economy. The higher desire for spending encourages producer to produce goods and services that demanded by the consumers. Such situation enables the country to achieve economic growth with higher inflation.

The Traditional Keynesian model comprises of the aggregate supply-aggregate demand (AS-AD) framework also postulated a positive relationship between inflation and growth where, as growth increased, so did inflation. The Traditional Keynesian model comprises of the Aggregate

Demand (*AD*) and Aggregate Supply (*AS*) curves, which illustrate the inflation-growth relationship. According to this model, in the short run, the (*AS*) curve is upward sloping rather than vertical, which is its critical feature. If the *AS* curve is vertical, changes on the demand side of the economy affect only prices. However, if it is upward sloping, changes in *AD* affect prices and output, (Dornbusch, et al, 1996). This holds with the fact that many factors drive the inflation rate and the level of output in the short-run. These include changes in: expectations; labor force; prices of other factors of production, fiscal and/or monetary policy. In moving from the short-run to the hypothetical long-run, the above-mentioned factors, and its 'shock' on the 'steady state' of the economy are assumed to balance out. In this 'steady state' situation, 'nothing is changing', as the name suggests. The 'dynamic adjustment' of the short-run AD and AS curves yields an 'adjustment path' which exhibits an initial positive relationship between inflation and growth,

Monetarism has several essential features, with its focus on the long-run supply-side properties of the economy as opposed to short-run dynamics. Milton Friedman, who coined the term "Monetarism", emphasized several key long-run properties of the economy, including the Quantity Theory of Money and the Neutrality of Money. The Quantity Theory of Money linked inflation and economic growth by simply equating the total amount of spending in the economy to the total amount of money in existence. Friedman proposed that inflation was the product of an increase in the supply or velocity of money at a rate greater than the rate of growth in the economy. Friedman also challenged the concept of the Phillips Curve. His argument was based on the premise of an economy where the cost of everything doubles. Individuals have to pay twice as much for goods and services, but they don't mind, because their wages are also twice as large. Individuals anticipate the rate of future inflation and incorporate its effects into their behavior. As such, employment and output is not affected. Economists call this concept the *neutrality of money*. Neutrality holds if the equilibrium values of real variables -including the level of GDP – are independent of the level of the money supply in the long-run. Super neutrality holds when real variables - including the rate of growth of GDP - are independent of the rate of growth in the money supply in the long-run. If inflation worked this way, then it would be harmless. In reality however, inflation does have real consequences for other, macroeconomic variables. Through its impact on capital accumulation, investment and exports, inflation can adversely impact a country's growth rate.

In summary, Monetarism suggests that in the long-run, prices are mainly affected by the growth rate in money, while having no real effect on growth. If the growth in the money supply is higher than the economic growth rate, inflation will result.

From the Neo-classical Theory, Mundell (1963) was one of the first to articulate a mechanism relating inflation and output growth separate from the excess demand for commodities. According to Mundell's model, an increase in inflation or inflation expectations immediately reduces people's wealth. This works on the premise that the rate of return on individual's real money balances falls. To accumulate the desired wealth, people save more by switching to assets, increasing their price, thus driving down the real interest rate. Greater savings means greater capital accumulation and thus faster output growth. Tobin (1972) suggests that inflation causes individuals to substitute out of money into interest earning assets, which leads to greater capital intensity and promotes economic growth. In effect, inflation exhibits a positive relationship to economic growth. Stockman (1981) developed a model this cash investment as a cash-in-advance restriction on both consumption and capital purchases. Since inflation erodes the purchasing power of money balances, people reduce their purchases of both cash goods and capital when the inflation rate rises. Correspondingly, the steady-state level of output falls in response to an increase in the inflation rate.

Neo-Keynesians initially emerged from the ideas of the Keynesians. One of the major developments under Neo-Keynesianism was the concept of 'potential output', which at times is referred to as natural output. This is a level of output where the economy is at its optimal level of production, given the institutional and natural constraints. This level of output also corresponds to the natural rate of unemployment, or what is also referred to as the non-accelerating inflation rate of unemployment (NAIRU). NAIRU is the unemployment rate at which the inflation rate is neither rising nor falling. In this particular framework, the 'built-in inflation rate' is determined endogenously, that is by the normal workings of the economy. According to this theory, inflation depends on the level of actual output (GDP) and the natural rate of employment.

Endogenous growth theories describe economic growth which is generated by factors within the production process, for example; economies of scale, increasing returns or induced technological change; as opposed to outside (exogenous) factors such as the increases in population. In endogenous growth theory, economic growth rate depends on the rate of return on capital; since inflation acts as a tax, it decreases the real rate of return, it follows that inflation impedes capital accumulation and hence decreases growth rate (Fama and Schwert, 1977; Boyd et al., 1996).

Inflation causes real appreciation of the domestic currency and reduces international competitiveness by making exports more expensive; in a country with fixed exchange rate, inflation would lead to the deterioration of the trade balance and capital outflow and impact negatively on the long-term economic growth (Dollar, 1992; Easterly, 1999). Moreover, the inflation can interact with the tax system to distort borrowing and lending decisions, raising the cost of capital and reducing the real rate of return, so discouraging investment and hence reducing economic growth (Feldstein, 1982; Jones and Manuelli, 1993).

Recently many economists started to believe that the relationship between inflation and economic growth is not linearly related. Espinosa and Yip (1999) reviewed the interaction between inflation and growth using model of endogenous growth with explicit financial intermediation.

In general from the theoretical models discussed above, it is clear that the results depend on the assumption about the economy identified and also depend on the set up of the models. All the models try to make their conclusion and policy implication in line with economic theories. Accordingly, inflation may have positive, negative, neutral or non linear relationship on economic growth in these theoretical models. Therefore, in line with this theoretical framework the researcher also motivated on this issue.

2.2. Empirical Literature

In this sub-section, a detailed review of international and national empirical research papers and articles have been conducted. The review is, therefore, presented precisely in two parts as follows. The first part presents the empirical works in other parts of the world and the second part is about research works conducted specific to Ethiopia.

2.2.1 Empirical review at international level

Up until the mid of 1970s there was little empirical evidence for any relationship between inflation and economic growth and even there were doubts in which direction the relationship should be. Like the theoretical models, results of empirical studies change through time from the widely known traditional point of view of positive relationship between inflation and economic growth to non linear relationship in recent years. Now many economists are convinced that low but positive inflation is good for the betterment of a given economy.

The traditional point of view does not consider inflation as an important factor in growth equation. Gillman and Nakov (2003) studies effects of inflation within an endogenous growth monetary economy. The result shows that accelerating inflation raises the ratio of the real wage to the real interest rate, and so raises the use of physical capital relative to human capital across all sectors. Their result is consistent with a general equilibrium, Tobin-type, effect of inflation on input prices and capital intensity.

Nevertheless, the traditional point of view changed when high and chronic inflation was present in many countries in the 1970s. As a result, different researchers showed that inflation has a negative impact on output growth. Fisher (1993) has investigated the link between inflation and growth in time-series, cross section and panel data sets for a large numbers of countries. The main result of these works is that there is a negative impact of inflation on growth.

Recently, numerous empirical studies found that inflation growth interaction is non linear and concave. Bruno and Easterly (1995) defining a period of inflation crisis as a period when inflation rate exceeds 40 percent, try to assess how the country perform before, during and after the crisis period. The result shows at higher level of inflation, there is a negative relationship between inflation and economic growth in which the cost of inflation will be higher. At smaller and moderate level of inflation the result is ambiguous which shows no consistent pattern. They believe that there will be recovery of the economy if there is successful reduction in inflation after the crisis.

Ghosh and Phillips (1998) use the panel regressions and combine a nonlinear treatment to estimate the relationship between inflation and growth for 145 countries over a period of 1960 to

1996. The results establish a statistically and economically negative relationship between these two variables. Besides this, the decision–tree technique identifies inflation as one of the most important determinants of growth. However, this study does not claim to precisely a ‘Growth-Maximizing Rate’ of inflation.

Girija and Anis (2001) use co-integration and error correction models to empirically test the long run and short run dynamics of the inflation-economic growth relationship for the four South Asian Countries viz., Bangladesh, India, Pakistan and Srilanka. Using the Annual Data, this study finds that there is long run positive relationship between growth and inflation. Further, the sensitivity of inflation to changes in growth rates is larger than that of growth to changes in inflation rates of all the selected countries. These findings have significant implications. This study concludes that inflation is helpful to growth, but faster economic growth feeds back into inflation. Thus, these countries are on a knife-edge. The challenge for these selected South Asian countries to find a growth rate which is consistent with a stable inflation rate, rather than beat inflation first to take them to a corridor of faster economic growth.

Hasan (2001) examines how inflation affects the economic growth in Turkey. This study uses Unrestricted Vector Autoregression (UVAR) technique to estimate a four variable system and concludes that Turkey faced the cost of high inflation in terms of lower economic growth. The findings of this study establish the fact that inflation adversely affected both private investments and the economic growth in Turkey.

Gokal and Hanif (2004) review several economic theories to ascertain consensus on the inflation-growth relationship and the empirical literature developed recently on this issue. This study tests whether a meaningful relationship held in case of Fiji. In order to estimate the effect of inflation on the economic growth, regression equations are used, in which many other determinants of growth are held constant. The structure of the study is based on an extended view of the neoclassical models as described by Barro and Sala-I-Martin. The findings indicate a weak negative correlation between inflation and growth, while the change in output remains significant. The results proves that the causality between the two variables run one-way from GDP growth to inflation.

Veni and Choudhury (2007) examined the relationship between inflation and growth of the Indian economy during 1981-2004 by applying causality and co-integration test. The results of the causality test prove that growth and inflation are independent of each other in India. The results of the co-integration test confirm the fact that the two variables inflation and growth are not co-integrated. Therefore, it is evident that there is no long run relationship between these two variables in India.

Salian, and Gopakumar. K2 (2011) examined the relationship between inflation and GDP growth in India. Empirical evidence is obtained from the co-integration and error correction models using annual data collected from the Reserve Bank of India. The result shows that there is a long-run negative relationship between inflation and GDP growth rate in India. According to the result inflation is harmful rather than helpful to growth.

Ayyoub, Farooq and Chaudhry (2011) analyze empirically the impact of inflation on GDP growth of the economy in Pakistan on annual time-series data for the period 1972-73 to 2009-10 by employing the method of Ordinary Least Squares (OLS). A negative and significant inflation growth relationship has been found to be existed in the economy of Pakistan. The results of the study show that prevailing inflation is harmful to the GDP growth of the economy after a certain threshold level.

Niyimbanira (2013) used annual secondary data to examine the interactions between inflation and economic growth in South Africa during the period of 1980-2010. The existence of a co-integrated relationship between inflation and economic growth is also tested using Johansen-Juselius co-integration technique. After confirming that a long run relationship between these two variables does exist, an extra effort was made to investigate the causality relationship by employing the Granger causality at two and four lag periods. The findings showed that uni-directional Causality is seen running from inflation to economic growth at both lag 2 and 4.

Mwakanemela (2013) examined the impact of inflation on economic growth and established the existence of inflation growth relationship. Time-series data for the period 1990 -2011 were used to examine the impact of inflation on economic growth. Correlation coefficient and co-integration technique established the relationship between inflation and GDP and Coefficient of elasticity were applied to measure the degree of responsiveness of change in GDP to changes in general price levels. Results suggest that inflation has a negative impact on economic growth. The study also revealed that there was no co-integration between inflation and economic growth during the period of study. No long-run relationship between inflation and economic growth in Tanzania.

2.2.2 Empirical Studies: Inflation and Economic Growth in Ethiopia

Literatures on the issue of inflation and economic growth in Ethiopia are not many. Most of the papers focus on the source and impacts of the current rampant inflation in the country. However, methodologies of most of the studies are theoretical description with individual argumentations.

Getachew (1996) in his study of inflation in Ethiopia using monthly data from July 1990 to February 1995 found that in the short run money stock has been significant determinant of inflation in Ethiopia. In the long run he founds that inflation in Ethiopia is determined by supply factors. He recommends that in the short run controlling money supply is important to control inflation while in the long run he suggests that removing the bottlenecks of the supply side of the economy should be policy priority. The short conclusion of Getachew is supported by the findings of Yohannes (2000) in which money supply is the basic determinant of inflation in Ethiopia. He also shows that inflation inertia and world inflation level affect the country's inflation in the short run. Yohannes argues that controlling inflation is not the feasible policy instead the government should have to focus on solving the supply side problem of the economy.

Loening and Takada (2008) study the dynamics of inflation in short run using error correction model fitted with monthly observations. The result shows that increased money supply and the nominal exchange rate significantly affect inflation in the short run and that monetary policy in Ethiopia triggers price inertia, which has large and persistent effects. A simulation suggests that monetary policy alone may be unfeasible to control inflation effectively. To circumvent an extreme tightening with discouraging impacts on growth, additional measures are needed. These should improve the transparency and credibility of monetary policy, and reduce structural barriers that affect price formation and market efficiency.

Alemayehu Geda and kibromTafere (2008) analyzed the forces behind the current inflationary experience in Ethiopia. To this end a synthesis monetarist and structuralism model of inflation were developed. The model estimated using vector autoregressive (VAR) formulation for the period 1994/95 to 2007/08 using quarterly data. They studied on the determinants of inflation for food and non-food sectors differently in the short and long run as well. The most important forces behind food inflation in the long run are a sharp rise in food demand triggered by an alarming rise in money supply/credit expansion, inflationary expectation and international food price rise. The result also shows that the long run determinants of non-food inflation, on the other hand, are money supply, interest rate and inflation expectations. In the short run model, wages, international prices, exchange rates and constraints in food supply are found to be prime sources of inflation.

Asayehgn Desta (2009) analyze on Economic Growth for Inflation: the Ethiopian dilemma. To determine the factors that have contributed to inflation in Ethiopia, time series data (1991/2 to 2006/7) were used based on the multiple regressions. He used as the main determinants of inflation in Ethiopia are imports, depreciation of the Ethiopian birr, and a decline in the domestic lending interest rates or an increase in broad money supply. He concludes that to successfully jump out of the inflationary trap, the Ethiopian monetary authorities need to tighten the stock of money in the country that is a tight monetary policy could serve as an anchor for inflationary pressure in Ethiopia. Finally he stated that economic policymakers design strategies that could curtail the on-going erosion of purchasing power to curb inflation before it deepens the economic crisis and contributes to political instability.

Durevall, Loening and Birru (2010) develop error correction terms that measure deviations from equilibrium in the money market, external sector, and agricultural market to evaluate the impact on inflation of excess money supply, changes in food and non-food world prices, and domestic agricultural supply shocks in Ethiopia. Even though the paper is not about the relationship between inflation and growth, it is important mentioning it here. Their primary purpose is to show the determinants of the current rampant inflation in the country. Since Ethiopia is a developing country with large agriculture sector dominance, it is crucial to give due emphasis to food inflation. The result shows that overall inflation in Ethiopia is closely associated with agriculture and food in the economy, and that the international food crisis had a strong impact on domestic food prices in the long run. An agricultural supply shock affects food inflation in short run. The evolution of money supply does not affect food prices directly, though money supply growth significantly affects non-food price inflation in the short run.

Teshome A. (2011) explains the relationship between inflation and economic growth in Ethiopia using statistical analysis, even though the method he applies for the analysis is open to critique. Accordingly, he states that it is difficult to specify the exact relationship between inflation and growth. However, one must study the structure of government spending and the nature of economic growth. By comparing the rate of inflation and economic growth of Ethiopia to that of Sub Saharan Africa, he explains how inflation affects economic growth through time. Using statistical comparison of the rate of inflation and economic growth, he tries to figure out the relation between them from 2004 to 2010. Accordingly, inflation affects economic growth nonlinearly in the country. Between 2004-2006 inflation and economic growth has positive relationship while from 2006-2008 they have negative relationship. Despite the variation in the magnitude between 2008 and 2010, he states that inflation and economic growth has positive relationship.

Finally, Fekadu Dereje Girma (2012) analyzes the short run and long run relationship between economic growth and inflation for the period 1980-2011. By using Vector Autoregression (VAR) model, the short run relationship between inflation and economic growth is examined. The result shown that, an increase economic growth decreases inflation, whereas inflation does not have significant effect on economic growth in the short run. The researcher included money supply and exchange rate to control their effects on the relationship between inflation and economic growth. Increase in money supply results in a high inflation during the study period while an increase in exchange rate does not have significant effect on inflation. Using a Granger Causality test, the researcher showed that economic growth has forecasting power about inflation while inflation does not have predicting power about economic growth. He also applies Co integration test, the result shows that there exist a long run relationship between economic growth and inflation in Ethiopia. Vector error correction estimates indicate that economic growth significantly reduces inflation in short run while inflation does not have any significant effect on economic growth. If inflation had previously been larger than normal share, then economic growth causes inflation to be lower in the long run.

As it appears in the above empirical literature review, most of the studies on the relationship between inflation and economic growth used cross-sectional or panel data covering a large number of countries and also there are studies on developing countries including Ethiopia by applying time series data. These studies confirmed the existence of inflation and economic growth relationship in positively, negatively and neutrally depended on the country and time specific cases.

2. Trend of Inflation and Economic Growth

Ethiopia is one of Africa's largest countries with an estimated population of 94 million people in 2013. According to the World Bank data, about 38 percent of the population lived below the official poverty line in 2005, but it is likely that a larger proportion experiences extended periods of poverty due to shocks (Bigsten and Shimeles, 2008). Evidence on the welfare impacts of high food inflation on the rural population is somewhat inconclusive, but there is evidence of a significant negative impact on the urban population (Loening and Oseni, 2008).

2.3.1 Trend of Inflation

Inflation in Ethiopia during 1991and1992 was relatively high, but in 1997 and 2001/02 there were a deflation. However, on the other period it showed a fluctuating behavior characterized by successive ups and downs. The impact of CPI food on the trend of CPI is also revealed by the similar trends of general and food inflation. Inflation non-food has also showed ups and downs but its impact on influencing the trend of inflation was minimal. But after 2005/06 non food inflation starts to have similar trends to that of general inflation and influencing the trend of general inflation.

Table 2. 1. Annual average inflation (source NBE)

Year	General	Food	Non-food
1991	20.0	17.9	12.2
1992	21.9	31.0	17.2
1993	7.7	9.2	10.1
1994	3.3	0.0	4.7
1995	13.4	16.8	2.6
1996	0.9	2.3	5.0
1997	-6.4	-8.1	-3.9
1998	3.9	1.0	3.0
1999	4.3	9.9	-2.0
2000	5.4	7.6	2.5
20001	-0.3	-1.7	1.4
2002	-10.6	-19.1	0.3
2003	10.9	21.5	0.2
2004	7.3	11.5	2.2
2005	6.1	7.4	4.4
2006	10.6	13.0	7.1
2007	15.8	17.5	13.5
2008	25.3	34.9	12.5
2009	36.4	44.3	23.7
2010	2.8	-5.4	18.2
2011	18.1	15.7	21.8
2012	34.1	42.9	22.4
2013	7.4	3.7	11.9
2014	8.5	6.2	11

Source: National Bank of Ethiopia

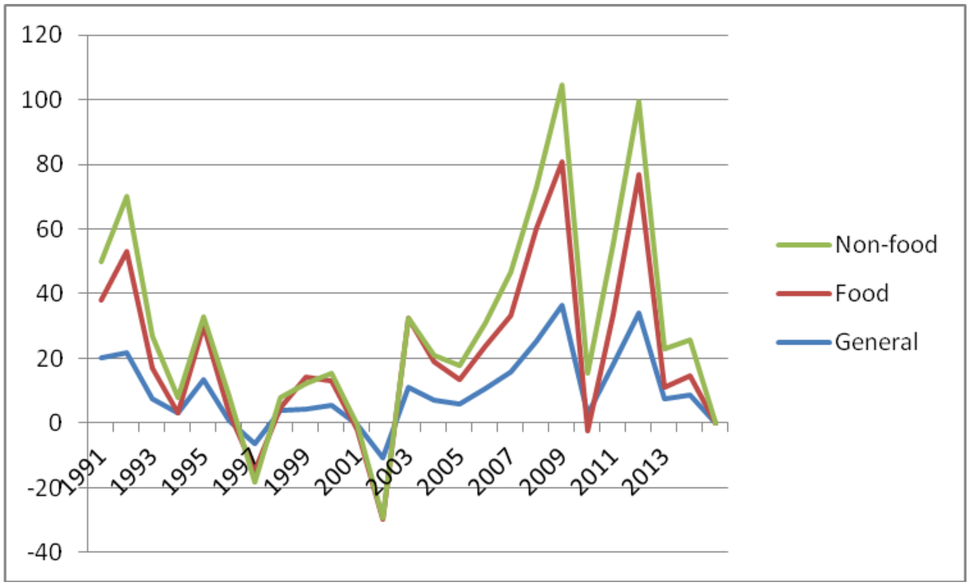


Figure 2. 1 Trend of Inflation in Ethiopia

From the chart we have seen that there is a high fluctuation on non-food inflation as we compared with that of food inflation.

2.3.2. Trend of Inflation and Economic Growth

According to economic theory inflation and output growth go in opposite direction.

In this section, we are interested to examine the historical trends of inflation and GDP growth rate during the study period. A number of severe fluctuations have been observed in CPI inflation and GDP growth of Ethiopia during the period 1991 to 2014.

Table 2.2; Trend of Economic Growth and Inflation in Ethiopia

Year	GDP Growth	Inflation rate (% CPI)
1991	**-2.3**	20.0
1992	11.2	21.9
1993	**0.0**	7.7
1994	5.7	3.3
1995	**10.1**	13.4
1996	4.2	0.9
1997	**-0.8**	-6.4
1998	6.3	3.9
1999	**3.4**	4.3
2000	7.4	5.4
2001	**1.6**	-0.3
2002	-2.1	-10.6
2003	**11.7**	10.9
2004	12.6	7.3
2005	**11.5**	6.1
2006	11.8	10.6
2007	**11.2**	15.8
2008	10.0	25.3
2009	**10.6**	36.4
2010	11.3	2.8
2011	**8.8**	18.1
2012	9.7	34.1
2013	10.3	7.4
2014	10.4	8.5

Source: National Bank of Ethiopia

Based on the available data, the relationship between inflation and economic growth until 2003 is somewhat similar trend even though the level and fluctuation of inflation is high as we compared with the fluctuation of economic growth. However, after 2003 the change in economic growth is almost constant trend as we compared with a high level and volatile in trend of inflation.

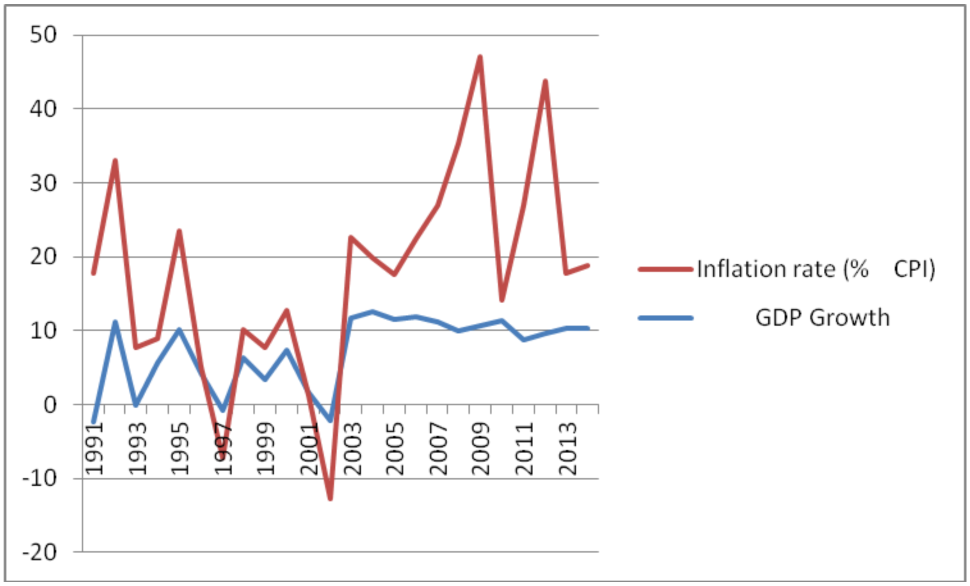


Figure 2.2 Trends in GDP Growth and Inflation in Ethiopia

The above figure reveals that in all years, except 1996 and 2002 where real GDP growth below inflation with high differences. Inflation and real GDP growth rates exceed one another with small amounts interchangeably. But in recent years (starting from 2004) inflation has exceeded output growth with higher difference. The figure also reveals the close association of inflation and real GDP growth. The highest inflation during the study period occurred when output growth was the least. Similarly lowest inflation rate occurred when output growth was the maximum.

The strong and inverse relationship between inflation and output growth is due to the dominance of Agriculture. As a result increased output is accompanied by increased food production; food is the major share holder in the CPI, which intern results in reduced inflation.

In 1991 Ethiopian economic growth was **-2.3** due to political instability that is Ethio - Eritrea war and decline agricultural productivity as a result of bad weather condition. However, after 1992 there was a good progress in economic growth due to better whether condition. In 1993, real GDP growth reached **0.0** percent.

The growth performance is expected to moderate between 1994 and 2001 as a result of improvement in agricultural productivity due to better supply of agricultural inputs and the increase in cultivated land as a result of the resettlement program and the favorable weather condition in the year has also contributed to the performance. But in 2002 it was declined about -2.1%. However, after 2004 there is steady growth. On the other hand inflation has been reached 21.9 percent, which was recorded in 1992, mainly due to the severe drought that hit agricultural production the most and absence of peace in the country and the increase in import prices of fuel and construction materials. The historical peak level of inflation was 36.4% in 2009. A significant deflation was observed during fiscal year 2002 (-10.6 percent) basically due to the decline in food prices associated with bumper agricultural production following the good weather condition of the period.

3. DATA AND METHODOLOGY

3.1 Type and Source of Data

Time serious secondary data were used in the study. The data were collected from National Bank of Ethiopia (annual report and bullet). For the purpose of analyzing inflation and economic growth of Ethiopia, the data will cover the period between1991-2014.

3.2 Methodology

For the proper investigation of the objective of the study, the researcher used econometric model as described below in detail.

3.2.1 Description of main variable

Economic Growth (Growth of real GDP): - is the increasing in the amount of goods and services produced by an economy over time. It is conventionally measured as the percentage rate of increase in real gross domestic products or real GDP.

Inflation: is defined as a sustainable or continuous increase in the general or average price level of goods and service. It is computed as annual percent change of average consumer price index.

3.2.2 Testing Stationary: Unit root test

Empirical work based on time series data assumes that the underlying time series is stationary. Stationary implies that the distribution of a process remains unchanged when shifted in time by an arbitrary value. More formally, a stochastic process is said to be weakly stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap between the two time periods and not the actual time at which the covariance is computed. A time series is strictly stationary if all the moments of its probability distribution are invariant over time. However, the normal stochastic process is fully specified by its two moments, the mean and the variance (Gujarati, 2003).

In times tries process there are two different types of stationary time series models based on whether the trend is deterministic or stochastic. Generally, if the trend in a time series is completely predictable and not variable, we call it a deterministic trend; otherwise we call it stochastic trend. A non-stationary variable of stochastic trend can be transformed into a stationary model by differencing and a non stationary variable of deterministic trend may be eliminated by de-trending (regressing it on time) to make it stationary. A series problem is encountered when inappropriate method is used to eliminate trend. It is important to note that most macroeconomic time series are difference stationary process than trend stationary process (Thomas, 1997: Gujarati, 2003).

Whether a variable is stationary depends on whether it has a unit root. If a variable contains a unit root then it is non stationary. Thus, regression involving unit root series can falsely imply the existence of a meaningful economic relationship. The first task in analyzing econometric time series data should be then testing for the presence of unit roots. In this case, it is important to test the order of integration of each variable to know how many times the variable needs to be differenced to result in a stationary series.

Therefore, Stationary occurs in a time series when the mean and autocovariance of the series remains constant over the time series. Therefore, the stochastic process Y_t is said to be stationary if:

I. E(Yt) = **μ**, constant for all value of t…………………………………………………(3.1)

II. $The\ Cov(Yt, Yt-j) = \Gamma j = E[(Yt - \mu)(Yt-j - \mu)^T] = \Gamma - j^T$ for all t and j= 0,1………………………………………………………………………………..….(3.2)

Condition [1] means that all Yt have the same finite mean vector μ and [2] requires that the autocovariance of the process do not depend on t but just on the time period j the two vectors Yt and Yt-j are apart. Therefore, a process is stationary if its first and second moments are time invariant.

A commonly applied formal test for existence of a unit root in the data is Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) Test.

3.2.2.1. Augmented Dickey-Fuller (ADF) Test

The Augmented Dickey-Fuller (ADF) test for autoregressive unit root tests the null hypothesis H0: μ=0 against the one sided alternative H1: μ< 0 in the regression.

$$\Delta Y_t = \beta 0 + \mu Y_{t-1} + \sigma 1 \Delta Y_{t-1} + \cdots .. + \sigma p \Delta Y_{t-p} + U_t \dots\dots\dots\dots\dots\dots (3.3)$$

Under the null hypothesis μ=0, Yt has a unit root; under the alternate hypothesis, Yt is stationary. The ADF statistic is the OLS t-statistic testing μ=0 in the equation above. If instead the alternate hypothesis is that Yt is stationary around a deterministic linear time trend, then this trend t (the period number), must be added as an additional regressor in which case the Dickey-Fuller regression becomes.

$$\Delta Y_t = \beta 0 + \alpha t + \mu Y_{t-1} + \sigma 1 \Delta Y_{t-1} + \cdots \dots .. + \sigma p \Delta Y_{t-p} + Ut \dots\dots\dots\dots\dots\dots (3.4)$$

Where, α is an unknown coefficient and the ADF statistic is the OLS statistic testing μ=0 in the above equation.

The null and alternative hypotheses may be written as,

H0: $\mu=0$

H1: $\mu<0$...[3.5]

And evaluated using the conventional t-ratio for μ:

$$t_{\mu} = \frac{\hat{\mu}}{(se(\hat{\mu}))} \quad \text{(3.6)}$$

Where, $\hat{\mu}$ is the estimate of μ , and $se(\hat{\mu})$ is the coefficient standard error.

The lag length p can be chosen using the Akaike's Information Criteria (AIC) because it known as the best information criteria to use. Burnham and Anderson (2004) argue that AIC has theoretical as well as practical advantage because it is derived from principles of information criteria. Yang (2005) also argues that the rate at which AIC converges to the optimum is the best possible. The general form for calculating AIC is

$$AIC = \frac{2p}{T} - \frac{2lnL}{T}$$

Where L is likelihood value, p is the number of parameters and T is number of observation. Given a set of candidate values for the data, the preferred value is the one with the minimum AIC value.

The ADF test does not have a normal distribution under the null hypothesis, even in large samples. Critical values for the one sided ADF test depends on the first two equations used above. The null hypothesis of non-stationary is tested using the t-statistic with critical values calculated by MacKinnon. The null hypothesis that Yt is non-stationary time series is rejected if μ are less than zero and statistically significant for each. The ADF test is unable to distinguish well between stationary and non stationary series with a high degree of auto regression. For example inflation, which is highly auto correlated, is in fact stationary although the ADF test shows that it is non stationary. The ADF test may also incorrectly indicate that a series contain a unit root when there is a structural break in the series (Culver and Papell, 1997). .

If the data are stationary in a level, estimations of the models proceed using the variables in a level. But if the time series variables are non stationary, problems of using it are avoided by taking the difference of the variable depending on the results of unit root test. Then, a Vector Auto regression (VAR) model is used to forecast inflation from the lagged values of its own and the lagged value of GDP growth rate and vice versa.

3.2.2.2. The Phillips-Perron (PP) Test

Phillips and Perron (1988) propose an alternative method of controlling for serial correlation when testing for a unit root. The PP method estimates the non-augmented DF test equation [3.6], and modifies the t -ratio of α coefficient so that serial correlation does not affect the asymptotic distribution of the test statistic. The PP test is based on the statistic:

$$\hat{t_\mu} = t_\mu \left(\frac{\gamma_0}{f_0}\right)^{\frac{1}{2}} - \frac{T(f_0 - \gamma_0)(se(\hat{\mu}))}{2f_0^{1/2}s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.7)$$

Where, $\hat{\mu}$ is the estimate, $t\hat{\mu}$ is the t -ratio of μ, *se* ($\hat{\mu}$) is coefficient standard error and *s* is the standard error of the test regression. In addition, γ_0 is a consistent estimate of the error variance in [3.7] (calculated as $(T-k)s^2/T$, where *k* is the number of regressor). The remaining term, f_0, is an estimator of the residual spectrum at frequency zero.

3.2.2 Vector Autoregressive (VAR) Models

A Vector Auto regression (VAR) expresses each variable as a linear function of its own past values, the past values of all other variables being considered, and a serially uncorrelated error term. It is a set of k time series regression in which the regressor are lagged values of all k series.

When the number of lags in each of the equations is the same and is equal to p, the system of the equation is called a VAR (p).

A bivariat-VAR time series variables consists of two equations

$$GRGDP = \beta 0 + \beta i\ GRGDPt - i + \alpha iINFt - i + U1_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ldots\ldots\ldots\ldots\ldots..(3.8)$$

$$INF = \delta + \theta iINF_{t-i} + \emptyset iGRGDP_t - i + U2_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3.9)$$

Where the β's, $\alpha' s, \theta' s, \emptyset/s$ are unknown coefficients and $U1t$ and $U2t$ are error terms.
The errors terms in these regressions are the "surprise" movements in the variables, after taking its past values into account. If the different variables are correlated with each other, as they typically are in macroeconomic applications, then the error terms in the model will also be correlated across equations.

The number of lagged values to include in each equation can be determined by different methods. The F-statistic approach or the Information Criterion approach can be used to determine the number of lags to be included in VAR model. The F-statistic approach starts with model of many lags and performs hypothesis test on the last lag. If the last lag is significant at the respective significance level, then the lag will be included in the model. Otherwise, the lag will be dropped from the model and proceeds to test the next lag and continue until lag that is significant will be obtained. The AIC approach is also applied to choose the lag length of the VAR model.

One application of VAR in time series forecast is to test whether the lags of included variable has useful predictive content above and beyond others variables in the model. The claim that a variable has a predictive content corresponds to the null hypothesis that the coefficients on all lags of that variable are different from zero. Granger causality test is used to know the predictive content of regressor.

3.2.2.1 Estimating Order of the VAR

The lag length for the VAR model may be determined using model selection criteria. The general approach is to fit VAR models with orders m = 0, pmax and choose the value of m which minimizes some model selection criteria (Lutkepohl, 2005). The general form model selection criteria have the form.

$$C(m) = log|\widetilde{\sum_m}| + CT.\varphi(m,k) \quad \text{..[3.10]}$$

Where, $\widehat{\sum}_m = T^{-1}\sum_{t=1}^{T}\widehat{\varepsilon t}\ \widehat{\varepsilon t}$ is the residual covariance matrix estimator for a model of order m, φ(m,k) is a function of order m which penalizes large VAR orders and cT is a sequence which may depend on the sample size and identifies the specific criterion. The term log| ∑*m*ˆ | is a non-increasing function of the order m while φ(m,k) increases with m .The lag order is chosen which optimally balances these two forces.

The three most commonly used information criteria for selecting the lag order are the Akaike information criterion (AIC), Schwarz information criterion (SC), Hannan-Quin (HQ) information criteria:

$$AIC(m) = log|\widetilde{\sum_m}| + \quad + \frac{2}{T}mk^2 \ldots\ldots\ldots\ldots\ldots\ldots(3.11)$$

$$SC(m) = log|\widetilde{\sum_m}| + \frac{logT}{T}mk^2 \ldots\ldots\ldots\ldots\ldots\ldots(3.12)$$

$$HQ(m) = log|\widetilde{\sum_m}| + \frac{2logT}{T}mk^2 \ldots\ldots\ldots\ldots\ldots\ldots(3.13)$$

In each case φ (m, k) = mk2 is the number of VAR parameters in a model with order *m* and *k* is number of variables. Denoting by *p*ˆ (AIC), *p*ˆ (SC) and *p*ˆ (HQ) the order selected by AIC, SC and HQ, respectively, the following relations hold for samples of fixed size T≥16 :(Lutkepohl, (2005).

*p*ˆ (SC) ≤ *p*ˆ (HQ) ≤ *p*ˆ (AIC)

Thus, among the three criteria AIC always suggests the largest order, SC chooses the smallest order and HQ is between .Of course, this does not preclude the possibility that all three criteria agree in their choice of VAR order. The HQ and SC criteria are both consistent, that is, the order estimated with these criteria converges in probability or almost surely to the true VAR order p under quite general conditions, if p max exceeds the true order.

3.2.2.2 Granger Causality tests

Granger Causality test examines whether lagged values of one variable helps to predict another variable. It is the F statistic testing the hypothesis that the coefficients on all the values of one variables in the above equation (for example the coefficients on are zero. Granger causality means that if *It* Granger causes *Gt*, and then *It* is useful predictor of *G*t whereas past values of *Gt* don't help to predict *It* when controlling for past values of *It*. It does not mean that change in *It* causes subsequent change in *Gt*. Therefore, in the VAR model we can identify whether inflation predicts GDP growth or GDP growth predicts inflation using Granger Causality test.
As it is hard to interpret parameters of VAR model directly, it is common to use the Impulse Response Function

Many researchers in the field of Time Series Econometrics have used Granger causality procedure to study the causal interactions that exists among economic indicators in various countries of the world. Moreover, several intelligent articles have surfaced in literature on the use of Granger causality tests to analyze time series data since its introduction by Granger (1969).
Given two time series variables Xt and Yt, Xt is said to Granger cause Yt if Yt can be better predicted using the histories of both Xt and Yt than it can by using the history of Yt alone. In this paper Granger causality analysis which is proposed by Granger (1969) used to model selected economic indicators.
To test the causal relationship between inflation and growth, initially the Granger Causality test will be made to examine the causal relationship between inflation (INF) and economic *growth* (GRGDP).

$$GRGDP = \alpha o + \sum_{i=1}^{m} \alpha 1tINFt - i + \sum_{i=1}^{n} \alpha 2tGRGDPt - i + \varepsilon t1 \ldots\ldots\ldots\ldots (3.14)$$

$$INFt = \beta o + \sum_{i=1}^{m} \beta 1tINF\mathrm{t} - \mathrm{i} + \sum_{i=1}^{n} \beta 2tGRGDPt - \mathrm{i} + \varepsilon t2 \ldots\ldots\ldots\ldots (3.14)$$

3.2.2.3 Impulse Response Function

Impulse responses trace out the response of current and future values of each of the variables to a one unit increase in the current value of one of the VAR errors, assuming that this error returns to zero in subsequent periods and that all other errors are equal to zero. More generally, an impulse response refers to the reaction of any dynamic system in response to some external change. According to Hamilton (1994), a VAR can be written in vector Moving Average (MA) form as follows

$$Yt = \beta + \varepsilon_t + \alpha 1\varepsilon_{t-1} + \varepsilon_{t-2} + \cdots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots \ldots . . (3.15)$$

Thus, $\partial \mathbf{Y}t+s/\partial \boldsymbol{\varepsilon}'t= \boldsymbol{\alpha}s$ is interpreted as, the I row and the j column element of $\boldsymbol{\alpha}s$ identifies the consequences of one unit increase in the j'th variable's innovation at date t (εjt) for the value of the i'th variable at time t+s (Yi(t+s)), holding all other innovations at all dates constant.

A plot of $\frac{\partial Yi(t+s)}{\partial \varepsilon Jt}$ as a function of s is called the impulse response function. It describes the response of Yi(t+s) to a one-time impulse in εjt with all other variables dated t or earlier held constant. So, this method is used to know the consequences of one unit increase in inflation on current and future values of GDP growth and vice versa.

3.2.3. Co-integration Analysis

The variables in the VAR system may have a long-run equilibrium relationship to which any deviating variable is gradually pulled over time. The long-run equilibrium relationship is called the co integrating vector. When there is a significant co integrating vector, the VAR model should be augmented with an Error Correction term. In other words, pure VAR can be applied only when there is no co integrating relationship among the variables in the VAR system. Hence, a prerequisite before running any VAR model is to run a co integration test.

The role of co integration is to link between the relations among a set of integrated (no stationary) series and the long-term equilibrium. The presence of a co integrating equation is interpreted as a long-run equilibrium relationship among the variables. If there is a set of k integrated variables of order one (I(1)), there may exist up to k-1 independent linear relationships that are I(0). In general, there can be $r \leq k-1$ linearly independent co integrating vectors, which are gathered together into the k x r co integrating matrix. Thus, each element in the r-dimensional vector is I(0), while each element in the k-dimensional vector is I(1) [Engle and Granger, 1987]. Johansen Co integration test depends on his Maximum Likelihood (ML) estimator of the parameters of the following VEC model of two co integrating variables.

$$\Delta Yt = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \mu_i \Delta Y_{t-i} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.16)$$

Where, $\pi = \sum_{i=1}^{p} A_i - I, \ \ or$

$$\pi = \alpha\beta, \quad where\ \alpha\ is\ speed\ of\ adjustment\ and\ \beta\ is\ the\ cointegrating\ vector$$

$$\mu_i = -\sum_{j=i+1}^{p} Aj$$

And $Yt = GRGDPt\ and\ INFt$ is a (2 x 1) vector of I(1) variables,

Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank $r<k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi=\alpha\beta'$ and $\beta' yt$ is I(0).Where r is the number of co integrating relations (the *co integrating rank*) and each column of is the co integrating vector. The elements of α are known as the adjustment parameters in the VEC model. It can be shown that for a given r, the maximum likelihood estimator of β defines the Combination of $Yt-1$ that yields the r largest canonical correlations of ΔYt with $Yt-1$ after Correcting for lagged differences.

Johansen (1988) proposed two tests for estimating the number of co integrating vectors: the Trace statistics and Maximum Eigen value. Trace statistics investigate the null hypothesis of r Co integrating relations against the alternative of n co integrating relations, where n is the number of variables in the system for r = 0, 1, 2…n-1. Define ϒi,i=1,2,…….,k to be a complex modulus of eigenvalues of $\hat{\pi}$ and let them be ordered such that ϒ1>ϒ2> …………ϒn.

3.2.3.1 The Trace Statistic

The null hypothesis of the trace statistic is that there are no more than r co integrating relations. Restricting the number of co integrating equations to be r or less implies that the remaining 2-r eigenvalues are zero. Johansen derives the distribution of the trace statistic

$$\Upsilon \text{tarce}(r) = -T \sum_{i=r+1}^{2} \ln \left(1 - \widehat{\Upsilon i}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.17)$$

Where T is the number of observations and the Υi are the estimated eigenvalues used in computing the log likelihood. For any given value of r, large values of the trace statistic are evidence against the null hypothesis that there are r or fewer co integrating relations in the VEC model.

3.2.3.2 The Maximum Eigen-value Statistic

The alternative hypothesis of the trace statistic is that the number of co integrating equations is strictly larger than the number r assumed under the null hypothesis. Instead, in the maximum eigenvalue test statistic, we could assume a given r under the null hypothesis and test this against the alternative that there are r+1 co integrating equations. Johansen derives an LR test of the null of r co integrating relations against the alternative of r+1 co integrating relations. Johansen derives the distribution of the trace statistic

$$\Upsilon \max(\mathrm{r},\mathrm{r}+1) = -T ln(1 - \widehat{\Upsilon}_{r+1)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.18)$$

Where T is the number of observations and that $\widehat{\gamma_i}$ are the estimated eigenvalues used in computing the log likelihood.

3.2.4. Vector Error Correction (VEC) Model

A vector error correction (VEC) model is a restricted VAR designed for use with no stationary series that are known to be co integrated. The VEC has co integration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their co integrating relationships while allowing for short-run adjustment dynamics. The co integration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

When the variables are co integrated, the corresponding error correction representations must be included in the system. By doing so, one can avoid misspecification and omission of the important constraints. Thus, the VAR in [3.8 and 3.9] can be reparametrized as a Vector Error Correction Model (VECM) form: (Helmut Lütkepohl, 2005.)

If *INFt* and GRGDP*t* are co integrated, the first difference of *INFt* and GRGDP*t* can be modeled using a VAR, augmented by including GRGDP*t-1* – *πINFt*-1as an additional regressor.

VEC with two time series variables

$$\begin{aligned}\Delta \mathbf{GRGDPt} = \boldsymbol{\beta}_{10} + \boldsymbol{\beta}_{11}\Delta \mathbf{GRGDP}_{t-1} + \cdots + \boldsymbol{\beta}_{1p}\Delta \mathbf{GRGDP}_{t-p} + \boldsymbol{\alpha}_{11}\Delta \mathbf{INF}_{t-1} + \cdots + \boldsymbol{\alpha}_{1p}\Delta \mathbf{INF}_{t-p} \\ + \boldsymbol{\delta}\mathbf{1}(\mathbf{GRGDP}_{t-1} - \boldsymbol{\pi}\mathbf{INF}_{t-1}) + \mathbf{u}_{1t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{3.19})\end{aligned}$$

$$\begin{aligned}\Delta \mathbf{INFt} = \boldsymbol{\beta}_{20} + \boldsymbol{\beta}_{21}\Delta \mathbf{GRGDP}_{t-1} + \cdots + \boldsymbol{\beta}_{2p}\Delta \mathbf{GRGDP}_{t-p} + \boldsymbol{\alpha}_{21}\Delta \mathbf{INF}_{t-1} + \cdots + \boldsymbol{\alpha}_{2p}\Delta \mathbf{INF}_{t-1} \\ + \boldsymbol{\delta}\mathbf{2}(\mathbf{GRGDP}_{t-1} - \boldsymbol{\pi}\mathbf{INF}_{t-1}) + \mathbf{u}_{2t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{3.20}).\end{aligned}$$

Where Δ is difference operator, GRGDP*t-1* – *πINFt*-1is the error correction term and ut is random term.

In VEC model, past values of the error correction term help to predict future values of ΔYt and ΔXt describes how variables behave in the short run being consistent with the long run cointegrational relationship. A significant coefficient of the error correction term indicates any short term fluctuations between the independent variable and dependent variable will give rise to a stable long run relationship. To identify the long run relationship between inflation and economic growth in Ethiopia, this model is applied.

3.2.5. Model Checking

A wide range of procedures is available for checking the adequacy of VAR and VECMs. They should be applied before a model is used for specific purpose to ensure that it represents the data adequately.

3.2.5.1. Test of residual autocorrelation

I. **P**ortmanteau autocorrelation test

The portmanteau test for residual autocorrelation checks the null hypothesis that all residual Autocovariance are zero, that is,

$$H0: E(\varepsilon_t, \varepsilon_{t-i}) = 0, (i = 1,2) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.21)$$

It is tested against the alternative that at least one auto covariance and, hence, one Autocorrelation is nonzero. The test statistics is based on the residual autocovariances and has the form

$$Q_h = T\sum_{j=1}^{h} tr(\widehat{\Upsilon}'j\widehat{\Upsilon}'o^{-1}\widehat{\Upsilon}j\widehat{\Upsilon}^{-1}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (3.22)$$

$$\widehat{\Upsilon}j = T^{-1}\sum_{t=j+1}^{T}\hat{\varepsilon}_t\hat{\varepsilon}_{t-j} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (3.23)$$

Where, the $\hat{\varepsilon}_t$'s are the estimated residuals. For unrestricted residuals stationary VAR (p) process the null distribution of *Qh* and approximated by $\chi^2(K^2\ (h-p))$ distributed if T and h approaches infinity such that h/T.

Alternatively (especially in small samples), a modified statistic is used

$$Q^*{}_h = T^2\sum_{j=1}^{h}\frac{1}{T-j} tr(\widehat{\Upsilon}'_j\widehat{\Upsilon}o^{-1}\widehat{\Upsilon}j\widehat{\Upsilon}o^{-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (3.24)$$

II. Autocorrelation LM Test

This test was developed by Breusch and Godfrey in 1978. Assume a VAR model for the error u_t given by

$$Ut = D_tU_{t-1} + \cdots \ldots\ldots\ldots .. + D_tU_{t-h} + Vt \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \ldots . (3.25)$$

The quantity ${}_t v$ denotes a white nose error term. Thus, to test autocorrelation in u_t, we test

H_0: $D_1 = \ldots = D_h = 0$

H_1: $D_j \neq 0$ for at least one $j < h$

The researcher uses LaGrange Multiplier method to perform the test. This method is very useful for finding optimal estimates under constraint conditions. Under H0, it is only needed to estimate the regular VAR model ($ut = vt$). So the constrained case estimates are simple. To determine the test statistic let's begin with the auxiliary regression model

$$\widehat{U} = BZ_t + D\widehat{U}_t + E \quad \text{.......(3.27)}$$

Where,

$$\widehat{U} = [\widehat{U}_1 \dots \dots \widehat{U}_T]$$

$$Z_t = \left[1^T y_t^T \dots \dots Y^T{}_{t-p+1}\right]^T \quad \text{.......(3.28)}$$

$$Z = [Z_o \dots \dots Z_{T-1}]$$

$$D = [D_1 \dots \dots D_h]$$

Define ,Fi such That

$$\widehat{U}F_t\widehat{U}^T = \sum_{t=i+1}^{T} \widehat{U}_t \widehat{U}_{t-1}{}^T \quad \text{.......(3.29)}$$

Then,

$$F = [F1 \dots \dots Fh]$$

$$\widehat{U} = \left(I \times \widehat{U}\right)F^T \quad \text{.......(3.30)}$$

This yields the least squares estimate of *D*

$$\widehat{D} = \widehat{U}\widehat{U}^T[\widehat{U}\widehat{U}^T - \widehat{U}Z^T(ZZ^T)^{-1}Z\widehat{U}^T]^{-1} \quad \text{.......(3.31)}$$

The standard X^2 test statistic for testing whether $D = 0$ (no autocorrelation) is

Under

Ho:

$$\lambda LM(h) = vec\left(\widehat{D}\right)^T([\widehat{U}\widehat{U}^T - \widehat{U}Z^T(ZZ^T)^{-1}\left(Z\widehat{U}^T\right]x\tilde{\Sigma}_u)\ vec(\widehat{D}) \quad \text{.......(3.32)}$$

$$\lambda LM(h) \rightarrow X^2(hk^2) \quad \text{.......(3.33)}$$

3.2.5.2. Normality of the Residuals

Lütkepohl (1993) suggests using the multivariate generalization of the Jarque-Bera test (Jarque & Bera 1987) to test the multivariate normality of the *ut*. This tests the skewness and kurtosis properties of the *ut* (3rd & 4th moments) against those of a multivariate normal distribution of the appropriate dimension.

H0: $E(U_t^s)^3 = 0(skewness) and\ E(U_t^s) = 3(kurtosis)$

$H1: E(U_t^s)^3 \neq 0\ or\ E(U_t^s)^4 \neq 3$

It is possible that the first four moments of the *ut* match the multivariate normal moments, and the *ut* are still not normally distributed. It is hoped that most of the "normal" properties desired by the model fitter in the *ut* are met by these four moments. This situation has an analog in linear regression. It is assumed that the errors are independent, but here let's test whether they are correlated. In linear regression, it is adequate to test the correlation of the residuals. If they are uncorrelated, that is enough "independence" for getting the variance calculations correct. I don't worry about the other forms of dependence.

Formulation of the Jarque-Bera test uses a mean adjusted form of the VAR (p) model

$$\widehat{U}_t = (Yt - \overline{Y}) - \hat{A}_1(Y_{t-1} - \overline{Y}) - \cdots \ldots . -\hat{A}p(Y_{t-p} - \overline{Y}) \ldots \ldots \ldots \ldots \ldots \ldots \ldots . . \ldots \ldots \ldots \ldots \ldots . (3.34)$$

$$\widehat{\Sigma}_u = \frac{1}{T - KP - 1} \sum_{t=1}^{T} \widehat{U}_t \widehat{U}_t^T$$

Let Pˆ be the matrix satisfying $\hat{P}\hat{P}^T = \widehat{\Sigma_u}$ such that plim($\hat{P} - P) = 0$

Now let's define the standardized residuals and their sample moments

$$\widehat{W}_t = \hat{P}^{-1}\widehat{U}_t$$

$$\hat{b}1 = (b_{11} \ldots \ldots \ldots b_{k1} \ni \ \hat{b}_{i1} = \frac{1}{T}\sum_{t=1}^{T} \widehat{W^3}_{it} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . . \ldots \ldots \ldots \ldots \ldots \ldots \ldots . . (3.35)$$

$$\hat{b}_2 = (\widehat{b_{12}} \dots\dots\dots\dots \hat{b}_{k2}) \ni \hat{b}_{i2} = \frac{1}{T}\sum_{t=1} \widehat{W}_{it}^4$$

Finally our test statistics are

$$\lambda s = \frac{T\hat{b}_1^T \hat{b}_1}{6}$$

$$\lambda s = T(\hat{b}_2 - 31)^T \frac{(\widehat{b_2} - 32)}{24} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.36)$$

$$\lambda sk = \lambda s + \lambda k$$

The third and fourth moments of *ut* should be 0 and 3.

Under the third moment assumption

$$\lambda s \rightarrow X^2(k) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.37)$$

Under the fourth moment assumption

$$\lambda k \rightarrow X^2(k) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.38)$$

Under both assumptions

$$\lambda sk \rightarrow X^2(2k) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.39)$$

4. RESULTS AND DISCUSSION

The study is based on annual time series data observed from 1991-2014. The discussion begins by describing the data set and the result from the model selection procedure. Then the result will be discussed and interpreted. The data analysis is performed using eviews7 and R programming software.

4.1. Descriptive Analysis

Under the empirical analysis, two aggregate series namely, the general inflation rate as measured by consumer price index (CPI) and growth rate of GDP were used. Some descriptive statistics including the mean, the standard deviation,, minimum, maximum , skewness, kurtosis and Jarque-Bera values of the series under study are presented in Table 4.1.

Table 4.1: Descriptive Statistics of Series

	INF	GRGDP
Mean	10.28333	7.275000
Median	7.550000	9.850000
Maximum	36.40000	12.60000
Minimum	-10.60000	-2.300000
Std. Dev.	11.36381	4.866411
Skewness	0.623792	-0.825038
Kurtosis	3.175481	2.237933
Jarque-Bera	1.587258	3.303495
Probability	0.452201	0.191715

Source: Author's Estimation using Eviews 7.0.

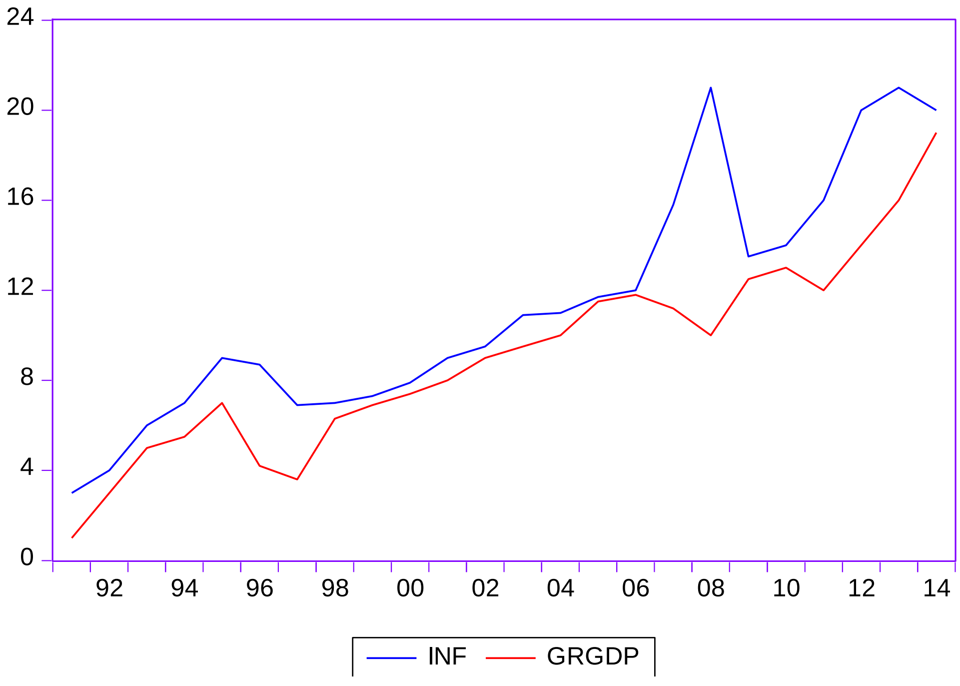
The results show that the values of summary statistics are more or less similar except standard deviation which indicates relatively high dispersion for inflation.

The table shows that output grows at an average rate of 7.3 percent from 1991-2014 in Ethiopia. However, the average of inflation rate is more than the average of output growth with a maximum value of up to 36.4 percent. The standard deviation shows that the spread of Inflation from its mean is higher than the spread of economic growth, i.e., 11.4% is greater than 4.8 %.

4.2. Unit Root Test Results

The time series under consideration should be checked for stationary before one can attempt to fit a suitable model. That is, variables have to be tested for the presence of unit root(s) thereby the order of integration of each series is determined. Figure 4.1 suggests that the series of the endogenous variables display a non stationary behavior.

Figure 4.1: Time series plot of INF and GRGDP (at level)



From the figure 4.1 we observe that the two series are more or less trending with an intercept, so this shows there is non-stationary at level.

Stationarity of the data is checked using the Augmented Dickey-Fuller (ADF) test and a Phillips and Perron test. The hypothesis to be tested is

Ho: the series is non stationary against

H1: the series is stationary.

Table 4.2 Unit Root Test result (at level)

Variable in level	at Level with Intercept				at Level with Intercept and trend			
	Test Statistic		Prob.*		Test Statistic		Prob.*	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
INF	-1.051071	-0.772	0.7167	0.8085	-3.47833	-3.0091	0.0668	0.1510
GRGDP	-0.147231	0.080787	0.9325	0.9569	-2.9071	-2.6005	0.1792	0.2831
Critical values at 5% significance level	-2.998				-3.622033			

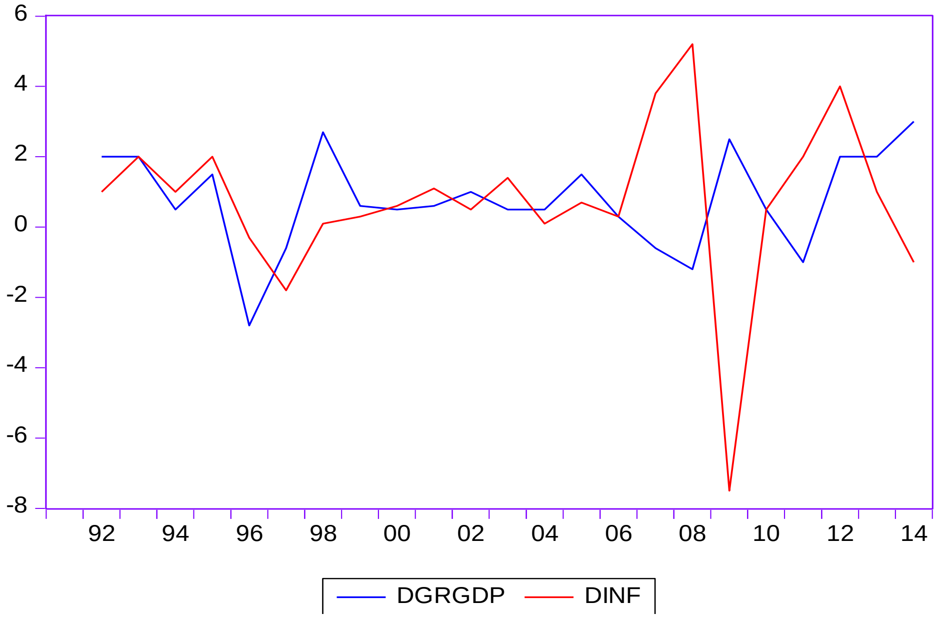
*MacKinnon (1996) one-sided p-values.

Source: Author's Estimation using Eviews 7.0.

The results of ADF and PP tests, with intercept but no trend, and with intercept and trend both at level and first difference for each series are presented in Table 4.2 and 4.3. The critical values used for the tests are the McKinnon (1996) critical values. Test results, presented in Table 4.2, indicate that the null hypothesis that the series in levels contain unit root could not be rejected for the two series. That is, the respective p-values are greater than conventional significance levels α =0.05.

Since the null hypothesis cannot be rejected, in order to determine the order of integration of the non stationary time series, the same tests were applied to their first differences (Figure 4.2). The order of integration is the number of unit roots that should be contained in the series so as to be stationary.

Figure 4.2: Time series plot of INF and GRGDP (after first deference)



The time series plot after first difference shows almost stationary, with exception in 2008 and 2009 with high variation.

Table 4.3. Unit test result (after first difference)

Variable in level	with Intercept				with Intercept and trend			
	Test Statistic		Prob.*		Test Statistic		Prob.*	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
INF	-4.430251	-9.88187	0.0027	0.0000	-4.40983	-9.88645	0.0119	0.0000
GRGDP	-3.955924	-4.01186	0.0069	0.0059	-3.96538	-4.13366	0.0271	0.0187
Critical values at 5% significance level	-3.020686				-3.632896			

*MacKinnon (1996) one-sided p-values.

Source: Author's Estimation using Eviews 7.0.

The results in table 4.3 indicate that the null hypothesis is rejected for the first differences of the two indices given that p-values less than 5% level of significance with intercept and trend in ADF test and PP test. This implies that the two time series are integrated of degree one (I (1)). Therefore, the ADF and PP test shows that all series are non stationary in the levels, and stationary in the first difference. Therefore, if the variables are integrated we can't apply VAR model at level rather either we should to check the existence of Cointegration or long run relationship or use difference in VAR model.

4.3. Johansen Co integration Test

Before proceeding to estimate vector error correction model, the first task is to check whether the two variables are co integrated. If the two variables are co integrated of the same order, then there is a long run relationship between the two variables. Table 4.4 below shows the result of co integration test using Johansen (1995) trace statistic and maximum Eigen value Statistic.

Table 4.4 Johansen Co integration test results

Number of Co integrating Vector	Eigen value	Trace Test			Maximum Eigen value Test		
		Statistic	0.05 Critical Value	Prob.**	Statistic	0.05 Critical Value 5	Prob.**
None *	0.516048	16.18210	15.49471	0.0394	15.96693	14.26460	0.0267
At most 1	0.009733	0.215172	3.841466	0.6427	0.215172	3.841466	0.6427
Normalized co integrating coefficients (standard error in parentheses)							
GRGDP	INF						
1.000000	-0.807306						
	(0.07823)						

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Both the Trace test and Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

Source: Author's Estimation using Eviews 7.0.

From the Johansen co integration test, it was determined that the rank of co integration matrix is equal to one. Consequently, the co integrating vector is given by

$\beta = (1.000000, -0.807306)$

The values correspond to the co integrating coefficients of GRGDP (normalized to one), and INF, respectively.

The Cointegration equation can be expressed as follows:

$GRGDP = -0.807306INF$……………………………………………………………..…….(4.1)

4.4. Vector Error Correction Model (VECM) Estimation Results

Having concluded that variables in the VAR model appeared to be co integrated, we proceed to estimate the short run behavior and the adjustment to the long run models, which is represented by VECM. The VEC model has the following structure:

$$\Delta Yt = \mu + \Pi Y_{t-1} + \sum_{i=1}^{p} \mu_i \Delta Y_{t-i} + \varepsilon_t$$

Where, $B'Y_t$ is the error correction term and β is the co integrating vector while μ_i is the short-term coefficient matrices. The α coefficient vector reveals the speed of adjustment to the equilibrium, which measures the deviation from the long-run relationship between the price indexes.

4.4.1. Estimating for Order of lag Results

Choosing an appropriate lag length has strong implications for subsequent modeling choices. Choosing too few lags could lead to systematic variation in the residuals whereas if too many lags are chosen it comes with the penalty of fewer degrees of freedom (as adding another lag, adds p x p variables). For determining the appropriate lag length for the VEC model the Akaike information criterion (AIC), Schwarz information criterion (SC), Hannan-Quin(HQ) information criteria were used.

In Table 4.5 the lag length selection criterion is tabulated. The AIC, SC and HQ test suggest appropriate lag length for the VEC model is one (1).That is, the best fitting model is the one that minimize AIC or SC or HQ .

Table 4.5: Lag order selection results (Eviews 7 software)

Lag	LR	FPE	AIC	SC	HQ
0	NA*	13.47896*	8.276717*	8.376291*	8.296155*
1	0.457337	19.66072	8.649815	8.948535	8.708129
2	4.990255	21.39225	8.717132	9.214998	8.814320
3	8.251811	17.60878	8.482377	9.179390	8.618441

* indicates lag order selected by the criterion

Source: Author's Estimation using Eviews 7.0.

All criteria satisfies that the appropriate lag for model is one

Coefficient estimates of the VEC model are presented in appendix. This table

consists of two parts; the first part contains the detail of the Co integration vector which is derived by normalizing the inflation rate. The result indicates that, the long run coefficients of inflation have a negative long run relationship with growth rate of GDP (economic growth). **The log run equation is given as follows:**

$$INF_t = -0.21 - 1.24GRGDP_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.2)$$

Where, $INF_t + 0.212870 + 1.238687GRGDP_t = \varepsilon_t$

The value -1.24 suggests that a one unit increase in economic growth on average results an increase of about -1.24 units decrease in inflation, which satisfies the theoretical negative relationship between inflation and economic growth.

4.4.2 Estimation results of the VEC model

$$\Delta \mathbf{INF_t} = -\mathbf{0.803ECT_{t-1}} + \mathbf{0.253\Delta INF_{t-1}} - \mathbf{0.390\Delta GRGDP_{t-1}} + \mathbf{0.7860} \ldots\ldots\ldots (4.3)$$

S.E.	(0.217008)	(0.204536)	(0.367759)	(0.513266)
(t-value)	(-3.702750)	(1.239255)	(-1.061555)	(1.531498)
P-value	[0.0016]	[0.2312]	[0.3025]	[0.1430]

R-squared 0.448927 F-statistic=4.887843 Prob. > F-statistic=0.0117

$$\Delta \mathbf{GRGDP_t} = \mathbf{0.333ECT_{t-1}} - \mathbf{0.108\Delta INF_{t-1}} + \mathbf{0.318\Delta GRGDP_{t-1}} + \mathbf{0.599} \ldots\ldots. (4.4).$$

S.E.	(0.148341)	(0.139815)	(0.251390)	(0.350855)
(t-value)	(2.245556)	(-0.777341)	(1.265082)	(1.708281)
P-value	[0.0375]	[0.4471]	[0.2220]	[0.1048]

R-squared 0.32 F-statistic=2.720240 Prob. > F-statistic=0.148613

Where: 'Δ' stands for first difference (D), the value in the bracket is the error correction term and the coefficients of error correction term are called adjustment coefficients.

The coefficient of the vector error correction term has the expected sign in the first equation and it is significant as stated in the Appendix A2 . The coefficient indicates a speed of adjustment of 80.3% from actual growth in the previous year to equilibrium rate of economic growth. This is a faster speed of adjustment implying that it takes few years for all errors deviations to be corrected.

The negative sign of vector error correction term implies that any shock in the system will return back to its long run path. Economic growth fail in explaining short-run fluctuations on Inflation, even its sign is as expected negative, this may be due to output lag in the short run, since Ethiopian economy is mainly depend on agricultural productivity.

The second equation shows that inflation does not have significant effect on economic growth in short run and also one period lag in inflation fail in explaining short run change in output may be due to monetary lag.

The coefficient of the ECT is significantly, but positive in the second equation, since there is only one co integrating relationship, it doesn't have any effect on the result.
Therefore, the VEC model estimation shows that the error correction terms in both equations are statistically significance level. This means if the two series are out of equilibrium, growth rate will adjust to reduce the equilibrium error in the long run and vice versa.

4.4.3. Granger Causality test Results

The result of a Granger causality test shows that economic growth is Granger-cause of inflation at 10% significance level in a sense that lagged values of economic growth has an incremental forecasting power when added to equation of inflation rate in Univariate autoregressive model.

Table 4.6. Granger Causality Tests Results

Null Hypothesis:	F-Statistic	Prob.
INF does not Granger Cause GRGDP	2.46780	0.1146
GRGDP does not Granger Cause INF	6.12114	0.0099*

*reject the null hypothesis

Source: Author's Estimation using Eviews 7.0.

In contrast inflation rate does not Granger-causes economic growth at any traditional significance level. This means that inflation rate does not predict anything about in explaining economic growth while the latter significantly suggest something about the behavior of inflation rate in Ethiopia during the study period of 1991-2014.

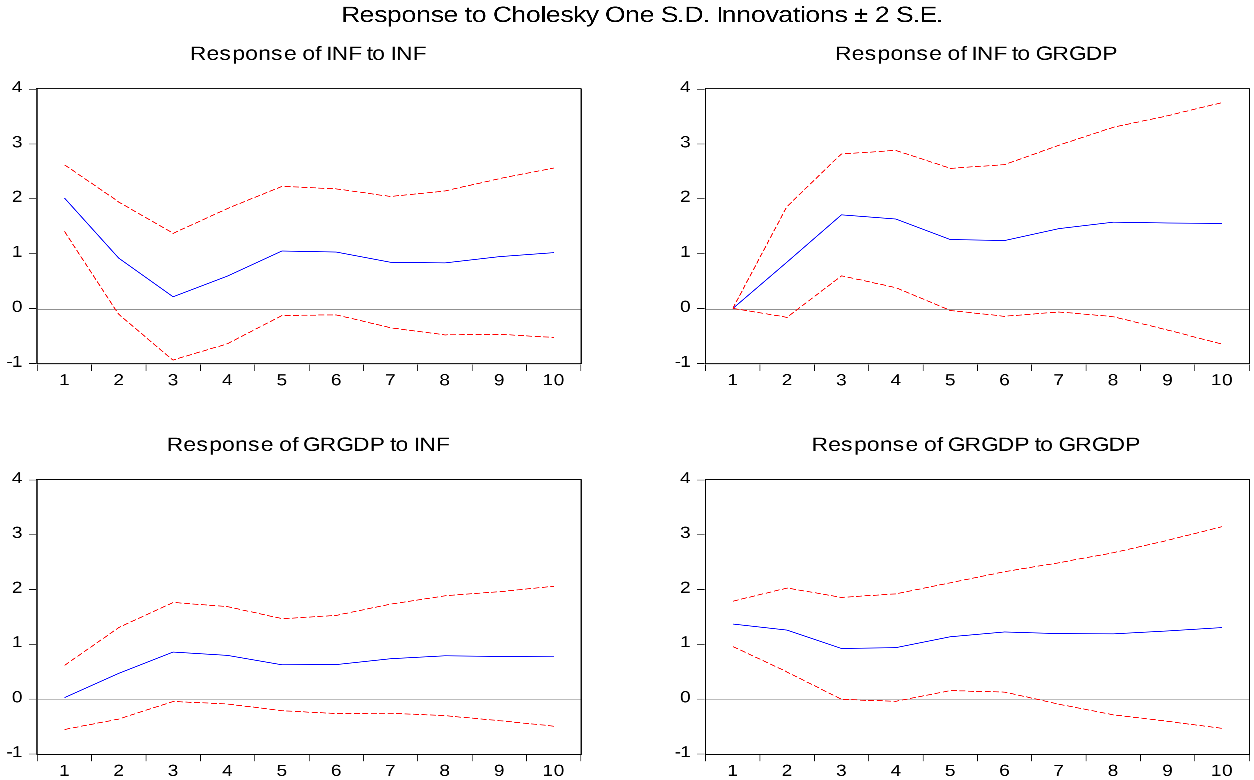
The test statistic indicates that the null hypothesis GRGDP does not Granger Cause INF is rejected at the 1 percent significance level as shown by the p-value of 0.0099*.This implies that economic growth causes inflation. Conversely, the null hypothesis that inflation does not cause growth is not rejected, meaning that inflation does not cause economic growth. It may then be concluded from these results that there is no feedback from output growth to inflation, suggesting that there is a unidirectional causality running from growth to inflation.

4.4.4 Impulse Response Function Results

The impulse response analysis allows us to determine the endogenous variables to onetime shock of other variables in the model. The following figure shows the impulse response of inflation to shock observed on economic growth and vice versa. It also shows the effect of one time shock to one of the innovations on current and future values of the variable itself.

From the figure it is clear that economic growth does not respond well for any impulse from inflation which supports our earlier VEC finding that inflation does not Granger-cause economic growth. However, the response of inflation rate to shocks in growth is in little sense better to some year in the future. After that it gradually shows almost insignificant responses to shocks of growth rate. This is also in line with our earlier finding that economic growth Granger-causes inflation in the country. The response of each variable to its own shocks is also effective up to some years in the future.

Figure 4.3 Impulse Response Function



Source: Author's Estimation using Eviews 7.0.

4.4.5. Model checking

In order to ascertain whether the model provides an appropriate representation, a test for misspecification should be performed.

4.4.5.1. Test of residual autocorrelation estimation Results

i. Portmanteau autocorrelation test.

VEC Residual Portmanteau Tests for Autocorrelations

Null Hypothesis: no residual autocorrelations up to lag h

Table 4.7 Portmanteau autocorrelation test

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.358724	NA*	0.375806	NA*	NA*
2	2.036128	0.9163	2.220950	0.8983	6
3	4.785051	0.9051	5.403914	0.8626	10
4	6.998867	0.9348	8.109689	0.8835	14
5	9.401260	0.9497	11.21867	0.8848	18
6	12.65610	0.9423	15.69407	0.8308	22
7	13.98997	0.9731	17.65042	0.8881	26
8	15.45722	0.9869	19.95609	0.9177	30
9	15.77881	0.9968	20.50032	0.9671	34
10	18.70764	0.9964	25.86985	0.9327	38

*The test is valid only for lags larger than the lag order.

df is degrees of freedom for (approximate) chi-square distribution

Source: Author's Estimation using Eviews 7.0.

From the table 4.7 it fail to reject the null for the existence of no serial correlation, since all the P -value are greater than 0.05%.

ii. Autocorrelation LM Test

VEC Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Table 4.8 LM Test for Residual Autocorrelation of VEC

Lag	LM-Stat	df	prob > chi2
1	2.795179	4	0.5927
2	2.611897	4	0.6247
3	0.302088	4	0.9897
4	3.731367	4	0.4436
5	0.875709	4	0.9280
6	2.966273	4	0.5635

Source: Author's Estimation using Eviews 7.0.

From the table LM test for residual autocorrelation is performed and the result in the table above shows that we cannot reject the null hypothesis of no autocorrelation in the residuals of the VEC model up to a maximum of six lags.

4.4.5.2. Testing Normality estimation Results

Multivariate version of the Jarque Bera tests is used to test the normality of the residuals. It compares the 3rd and 4th moments (skewness and kurtosis) to those from a normal distribution.

The test has null hypothesis indicating that the error term in the model has skwness and kurtosis corresponding to a normal distribution. The results in Table 4.9 below show that the null hypothesis has to fail to be rejected Jarque-Bera test is a common phenomenon, which will not crucially distort final results.

Null Hypothesis: residuals are multivariate normal

Table 4. 9: VEC Residual Normality Tests

Component	JarqueBera	Prob.	Skewness	Prob.	Kurtosis	Prob.
1	9.105103	0.0105	-1.245287	0.0198	5.050092	0.0552
2	5.319404	0.0424	0.298039	0.0771	2.901394	0.0665
Joint	14.424404	0.0313		0.050002	3.686025	0.0583

Source: Author's Estimation using Eviews 7.0.

The skewness test shows that the VEC model disturbances are normally distributed at 5 percent significance level. The Kurtosis test shows that the disturbances of the VEC are probably normally distributed at 10% level.

5. CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

Generally high and stable output growth and low inflation are the two main goals of macroeconomic policy. Therefore, it is important to investigate the existence and nature of the link between inflation and growth. In this regard there have been different theories and empirical evidence. Moreover, recent macroeconomics research result shows the positive short-term relationship between the rate of increase in prices, and output. And also there has been an exploration into the nature of the long-term relationship between inflation and growth in output.

The main objective of this paper was to empirically investigate the relationship between inflation and economic growth in Ethiopia. To this end, annual time series from the period 1991-2014 have been used to estimate the Vector Error Correction (VEC) model. The result estimates of the VEC model provided evidence supporting the hypothesis of a relationship in the inflation-growth nexus in Ethiopia.

Over the time period considered, both series showed an increasing pattern, that is, there is the sign of non stationary in each o f the series. Therefore, before fitting the model, unit root tests are performed (ADF and Phillips-Perron tests). The unit root test result shows that the variable are non stationary at level and are stationary at first difference.

The Johansen co integration test suggests that there is at least one co integration vector, which describes the long run relationship between inflation and Economic growth. Historical high values Co integration test shows that there exist a long run relationship between economic growth and inflation in Ethiopia. Therefore we use a vector error correction model to estimate the long run relationship between Inflation and economic growth in the country. The appropriate number of lag identified using different information criteria (AIC, SC, HQ). And the result shows that one lag is appropriate.

Vector error correction estimates indicate that there is no any relationship between economic growth and inflation in short run, this is due to monetary lag for the effect of inflation on growth and inelastic nature of output growth (especially agricultural product) to rapidly affect price change. However in the long run economic growth have an impact for change in inflation, which implies economic growth causes inflation to be lower in the long run. The error correction terms are statistically significant which shows that if both inflation and economic growth are out of equilibrium, inflation will adjust to reduce the equilibrium error in the long run.

Granger causality test are applied to explore the casual relationships. The result indicates in the long run economic growth Granger-causes inflation which means that economic growth can predict movements in inflation. It also shows that inflation does not have any forecasting power about economic growth that is having a unidirectional causality from economic growth to inflation.

Furthermore, Impulse response function were also employed to study the short run dynamic relationship of the variables. The results of impulse response functions obtained by applying a standard Choleski decomposition indicates that economic growth show response to impulse of inflation with little sense after some period. While the response of inflation rate to impulses in growth is also at the end of the study period. If a shock like drought which significantly reduces output occurs, then the response of inflation will be very high. The response of inflation to growth impulse gradually disappears over the time horizon. Furthermore, the response of inflation and economic growth for itself innovation has little effect. Generally the short run response of each variable is very week.

Generally it should be borne in mind that the study did not consider as various studies reviewed in the literature has come out with the result that high inflation is and has never been favorable to economic growth, that is why in my result inflation doesn't have any negative or positive effect on growth rather economic growth causes inflation. Therefore, the finding supports the alternative hypothesis of the existence of a unidirectional relationship between inflation and economic growth that run from economic growth to inflation.

5.2. RECOMMENDATION

Based on the findings the researcher would recommend that the government and policy maker should be responsible for the following actions that will help in minimizing inflationary effect on economic growth and the long run inflation effect on economic growth.

- The insignificant inflation coefficient in the short-run model could signify that the monetary lag for the effect of inflation on growth, therefore this needs the monetary authority to create an appropriate monetary policy that leads to faster adjustment in response of output to the change in inflation. Monetary policy should be used as a short term tool for macroeconomic stabilization in Ethiopia. Therefore, Policy makers need to ascertain the liquidity needs of the economy and thereby create greater certainty in the amount of credit and money to be supplied to achieve macroeconomic objectives. Furthermore, monetary authorities should be transparent to thes public about their policy objectives and should do to their level best to win credibility among the public that they truly pursue the predefined objectives. This helps to harness expectations of the public and thereby ensure macroeconomic growth. For sustained economic growth, policy makers should make sure that monetary actions do not adversely affect economic growth.
- The insignificant magnitude of economic growth coefficient in the relationship between inflation and economic growth in the short run is due to inelastic nature of output growth in the short-run since in Ethiopia the economy is dependent on agricultural productivity which is inelastic in the short run. Thus, efforts should be exerted by government bodies at different level to identify the specific failure of the economy. Therefore, government needs to do its level best to solve supply-side constraints, build national productive capacity and develop an efficient trading and transport infrastructure
- Generally based on the result there is no any short run relationship between inflation and economic growth, hence the government and policy maker together cooperate to tackle the short run output lag and monetary lag through appropriate fiscal and monetary policy.
- The significant negative sign long run coefficient of economic growth on inflation shows that an excess supply of output results a decrease in inflationary pressure in the economy.

Therefore, the basic long run solution of the macro economy stabilization is tackling of supply constraint.

- Finally, we suggest further research and developments specific to such macroeconomic area and it needs to move towards making smooth the macroeconomic environment.

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7. APPENDICES

Table A1: Vector Error Correction Estimates

Vector Error Correction Estimates

Date: 10/25/15 Time: 07:29

Sample (adjusted): 3 24

Included observations: 22 after adjustments

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
INF(-1)	1.000000	
GRGDP(-1)	-1.238687	
	(0.12842)	
	[-9.64573]	
C	-0.212870	
Error Correction:	**D(INF)**	**D(GRGDP)**
CointEq1	-0.803527	0.333108
	(0.21701)	(0.14834)
	[-3.70275]	[2.24556]
D(INF(-1))	0.253472	-0.108684
	(0.20454)	(0.13982)
	[1.23926]	[-0.77734]
D(GRGDP(-1))	-0.390396	0.318029
	(0.36776)	(0.25139)
	[-1.06156]	[1.26508]

C	0.786065	0.599358
	(0.51327)	(0.35085)
	[1.53150]	[1.70828]
R-squared	0.448927	0.222822
Adj. R-squared	0.357081	0.093292
Sum sq. resids	68.96332	32.22462
S.E. equation	1.957370	1.338005
F-statistic	4.887843	1.720240
Log likelihood	-43.78450	-35.41522
Akaike AIC	4.344046	3.583202
Schwarz SC	4.542417	3.781573
Mean dependent	0.727273	0.727273
S.D. dependent	2.441152	1.405154
Determinant resid covariance (dof adj.)		6.854456
Determinant resid covariance		4.588520
Log likelihood		-79.19243
Akaike information criterion		8.108403
Schwarz criterion		8.604331

Table A2: Least squares estimator of GRGDP

Dependent Variable: D(INF)

Method: Least Squares

Date: 10/25/15 Time: 07:31

Sample (adjusted): 3 24

Included observations: 22 after adjustments

D(INF) = C(1)*(INF(-1) - 1.23868723759*GRGDP(-1) - 0.212869968163) +

C(2)*D(INF(-1)) + C(3)*D(GRGDP(-1)) + C(4)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.803527	0.217008	-3.702750	0.0016
C(2)	0.253472	0.204536	1.239255	0.2312
C(3)	-0.390396	0.367759	-1.061555	0.3025
C(4)	0.786065	0.513266	1.531498	0.1430

R-squared	0.448927	Mean dependent var	0.727273
Adjusted R-squared	0.357081	S.D. dependent var	2.441152
S.E. of regression	1.957370	Akaike info criterion	4.344046
Sum squared resid	68.96332	Schwarz criterion	4.542417
Log likelihood	-43.78450	Hannan-Quinn criter.	4.390776
F-statistic	4.887843	Durbin-Watson stat	2.117341
Prob(F-statistic)	0.011712		

D(INF) = -0.803527252199*(INF(-1) - 1.23868723759*GRGDP(-1) - 0.212869968163) + 0.253472474975*D(INF(-1)) - 0.390396174512*D(GRGDP(-1)) + 0.786065366738

Table A3: Least squares estimator of INF

Dependent Variable: D(GRGDP)

Method: Least Squares

Date: 10/25/15 Time: 07:33

Sample (adjusted): 3 24

Included observations: 22 after adjustments

D(GRGDP) = C(5)*(INF(-1) - 1.23868723759*GRGDP(-1) -
0.212869968163) + C(6)*D(INF(-1)) + C(7)*D(GRGDP(-1))
+ C(8)

	Coefficient	Std. Error	t-Statistic	Prob.
C(5)	0.333108	0.148341	2.245556	0.0375

C(6)	-0.108684	0.139815	-0.777341	0.4471
C(7)	0.318029	0.251390	1.265082	0.2220
C(8)	0.599358	0.350855	1.708281	0.1048

R-squared	0.222822	Mean dependent var	0.727273
Adjusted R-squared	0.093292	S.D. dependent var	1.405154
S.E. of regression	1.338005	Akaike info criterion	3.583202
Sum squared resid	32.22462	Schwarz criterion	3.781573
Log likelihood	-35.41522	Hannan-Quinn criter.	3.629932
F-statistic	1.720240	Durbin-Watson stat	1.845147
Prob(F-statistic)	0.198613		

D (GRGDP) = 0.333107935068*(INF (-1) - 1.23868723759*GRGDP (-1) - 0.212869968163) - 0.108684198104*D (INF (-1)) + 0.318028779635*D (GRGDP (-1)) + 0.599358357786

DECLARATION

I, the undersigned, declare that this thesis is my original work and 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.

Declared by:

Name: _________________________________

Signature: ______________________________

Date: __________________________________

Confirmed by Advisor:

Name: _________________________________

Signature: ______________________________

Date: ________________________