Economic Growth and Inflation
A panel data analysis

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ABSTRACT

One of the most important objectives for any countries is to sustain high economic growth. Even though there are main factors that affect economic growth, the concern of this paper is only about inflation. The relationship between economic growth and inflation is debatable. The first objective of this study is to investigate the relationship between inflation and economic growth. This study uses panel data which includes 13 SSA countries from 1969 to 2009. To analyze the data the model is formed by taking economic growth as dependent variable and four variables (i.e. inflation, investment, population and initial GDP) as independent variables. The result indicates that there is a negative relationship between economic growth and inflation. This study is also examined the causality relationship between economic growth and inflation by using panel Granger causality test. Panel granger causality test shows that inflation can be used in order to predict growth for all countries in the sample, while the opposite it is only true for Congo, Dep. Rep and Zimbabwe.

Key words: economic growth, inflation, panel data, fixed effects, panel Granger causality test
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Chapter one

1.1 Introduction

Achieving sustainable rapid economic growth is the objective of most countries. It has been a problem to achieve such objective due to many factors that affects economic growth. Economic growth and the rate of inflation is central subject of macroeconomics policy. Among many variables that can be stated as the determinant of economic growth is inflation (Barro, 1995). However there is no a clear cut decision about the relationship between economic growth and inflation. Researchers investigated about inflation and economic growth and arrived came up with different views. It has been a controversial in both theory and empirical findings.

The first controversial issue about economic growth and inflation is the relationship between them. Theories and previous studies about the relationship between inflation and economic growth have shown that there might be no relationship (Sidrauski, 1967), negative relationship (Fisher, 1993) or positive relationship (Mallik and Chowdhury, 2001) between these two variables. Today the question is not only the simple relationship but also the level of inflation that can affect economic growth. The structuralists view that inflation has a positive effect on economic growth, where as monetarists see inflation as detrimental to economic growth. Both views have their own explanation for why inflation has a positive or a negative impact on economic growth. For instance in neo classical views, inflation increases economic growth by shifting the income distribution in favor of higher saving capitalists. This increases saving and thus economic growth. Moreover, Keynesians also said that inflation may increase growth by raising the rate of profit, thus increasing private investment. On other hand, theories or empirical studies shows why inflation is negatively related to economic growth. For example, Barro (1995) said that high inflation reduces the level of investment and a reduction in investment adversely affects economic growth. Gultekin (1983) also explained why inflation and economic growth have a negative relationship as growth rate is depended on rate of return but rate of return is decreased by inflation and hence economic growth is negatively related to inflation.

The second controversial issue is the causality relationship between inflation and economic growth. The question about the forecasting power of inflation for economic growth and vice
verse has been debatable. Granger causality assesses whether there is any potential predictability power of one indicator for the other. For instance, inflation Granger causes economic growth means inflation contains information about the future economic growth. Empirical studies has been indicated a bi-directional causality, a unidirectional causality (either from inflation to economic growth or from economic growth to inflation) and no causality between inflation and economic growth. A study by Paul, Kearney and Chowdhury (1997) indicated three different possibilities about the causality relationship between inflation and economic growth. They found no causality relationship between inflation and economic growth in 40% of the countries; bidirectional causality in about 20% of countries and a unidirectional (either inflation to economic growth or vice versa) relationship in the rest of the countries.

Due to the controversial issues about economic growth and inflation, the investigator is highly interested to examine the relationship between inflation and economic growth in sub Saharan Africa countries (SSA). In addition, this paper tests the causality relationship between inflation and economic growth as such whether the causal relation is bidirectional, unidirectional or no causal relation in SSA countries.

This paper is organized into five chapters. The first chapter is about introducing the study area, formulating the study problem, showing the scope of the study and background of the study. Chapter two is all about empirical review literature. Theoretical framework, econometric modeling and panel Granger causality test are available in chapter three. Chapter three shows how data is analyzed and the description of each variable. Chapter four contains information about the data. Following chapter four empirical results, explanation of the result and general conclusion of the study is available in chapter five.
1.2 Formulating the study Problem

This paper examines the relationship between inflation and economic growth, and analyzes the causality relationship between inflation and economic growth. Therefore, at the end this study will answer the following question;

1. Is there a significant relationship between inflation and economic growth? If so, is the relationship a positive or a negative?
2. Is the causality relationship between inflation and economic growth bidirectional, unidirectional (either from inflation to economic growth or from economic growth to inflation) or no causality relation?

1.3 Delimitation of the study

There are about 47 countries in SSA countries. Of all, the study is only focus on 13 countries. The data set cover from 1969 to 2009. This study only tries to see the linear relationship between inflation and economic growth.

1.4 Background of the study

Inflation and economic growth are the main concern of most countries of the world. Thus; inflation and economic growth have gotten attention since the classical period of time. Macroeconomists, policy makers and central monetary authorities of all the nations need to know whether inflation is beneficial to growth or detrimental to growth.

We can see the complexity of the relationship between inflation and economic growth from the result of studies conducted by different researchers. Studies that have been conducted about the relationship between inflation and economic growth found different results. Theories also have different views on issue of inflation and economic growth. Moreover, the direction of causal relationship between inflation and economic growth also debatable. Some have shown bidirectional causality, unidirectional causality and no causality relationship between inflation and economic growth.
Many studies have done on the issue of inflation and economic growth for industrialized as well as developing countries. Fisher (1993) studied about the relationship between inflation and economic growth and concluded a negative relation between these two variables. In contrary, a study took place on Bangladesh, India, Pakistan, and Sri Lanka by Mallik and Chowdhury (2001) found a positive relationship between inflation and economic growth. Ghosh and Phillips (1998) studied about the relationship between inflation and economic growth for 145 countries and concluded that there is a positive relationship between inflation and economic growth when inflation is low but the relation becomes negative for high inflation. Results of studies on Sub Saharan Africa countries also show different view about these two issues. One study by Muritala (2011) on Nigeria indicates that inflation and economic growth are negatively related.

In order to have a clear understanding about relationship between inflation and economic growth from 1995 to 2010 on SSA countries, the investigator uses the following graph.

Figure 1. GDP and inflation of SSA countries

It is possible to see a rough outlook of a relationship between inflation and economic growth from the graph. The graph shows how much it is difficult to say inflation and economic growth are positively or negatively related.

The investigator of this study is highly motivated to examine the relationship between inflation and economic growth in SSA countries due to its controversial nature. Moreover, Inflation rates
in SSA countries are among the highest in the contemporary world. Such phenomenon also makes the investigator more interested to see the relation of inflation and economic growth of SSA countries.

Researchers get different results about the causality between inflation and economic growth. Fisher (1993) verifies that causality goes from inflation to economic growth. Contrary to Fisher, Umaru and Zubariu (2011) examined the causality between inflation and economic growth on Nigeria by using Granger causality test. The test revealed that GDP causes inflation and not inflation causing GDP. Studies also show that the causality relation can be different in the short run and in the long run. Datta and Chanda (2011) study on Malaysia, have shown that causality exist between inflation and economic growth in the short run and direction of causality is from inflation to economic growth but in the long run economic growth causes inflation.

Now a days, politician of some SSA countries also argued that high inflation is the consequence of the country's economic growth. David (1999) explained this issue as “for the last few years, the claim that an increase in economic growth leads to an increase in inflation and that decreased growth reduces inflation has been mantra.” Thus, the investigator would like to see the causal relationship between inflation and economic growth too.
Chapter two

2.1 Literature review - Empirical

This section contains different empirical studies that show the relationship between inflation and economic growth. The concern of previous studies was not only finding simple relationship between inflation and economic growth but also finding whether the relationship holds in the long run or just a short run phenomenon, causal direction of the relationship, whether the relationship is linear or non-linear and the like.

Empirical review for relationship between inflation and economic growth

Fisher (1993) has studied about the relationship between inflation and economic growth entitled “role of macroeconomic factor in growth”. In this paper, the data set consists of several macroeconomic variables including inflation for 93 countries. He applied a simple alternative to mixed regression. The result of the paper has shown that the channel through which inflation affect economic growth and inflation negatively affects growth by reducing investment, and by reducing rate of productivity growth. Fisher also argues that inflation distorts price mechanism, and this will affect the efficiency of resource's allocation and hence influence economic growth negatively. Barro (1997) also studied the relationship between inflation and economic growth. He used 30 years data from 1960 to 1990 of 100 countries. He included other determinants of economic growth additional to inflation. To analyze the data, systems of regression equation were used. The regression results indicated that an increase in average inflation by 10% per year leads to a reduction of the growth rate of real per capita GDP by 0.2% - 0.3% per year and a decrease in the ratio of investment to GDP by 0.4% - 0.6%. But the result is becoming statistically significant only when high inflation experiences are included in the sample. Moltey (1994) includes inflation in his model to examine the effect of inflation on the growth rate of real GDP. He extend the model of Mankiw, Romer and Weil (1992) which was based on Solow growth model by allowing for the possibility that inflation tends to reduce the rate of technical change. The result indicates a negative relationship between inflation and the growth rate of real GDP.

Khan and Senhadji (2001) analyzed the relationship between inflation and economic growth separately for industrial and developing countries. They have used new econometric techniques
initially developed by Chan and Tsay (1998) and Hansen (1999), to show the existence of threshold effects in the relationship between inflation and economic growth. The authors have used unbalanced panels data containing 140 countries for the period 1960-1998. The estimated value of threshold is 1-3 percent and 11-12 percent for developed countries and developing countries respectively. The result indicated that the threshold for industrialized countries is lower than developing countries. It also indicated that inflation level below the threshold level of inflation have no effect on growth. But inflation rates above the threshold level have a significant negative effect on growth.

Mubarik (2005) also tried to estimate threshold level of inflation for Pakistan. He found 9 percent threshold level of inflation and inflation above this level affect economic growth negatively. But inflation below the estimated level is conductive for economic growth.

There are empirical evidences that support the findings of Mundell (1963) and Tobin (1965) of a positive relationship between economic growth and inflation. Mallik and Chowdhury (2001) are among the supporters of positive relationships between the two variables. To reach this conclusion they used co-integration and error correction model to analyze data collected from four south Asian countries (Bangladesh, India, Pakistan and Sirlank) and found a long run positive relationship between inflation and economic growth. They concluded that moderate inflation is helpful to faster the economic growth.

Empirical literature also shows a positive relationship between inflation and economic growth below threshold level of inflation. Ghosh and Phillips (1998) found that at very low inflation rates (less than 2-3 percent) inflation and growth are positively related. Similarly Fabayo and Ajilore (2006) examined the existence of threshold effect in inflation growth relationship on Nigeria using data for the period of 1970-2003. They found 6 percent level of inflation as a threshold. Inflation has a positive impact on economic growth below the threshold level of inflation. Moreover, Wang Zhiyong (2008) studies indicated that economic growth positively relates to inflation with above three quarters’ lag. He used co integration and error correction model to detect the result.

In the other hand, some empirical studies found that zero relationship between inflation and economic growth. One study by Sidrauski (1967) indicates that inflation has no relationship with
growth in the long run. Moreover, he testifies the super neutrality of money in his model. In addition to Sidrauski, Bruno and Easterly (1995) have shown insignificant relationship between inflation and economic growth. They found this result after deleting high observation of inflation. There are also studies that indicate insignificant relationship between the two variables below the threshold level of inflation. For example Christoffersen and Doyel (1998) detected 13 percent threshold level of inflation below which no significant relationship between inflation and economic growth but above the level they have a negative relation.

**Empirical review for causality relationship between inflation and economic growth**

Mubarik (2005) analyzed the causal relationship between inflation and economic growth. The test result indicated that the causality between the two variables is uni-directional i.e. inflation is causing GDP growth but not vice verse. Odhiambo (2011) also examined the short run and long run causal relationship between inflation, investment, and economic growth in Tanzania. He used ARDL-bounding testing approach and found that a unidirectional causal flow from inflation to economic growth. By using VAR granger causality test, Chimobi (2010) studied about inflation and economic growth in Nigeria and found unidirectional causality from inflation to growth. Another paper which is worked in case of Hungary and Poland by Gillman and Nakov (2003) indicated that a causal relationship with direction from inflation to growth and from money to inflation. Moreover, Erbaykal and Okuyan (2008) analyzed the causal relationship between inflation and economic growth in the framework of the causality test developed by Toda Yamamoto (1995). The result indicated no causal relationship from economic growth to inflation where as there is a causality relationship from inflation to economic growth.

Chuan Yeh (2009) estimated the causal interrelationships between inflation and economic growth within a simultaneous equation frame work. They used cross sectional data of 140 countries over the 1970-2005 periods. The result indicated that a bilateral causal relationship between growth and inflation. It also showed that inflation is harmful to growth where as the effect from growth to inflation is beneficial. In their analysis, they grouped the data set into high income, low income and developing countries, and the results indicated that the negative impact of inflation on growth in low income countries is greater than in developing countries and high income countries.
In addition to unidirectional causality from inflation to economic growth and bilateral causality, there are studies which indicated unidirectional causality from growth to inflation. Gokal and Hanif (2004) studied about inflation and economic growth in Fiji. They obtain that granger causality runs one way, from growth to inflation but not from inflation to growth. It means that it is unidirectional. Datta (2011) examined relationship between inflation and economic growth in Malaysia with the data covering from 1971 to 2007. The findings show that there exist short run causality between the variables and direction of causality is from inflation to economic growth and in the long run economic growth Granger cause inflation.

Finally there also studies which indicates, no causality relationship between inflation and economic growth. Kigume (2011) studies about inflation and economic growth in Kenya from 1963 to 200. The Granger causality test of this study revealed that no causality relation between these two variables.
Chapter three

3.1 Theoretical framework

Theories on economic growth and inflation

Economists have been studying about inflation and its impact on economic growth starting from the appearance of classical economic theory to modern economic theories. This section is about the view of growth theories (i.e. classical, Keynesian, monetarist, neo classical and endogenous) on the relationship between inflation and economic growth.

Classical growth theory

Classical theory was founded by Adam Smith. He recognized three factors of production such as land, labor, and capital. His production function can be expressed as:

\[ Y = f(L, K, T) \]

Where \( Y \) is output, \( L \) is labor, \( K \) is capital and \( T \) is land.

Smith considered saving as the most important factor affecting the growth rate. In classical theories there is no direct explanation between inflation and its tax effect on profit level and output. But the relationship between the two variables is implicitly negative by the reduction in firms’ profit level and saving through higher wage costs (Gokal and Harfi, 2004).

Keynesian theory

In 1936, John Maynard Keynes wrote the book “The general Theory of employment, Interest and Money” which established the foundation of Keynesianism. Keynesians believes on the intervention of government to reach full production. They believe that intervention in economy by government through expansionary economic policies will boost investment and promote demand to reach full production. The Keynesian model is based on Aggregate Demand (AD) and Aggregate Supply (AS) curves. In this model AS curve is upward sloping in the short run so that the change in the demand side of the economy affects both price and output (Dornbusch, et al, 1996).
Dornbusch, et al (1996) also argues that AD and AS yields an adjustment path. It shows an initial positive relationship between inflation and economic growth but eventually turns negative towards the latter part of the adjustment path. The initial positive relationship between inflation and economic growth is due to the time inconsistency problem. Producers feel that only the prices of their products have increased while the other producers are operating at the same price level. However, in reality overall prices have increased. Therefore, the producer continues more and more output. Moreover, Blanchard and Kiyotaki (1987) said inflation and economic growth are positively related because of the agreement of firms to supply on agreed price. So the firm has to produce even at increased price. Later on the relationship becomes negative. This describes phenomena of stagflation that is output decreases or remains the same when price rises (Gokal and Hanif, 2004).

**Monetarism**

Monetarism was proposed by Milton Friedman. For this school money supply is the only factor that determines price levels in an economy. They argued that government intervention manages the growth rate of money supply to harmonize it with the growth rate of output in the long run. Monetarists argue that inflation will occur when money supply rises faster than the rate of growth of national income. But the effect of money supply is different for the long run and short run. In the short run, money supply has the dominant influence on the real variables (i.e. real GDP and employment) and price level. But in the long run the influence of variation in the money supply is primarily on price level and on other nominal variables but not on real variable like real output and employment (Richard Froyen, 1998).

Monetarism looks the concept of anticipation into Phillips curve and divide Phillips curve in to short run and long run. For this theory Phillips curve will hold in short run but not in the long run. In the long run, anticipated inflation will be consistent with actual inflation. So inflation will not influence unemployment, output and other real economic variables. This concept is called neutrality of money. Gokal and Hanif (2004) explained the concept of neutrality and super neutrality as 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 and super neutrality holds

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when real variables including the rate of growth of GDP, are independent of the rate of growth in the money supply is the long run. Inflation will be harmless in the case of neutrality and super neutrality. But this may not be true in reality. Inflation is bad for economy because it affects capital accumulation, investment and export and hence affects output.

**Neo – classical growth theory**

The neo – classical growth model was devised by Solow and Swan. They developed growth model that scientific innovation or technological change replaced investment (growth of capital) as the primary factor explain long term growth and level of technological change is determined exogenously, that is independent of all other factors including inflation. Gokal and Hanif (2004) said that in neoclassical economics the theory of growth is built on a concept of diminishing returns to labor and capital separately and constant returns to both factors jointly. The determinants of output growth for neo classical growth theory are technology, labor and capital.

Economists in neo classical growth gave their own explanation about the relationship between inflation and economic growth. Mudell (1963) has explained the effect of inflation on economic growth. According to him, inflation might permanently increase output growth rate by stimulating capital accumulation, because in response to inflation households would hold less in money balance and more in other asset. Tobin (1965) also supported Mundell's idea that inflation is positively related to economic growth. His argument is that inflation causes individuals to change the money into other assets, which leads to greater capital intensity and promotes economic growth.

Contrary to Mundell and Tobin idea, Stockman (1981) developed a model that shows a negative relationship between inflation and economic growth. Stockman's model shows that an increase in the inflation rate results in a lower steady state level of output people's welfare declines. In Stockman's model, money is a compliment to capital, accounting for a negative relationship between the steady state level of output and the inflation rate. But it is substitute goods for Mundell and Tobin.
In this theory there are supporters of no relationship between inflation and economic growth. Sidrauskin (1967) said that an increase in the inflation rate does not change the steady capital stock and economic growth.

Generally, theoretical review in neo classical growth theory demonstrates mixed results regarding relationship of inflation and economic growth.

**Endogenous growth theory**

In endogenous growth theories economic growth is generated by factors within production process. Endogenous growth model assumes that technological progress is endogenous. This assumption is contrary to neo classical growth theory. The other basic difference between the endogenous growth models and the neo classical economies is that in the neo classical growth theory capital is assumed to be diminishing on return while endogenous growth theory assumes that marginal product of capital is constant.

In endogenous growth theory, the rate of return on capital i.e. human capital and physical capital determine the growth rate. A tax on either form of capital induce a lower return. Macallum and Goodfriend (1987) said that the inflation rate (tax) lower both the return on all capital and the growth rate.

**3.2 Econometric modeling**

This section explains how to examine the relationship between inflation and economic growth. To reach the objective of this study I formulate model by including inflation and initial GDP in Solow growth model. I substitute population and investment for labor and capital of Solow growth model. Therefore, five variables such as real GDP per capita, inflation, population, initial per capita GDP, and investment rate are included in the model. Population, initial per capital GDP and investment are used as control variables. Each variable and the way to measure each variable are explained as follows:
Economic growth

Economic growth is the dependent variable of the study and it is measured by the growth rate of real GDP per capita. The data is taken from World Bank’s database. This variable is denoted by GGDP.

Inflation

Inflation is the first explanatory variable and it is also the main concern of this paper. As stated in literature review, there is no a clear cut decision about relationship between inflation and economic growth. Figure (3) is clearly shown that the distribution of inflation is highly skewed. Doing regression based on level of inflation would give more weight for extremes observation (Khan and Senhadji, 2001). Sarel (1996) said that log transformation eliminates, at least partially, the strong asymmetry in the inflation distribution. In this paper log of inflation used in order to solve this problem. This variable is denoted by INF. Inflation data has been taken from World Bank’s database.

Figure 2 Distribution of inflation for the sample countries (491 number of observation) in level
Investment rate

Investment rate is the second explanatory variable. Most studies indicated a positive impact of investment on economic growth. For instance Barro and Sala-i-Martin found a positive impact of the investment on the economic growth. The data has been taken from the Penn World Tables webpage. In this paper investment rate is denoted by INVT.

Population growth

The third explanatory variable is population. It is the exponential rate of growth of midyear population. Evidence on relationship between population and economic growth does not point to any uniform conclusion. Some said high population growth creates pressure on limited natural resources, and reduces private and public capital formation and economic growth. Others argued to positive effects of population on economic growth. Population growth rate is denoted by GPOP. This series is obtained from World Bank database.
Initial per capita GDP

Initial per capita GDP is the last explanatory variable for this model. Researches show different result for the effect of initial per capita GDP on economic growth. Barro(1997) has shown a negative relationship between initial GDP and economic growth. But Blomstrom (1996) has found a positive relationship between initial GDP and economic growth. Real GDP per capita of year 1969 is considered as initial per capita GDP for this study. It is denoted by GDP0. The data on initial per capita GDP are from World Bank’s database.

3.2.1 Regression model

The following equation is used to see the relationship between inflation and economic growth:

\[
\text{GGDP}_{it} = \beta_0 + \beta_1 \text{INVT}_{it} + \beta_2 \text{GPOP}_{it} + \beta_3 \ln \text{INF}_{it} + \beta_4 \ln \text{GDP0}_{i} + \epsilon_{it} \quad (1)
\]

Where \( \text{GGDP}_{it} \) is the growth rate of real GDP per capita of country \( i \) in year \( t \), \( \text{GPOP}_{it} \) the growth rate of population of country \( i \) in year \( t \), \( \text{INF}_{it} \) is the inflation rate of country \( i \) in year \( t \), and \( \text{GDP0}_{i} \) is the initial level of GDP of country \( i \) in year 1969. The main concern of the above model is to test whether the margin impact of inflation on economic growth, \( \beta_3 \), is positive or negative and statistically significant. The expected sign of the coefficients \( \beta_1 \) is positive and that of \( \beta_2 \) and \( \beta_4 \) are either positive or negative.

The estimation is done by fixed effect. Stata software has been used to analyze the data. Equation (1) can be modified into three different ways. The first is formed without considering time and country effect. In second model country effect is considered by including country dummies. Model three includes both time effect and country effect. Hence, equation (1) is written in three ways as follows;

1. \( \text{GGDP}_{it} = \beta_0 + \beta_1 \text{INVT}_{it} + \beta_2 \text{GPOP}_{it} + \beta_3 \ln \text{INF}_{it} + \beta_4 \ln \text{GDP0}_{i} + \epsilon_{it} \)

2. \( \text{GGDP}_{it} = \beta_0 + \sum_{i=1}^{12} D_i + \beta_1 \text{INVT}_{it} + \beta_2 \text{GPOP}_{it} + \beta_3 \ln \text{INF}_{it} + \beta_4 \ln \text{GDP0}_{i} + \epsilon_{it} \)
3. GDP_{it} = \beta_0 + \sum_{t=1}^{41} D_t + \sum_{i=1}^{12} D_i + \beta_1 \text{INV}_{it} + \beta_2 \text{GPOP}_{it} + \beta_3 \ln \text{INF}_{it} + \beta_4 \ln \text{GDP}_{it} + \epsilon_{it}

Where \sum_{t=1}^{41} D_t is a dummy variable indicating time effects, \sum_{i=1}^{12} D_i is dummy variables indicating country effects.

3.3 Panel Granger causality test

To meet the second objective i.e. testing the causality between economic growth and inflation, I use a modified Granger causality test. To show causal relationship Granger test is the common one. The null hypothesis that x does not Granger causal y is evaluated by estimating an equation in which y is regressed on lagged values of y and the lagged values of an additional variable x. Granger test is modified to incorporate panel dynamics (Arellano and Bond, 1991; and Hurlin and Venet, 2001). In panel frameworks Granger tests generate meaningful results with shorter time, incorporate more observations and produce more efficient than Granger test in conventional context (Hurlin and Venet, 2001).

The common method used with time series variables proposed by Granger (1969) cannot be implemented for a panel data analysis. Granger causality test applies for homogenous time series when N causality relationships exist and when the individual predictors of y obtained conditionally on past values of y and x are identical. Hurlin and Venet (2001) incorporated Granger causality testing between x and y, taking into account potential cross sectional heterogeneity in the panel.

Hurlin and Venet (2001) outlined a procedure for evaluating the character of the causal process (homogenous vs. heterogeneous) within a panel framework. They proposed an extension of the Granger causality definition to panel data models with fixed coefficients. They used the following model, where for each of the individual i and for all t in [1, T]:

\[ y_{i,t} = \sum_{k=1}^{n} \gamma_{i,t-k} y_{i,t-k} + \sum_{k=0}^{n} \beta_{i,t-k} x_{i,t-k} + v_{i,t} \]  

(2)
With $p \in \mathbb{N}^{*}$ and $v_{i,t} = a_{i} + \epsilon_{i,t}$, where $\epsilon_{i,t}$ are i.i.d. $(0, \sigma_{\epsilon}^{2})$.

Contrary to the primary alternative to panel VAR modeling, Hurlin and Venet model assumed that the autoregressive coefficient $\gamma^{(k)}$ and the regression coefficient slopes $\beta_{i}^{(k)}$ are constant $\forall k \in [1, p]$. They also assumed that parameter $\gamma^{(k)}$ are identical for all individual, where as the regression coefficients slopes $\beta_{i}^{(k)}$ could have individual dimension.

The standard causality tests consist in testing linear restrictions on parameter $\beta_{i}^{(k)}$. If panel are used to test causality, the researcher should pay attention to the question of heterogeneity between cross sectional units. The first source of heterogeneity is caused by permanent cross sectional disparities. Such heterogeneity is controlled by the introduction individual effect $a_{i}$ in the model. A pooled estimation without heterogeneous intercepts leads to a bias of the slope estimates and could lead to a fallacious inference in causality tests (Hurlin, 2004). To see the causal relation of panel data, Hurlin and Venet identify three types of causality hypothesis to be tested.

**A test procedure**

The first test, named as homogenous non causality (HNC) hypothesis, is to test whether or not the regression slope coefficients associated to $x_{i,t-k}$ are simultaneously null for all individual $i$ and all lags $k$. In model (4), the hypotheses to be tested are:

$$H_{0} : \beta_{i}^{(k)} = 0 \forall i \in [1, N], \forall k \in [1, P]$$

$$H_{a} : \beta_{i}^{(k)} \neq 0 \exists (i, k)$$

The Homogenous Non Causality test statistic ($F_{hnc}$) is calculated as:

$$F_{hnc} = \frac{(RSS_{2} - RSS_{1})/Np}{RSS_{1}/[NT - N(1 + p) - p]}$$

Where $N$ is the number of cross-section, $P$ is the number of lags, and $T$ is the number of time period. $RSS_{2}$ is the restricted sum of squared residual obtained by making the slope coefficients...
and the lags of model (2) zero. The restricted model only contains the unit specific effects and the various lags of the dependent variable to predict current value of \( y \). RSS\(_1\) is unrestricted sum of square residual calculated from model (2).

Accepting the Homogenous Non causality Hypothesis is an indication that \( x \) does not Granger cause \( y \) for any of the panel members. As a result, the testing process ends here. If the result leads to reject the null hypothesis, the next step proceeds to test the hypothesis of homogenous causality.

Following the rejection of Homogenous Non Causality Hypothesis, the second test which refers to Homogenous Causality (HC) Hypothesis is to continue. The objective of the second test is to show whether the regression slope coefficients of \( x_{i,t-k} \) in (4) are identical for all lags \( k \) or not. The following hypotheses are to tested:

\[
H_0 : \beta_i^k = \beta^k \quad \forall k \in [1, p] \forall i \in [1, N]
\]

\[
H_a : \beta_i^k \neq \beta_j^k \quad \exists k \in [1, p], \exists (i, j) \in [1, N]
\]

In order to test HC hypothesis, the following statistics is calculated:

\[
F_{hc} = \frac{(RSS_3 - RSS_1)/[P(N - 1)]}{RSS_1/[NT - N(1 + P) - P]}
\]

Where \( N \) is the number of cross-section, \( P \) is the number of lags, and \( T \) is the number of time period. RSS\(_3\) is the restricted sum of squared residual under \( H_0 \). RSS\(_1\) is unrestricted sum of square residual calculated from model (2).

If the \( F_{hc} \) statistics is not significant, the null hypothesis is accepted and it indicates that the causal relationship is homogenous for every individual of the sample. So it is not necessary to go further. But if the result is significant, it is necessary to go further. Because the result indicates that at least one individual of the sample \( x \) does not cause \( y \). Therefore, it is necessary to determine for which individual \( i \), the causal relation is rejected.
The last step is testing Heterogeneous Non Causality (HENC) hypothesis. A third hypothesis is tested in order to determine for which panel members $x$ Granger causes $y$. The hypothesis under this case is stated as follow:

$$H_0: \beta^k_i = 0 \quad \forall i \in [1, N], \forall k \in [0, P]$$

$$H_a: \beta^k_i \neq 0 \quad \forall i \in [1, N], \forall k \in [0, P]$$

Here the test is running for each cross sectional unit and it tests the nullity of all the coefficients of the lagged explanatory variable $x_{i,t-k}$. The statistic to test the Heterogeneous Non Causality Hypothesis for panel member $(i)$ is calculated as follows:

$$F_{henc}^i = \frac{(RSS_{2,i} - RSS_{1})/P}{RSS_{1}/[NT - N(1 + 2P) + P]}$$

Where $RSS_{2,i}$ is sum of squared residuals for each individual $i$ and it is found in model 1 by imposing the nullity of the $k$ coefficients associated with the variable $x_{i,t-k}$. If the $F_{henc}^i$ is significant, it is possible to reject the null hypothesis, indicating that $x$ Granger cause $y$ for panel member $(i)$. But if it is insignificant, it leads to accept the null hypothesis that shows $x$ does not Granger cause $y$ for panel member $(i)$.

Therefore to test the causality between economic growth and inflation I use Hurlin and Venet procedure by including two variables i.e. inflation rate and economic growth in the model.
Chapter four

4.1 Data description

The two main objectives of this paper are to find the relationship between economic growth and inflation, and to examine its causal relationship in SSA. In order to achieve the objective of this paper panel data is used. Panel data is chosen because it exploits both time series and cross sectional information and it gives large number of observations, increasing the degree of freedom and reducing the colinearity among explanatory variables. Gujarati (2004) said that panel data improves empirical analysis in ways that may not be possible if we use only cross-section or time series data. It allows for considerably more flexibility modeling the behavior of cross sectional units than convectional time series analysis (Green, 2000).

The dataset of the present study includes 13 Sub Saharan Africa countries and covers the period from 1969 to 2009. Sub Saharan African countries are became the target of this study since nowadays the inflation of these countries is increased. Moreover, this study includes some Sub-Saharan countries which are suffering by high inflation. Lists of countries which include in this study are presented in table (1).

The data is arranged into panel form. The first panel is formed by including five variables such as the growth rate of real GDP per capita, inflation, investment, population and initial real GDP per capita. The second panel is formed with two variables such as the growth rate of real GDP and inflation. The first panel is arranged to test the relationship between inflation and economic growth. The second panel is formed to test the causal relationship between inflation and economic growth.
Table 1 Countries of observations

<table>
<thead>
<tr>
<th>Country</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameroon</td>
<td>Kenya</td>
</tr>
<tr>
<td>Congo, dep.Rep.</td>
<td>Madagascar</td>
</tr>
<tr>
<td>Cote d Ivory</td>
<td>Nigeria</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Senegal</td>
</tr>
<tr>
<td>Gabon</td>
<td>South Africa</td>
</tr>
<tr>
<td>Gambia, The</td>
<td>Zimbabwe</td>
</tr>
<tr>
<td>Ghana</td>
<td></td>
</tr>
</tbody>
</table>

4.2 Descriptive statistics of the data

Table (2) is containing the sum of all variables in the analysis. It is calculated by using stata. It contains the mean, the standard deviation, the maximum and the minimum value of the data which can be observed. It is used to see the overall outlook of the data.

Table 2. Descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of observations</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGDP (real)</td>
<td>491</td>
<td>2.9299</td>
<td>5.7923</td>
<td>-16.0492</td>
<td>19.48</td>
</tr>
<tr>
<td>INVT (%)</td>
<td>490</td>
<td>19.1733</td>
<td>9.2088</td>
<td>0.9</td>
<td>21.37</td>
</tr>
<tr>
<td>GPOP (%)</td>
<td>491</td>
<td>2.7673</td>
<td>0.7639</td>
<td>-0.3871</td>
<td>4.8644</td>
</tr>
<tr>
<td>InINF (%)</td>
<td>491</td>
<td>0.0158</td>
<td>1.4789</td>
<td>-6.7196</td>
<td>7.0168</td>
</tr>
<tr>
<td>InGDP0 (real)</td>
<td>491</td>
<td>3.4908</td>
<td>1.0147</td>
<td>2.202</td>
<td>4.9267</td>
</tr>
</tbody>
</table>
Chapter five

5.1 Empirical results

5.1.1 Correlation matrix and Unit root test

Unit root test for time series is not used for panel data. Panel unit root tests have advantage over time series unit root test in that it increases the power of unit root test due to the span of observation, and also minimize the risks of structural breaks (Ferreir, 2009).

Among the available panel unit root tests, Levin, Lin and Chu (2002) test is used for this study. The test may be viewed as a pooled Dickey – Fuller test, or an augmented Dickey-Fuller (ADF) test when lags are included. LLC assume that the individual processes are cross-sectional independent. Their test is based on the analysis of the equation:

\[ \Delta y_{it} = c_i + \rho_i y_{i,t-1} + \sum_{j=1}^{k} c_j \Delta y_{i,t-j} + \varepsilon_{i,t} \]

Where \( t=1,\ldots,T \) time periods and \( i=1,\ldots,N \) members of the panel. The null hypothesis for the Levin, Lin and Chu test is that \( \rho_i = 0 \) for all \( i \), and the alternative is that \( \rho_i = \rho_i < 0 \) for all \( i \). In other words, the null hypothesis indicates the series contains unit root whereas the alternative shows the series is stationary.

Since each variable is transformed to log form, the tests of the presence of unit root are based on log form. The result of the test is reported in table (3). Levin, Lin and Chu test result indicates the null hypothesis is rejected for all variables at different significant level. It means all variables are stationary in the level form.
Table 3. Unit root test

<table>
<thead>
<tr>
<th>Test</th>
<th>Test statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGDP</td>
<td>-13.2104*</td>
</tr>
<tr>
<td>INVVT</td>
<td>-6.1023**</td>
</tr>
<tr>
<td>GPOP</td>
<td>-9.6654*</td>
</tr>
<tr>
<td>lnINF</td>
<td>-10.7034*</td>
</tr>
</tbody>
</table>

*Note*: * is significant at 1%, ** is significant at 5% and *** is significant at 10%

Followed by unit root test, the correlation matrix is done to detect the correlation among the variables: GGDP, INVVT, GPOP, lnINF, and lnGDP0. Table (4) shows the correlation matrix of the variables used, and the growth rate of real GDP per capita has a negative correlation with inflation and initial GDP. From the result we can also see that there is negative correlation between inflation and investment. The growth rate of real GDP per capita is positively correlated with investment and population growth. The result of a negative correlation between inflation and investment is supported by Fisher (1993) argument that inflation is detrimental to investment.

Table 4. Correlation matrix

<table>
<thead>
<tr>
<th></th>
<th>GGDP</th>
<th>INVVT</th>
<th>GPOP</th>
<th>lnINF</th>
<th>lnGDP0</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGDP</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INVVT</td>
<td>0.2737</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPOP</td>
<td>0.1295</td>
<td>-0.0760</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnINF</td>
<td>-0.1359</td>
<td>-0.0383</td>
<td>0.0592</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>lnGDP0</td>
<td>-0.0255</td>
<td>0.0927</td>
<td>-0.2371</td>
<td>-0.1844</td>
<td>1</td>
</tr>
</tbody>
</table>
5.1.2 Regression result

Table 5. Regression results

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>INVT</td>
<td>0.191*</td>
<td>0.265*</td>
<td>0.244*</td>
</tr>
<tr>
<td></td>
<td>(6.76)</td>
<td>(7.0)</td>
<td>(5.33)</td>
</tr>
<tr>
<td>GPOP</td>
<td>1.22</td>
<td>-0.438</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>(0.63)</td>
<td>(-1.14)</td>
<td>(-0.21)</td>
</tr>
<tr>
<td>lnINF</td>
<td>-0.58*</td>
<td>-0.823*</td>
<td>-0.61**</td>
</tr>
<tr>
<td></td>
<td>(-3.24)</td>
<td>(-3.80)</td>
<td>(-2.5)</td>
</tr>
<tr>
<td>lnGDP0</td>
<td>-0.5</td>
<td>-4.13*</td>
<td>-3.28**</td>
</tr>
<tr>
<td></td>
<td>(-0.19)</td>
<td>(-3.8)</td>
<td>(-2.13)</td>
</tr>
<tr>
<td>Country dummies</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time dummies</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of observation</td>
<td>491</td>
<td>491</td>
<td>491</td>
</tr>
<tr>
<td>R²</td>
<td>0.2927</td>
<td>0.3366</td>
<td>0.4970</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.2854</td>
<td>0.3118</td>
<td>0.4025</td>
</tr>
</tbody>
</table>

Note: figures in brackets are t values, * is significant at 1%, ** is significant at 5% and *** is significant at 10%

Model 1

The result of model 1 shows that the coefficient of inflation is negative sign, indicating that inflation has adverse effects on economic growth. The t value and the p value of the regression result show that whether the variable is significant for the model or not. Inflation is statistically significant at 1 percent significant level. Thus, from this we can understand that inflation is
significantly determining economic growth of the sample countries. The coefficient of inflation is equal to -0.58. It means that one percent increase (decrease) in inflation result in 0.58 percent decrease (increase) in economic growth while other variables holding constant. Investment has positive sign and it is statistically significant at 1 percent significant level. The coefficient value indicates that if investment rises by 1 percent, economic growth will increase about 0.191 percent by holding other independent variables constant. The result indicates that investment is a one variable that promote economic growth significantly. Population has a positive relationship with economic growth but it is statistically insignificant. The coefficient of the initial per capita GDP has a negative sign but it is statistically insignificant. The \( R^2 \) value for the model 1 is 0.2927. It implies that inflation, investment, population growth rate, and initial per capita GDP explained about 29% systematic variation on real GDP growth over the observed years while the remaining variation is explained by other determinant variables outside the model.

**Model 2**
The second regression is run by including country dummies to account country effect. The result of model 2 is almost the same as the result of model 1 except inflation. The coefficient of inflation is still negative and significant. Investment is positively and significantly related to economic growth. Population growth is insignificant for the model. The coefficient of initial GDP in model 2 is negative and statistically significant. A coefficient value of -4.13 for the initial per capita GDP implies that a 1 percent increase in initial per capita GDP decreases the current growth rate of GDP per capita by 4.13 percent. Value of \( R^2 \) is became 0.3366 which is greater than value of model 1.

The regression results for dummy variables indicated us the individuality of each country in the relationship between inflation and economic growth. Cameroon is a comparison country and its coefficient is 4.04. All intercept values of the countries are statistically significant except Congo, Dep.Rep and Ghana.

**Model 3**
Model 3 is estimated by including both time dummies and country dummies. The result indicates that inflation is still negative and statistically significant at 1% significant level. The coefficient of initial GDP is negative and statistically significant. Investment has positive and statistically
significant coefficient in this model. Population growth is still insignificant for the model. The $R^2$ value of model 3 is 0.4970 which is greater than both model 1 and model 2.

Estimated value of time dummies is presented in the appendix. Dummy for year 1969 acts as a base to which other estimates add to, resulting in a value for each specific year. For instance result of D1969 is -0.9564 and D1970 is 3.9598(4.4504-0.4906). The estimate values show that all year dummies are statistically significant at different significant level except some years, indicating that they are significantly different from each other.

### 5.1.3 Testing for time fixed effects

This test will give us a guarantee for the inclusion of time effect or not. The null hypothesis for this test is the time dummies are not jointly significant. If the F value is significant, we can reject the null hypothesis and accept the alternative hypothesis, and as a result fixed effects regression should include time effects. Otherwise, if it is insignificant, we failed to reject the null hypothesis that all years coefficient are jointly equal to zero thus no time effect is needed.

The calculated F values are equal to 46.47. Since calculated F value is greater than critical F value, we can reject the null hypothesis, thus time fixed effect is needed in the estimation.

### 5.1.4 Heteroscedasticity

Heteroscedasticity is occurred when the error terms do not have constant variance. Heteroscedasticity is easily checked by stata. The null hypothesis is homoskedasticity (or constant) variance. The following is the test result for this problem.

$\chi^2(12) = 63.92$

prob $> \chi^2 = 0.0000$

From the result, we reject the null hypothesis and conclude that there is heteroscedasticity problem. To control this problem the estimation is done by using the option robust and the result is already presented in table 5.

### 5.1.5 Result of panel Granger causality test

The second objective of this paper is to know if:
inflation_{(i,t-k)} \xrightarrow{\text{granger}} \text{economic growth}_{(i,t)}

and if

economic growth_{(i,t-k)} \xrightarrow{\text{granger}} \text{inflation}_{(i,t)}

collectively for 13 countries in my sample. As Hurlin and Venet proposed the first step is testing homogenous non causality (hnc) hypothesis. That is stated as:

\( H_{\text{hnc}} : \text{for all countries in the sample, inflation (economic growth) does not cause economic growth (inflation).} \)

To test \( H_{\text{hnc}} \), I calculate \( F_{\text{hnc}} \) test statistics using sum of square residuals from an unrestricted model and sum of square residuals from a restricted model. The formula of \( F_{\text{hnc}} \) test is already stated in methodology part of this paper. Unrestricted model is defined below:

\[
\text{GGDP}_{i,t} = \gamma_{i,t-1}\text{GGDP}_{i,t-1} \ldots \gamma_{i,t-k}\text{GGDP}_{i,t-k} + \beta_{i,t-1}\text{INF}_{i,t-k} \ldots \beta_{i,t-k}\text{INF}_{i,t-k}
\]
\[
\alpha_i + \varepsilon_{i,t-1} \ldots \varepsilon_{i,t-k}
\]

(3)

\[
\text{INF}_{i,t} = \gamma_{i,t-1}\text{INF}_{i,t-1} \ldots \gamma_{i,t-k}\text{INF}_{i,t-k} + \beta_{i,t-1}\text{GGDP}_{i,t-1} \ldots \beta_{i,t-k}\text{GGDP}_{i,t-k} +
\]
\[
\alpha_i + \varepsilon_{i,t-1} \ldots \varepsilon_{i,t-k}
\]

(4)

Where the slope coefficients for subsequent lags within the countries are constrained to be equal and a restricted model is found from unrestricted model by making the slope coefficient and subsequent lags for all countries in the sample are constrained to zero. If \( F_{\text{hnc}} \) test statistics is significant, then it is possible to say that economic growth Granger causes for inflation or inflation Granger causes for economic growth for at least one of the countries in the sample.

The result of \( F_{\text{hnc}} \) test statistics for inflation Granger causes economic growth and economic growth granger causes inflation are presented in table (6). The result of \( F_{\text{hnc}} \) test statistics for
inflation Granger causes economic growth is statistically significant at lag 2. This indicates that there is a possibility to inflation granger causes economic growth at least for one country in the sample. In addition to this, table (6) shows the value of $F_{hnc}$ test statistics for economic growth granger causes inflation and it is statistically significant at lag 1 to 3. It means that $H_{hnc}$ is rejected for the given lag and accept the alternative that is economic growth Granger causes inflation for at least one country. Thus, this leads to second test.

Table 6. $F_{hnc}$ test statistics

<table>
<thead>
<tr>
<th>Lags</th>
<th>$F_{hnc}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>causality from inflation to economic growth</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.348</td>
</tr>
<tr>
<td>2</td>
<td>1.7641*</td>
</tr>
<tr>
<td>3</td>
<td>0.1973</td>
</tr>
<tr>
<td><strong>causality from economic growth to inflation</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5.0112*</td>
</tr>
<tr>
<td>2</td>
<td>2.4795*</td>
</tr>
<tr>
<td>3</td>
<td>1.8213*</td>
</tr>
</tbody>
</table>

*Note: critical values of $F_{hnc}$ is based on an $F$-distribution with $NP,NT-N(1+P)-P$ df (Hurlin and Venet, 2001). * is significant at 1% significant, ** is significant at 5% and *** is significant at 10%*

Following the rejection of homogenous non causality hypothesis, the second hypothesis refers to homogenous causality is going to be tested. The second hypothesis is homogenous causality hypothesis or overall causality hypothesis. Homogenous causality hypothesis is stated as follow

$H_{hc}$ : For all countries : inflation (economic growth) causes economic growth (inflation).

For accepting or rejecting $H_{hc}$ , $F_{hc}$ is calculated by using the sum of squared residuals from the unrestricted model of equation (3) (4 ) and sum of square residual from restricted model where the coefficients are constrained to be equal for all countries and lag periods (i.e. $\beta_{1,t-1}=\beta_{2,t-2}=\beta_{n,t-k}$).

From value of $F_{hc}$ we can accept or reject the hypothesis of homogenous causality. $H_{hc}$ is accepted when $F_{hc}$ is insignificant. Accepting $H_{hc}$ indicates that the causal process is homogenous for all 13 counties in the sample. Here further testing is unnecessary. $H_{hc}$ is rejected
when \( F_{hc} \) is significant. Rejecting \( H_{hc} \) indicates that for at least one or more countries, inflation (economic growth) causes economic growth (inflation).

The calculated value of \( F_{hc} \) is presented in table (6). It shows that \( H_{hc} \) is accepting for at all three lags for causality from inflation to economic growth. For this case making further testing is unnecessary. While \( H_{hc} \) is rejecting at one and two lags at 1 percent and 5 percent significant level respectively for causality from economic growth to inflation. The result leads to another test i.e. heterogeneous causality tests.

Table 7. \( F_{hn} \) test statistics

<table>
<thead>
<tr>
<th>Lags</th>
<th>( F_{hn} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>causality from inflation to economic growth</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.3141</td>
</tr>
<tr>
<td>2</td>
<td>0.1085</td>
</tr>
<tr>
<td>3</td>
<td>1.2211</td>
</tr>
<tr>
<td>causality from economic growth to inflation</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.9450*</td>
</tr>
<tr>
<td>2</td>
<td>1.5783**</td>
</tr>
<tr>
<td>3</td>
<td>1.2208</td>
</tr>
</tbody>
</table>

Note: critical values of \( F_{hn} \) is based on an F-distribution with \( NP,NT-N(1+P)-P \) df (Hurlin and Venet, 2001). * is significant at 1% significant, ** is significant at 5% and *** is significant at 10%.

In order to determine for which countries causality from economic growth to inflation holds, the third hypothesis is formulated and it stated as :

\[ H_{henc}^i : \text{for country } i, \text{ economic growth do not cause inflation.} \]

The \( F_{henc} \) test statistics is calculated by using sum of squared residual from unrestricted model in equation (3)(4) and sum of square residual from restricted model in which the slope coefficients and subsequent lags for the country under testing are constrained to be zero.

The test result is presented in table (8). The hypothesis is tested only for lag one and lag two because there is little evidence that the causality relation exists beyond the first two lag. The result indicates that the F value is highly significant for Congo, Dep.Rep and Zimbabwe, therefore there is no reason to accept heterogeneous causality hypothesis. Of all countries in the
sample, causality from economic growth to inflation holds only for Congo Dep.Rep and Zimbabwe.

Table 8. $F^{i}_{henc}$ test statistics

<table>
<thead>
<tr>
<th>Lags</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameroon</td>
<td>0.1898</td>
<td>0.1316</td>
</tr>
<tr>
<td>Congo, Dep.Rep</td>
<td>58.5281*</td>
<td>30.060*</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>0.1657</td>
<td>0.1073</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>0.1531</td>
<td>0.1152</td>
</tr>
<tr>
<td>Gabon</td>
<td>0.0776</td>
<td>0.1233</td>
</tr>
<tr>
<td>Gambia, The</td>
<td>0.3593</td>
<td>0.2474</td>
</tr>
<tr>
<td>Ghana</td>
<td>0.2222</td>
<td>0.1516</td>
</tr>
<tr>
<td>Kenya</td>
<td>0.3029</td>
<td>0.2029</td>
</tr>
<tr>
<td>Madagascar</td>
<td>0.0963</td>
<td>0.8731</td>
</tr>
<tr>
<td>Nigeria</td>
<td>0.1841</td>
<td>0.1269</td>
</tr>
<tr>
<td>Senegal</td>
<td>0.2223</td>
<td>0.2247</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.3688</td>
<td>0.2259</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>4.3743</td>
<td>2.8473*</td>
</tr>
</tbody>
</table>

Note: critical values of $F^{i}_{henc}$ is based on an F-distribution with NP,NT-N(1+P)-P df (Hurlin and Venet, 2001). * is significant at 1% significant, ** is significant at 5% and *** is significant at 10%

5.2 Discussion of the result

The main attention of this paper was to see the relationship between inflation and economic growth, and to examine the causal relationship between inflation and economic growth.

To examine the relationship between inflation and economic growth, growth model was formulated by including other three variables (i.e., investment, population and initial GDP) in addition to inflation. Since time effect is necessary for the model, the discussion is relied on model 3. The result indicated that inflation is statistically significant while it has a negative sign, indicating that inflation appears to have a negative effect on growth. The estimation is taken place in three different models but the result is all the same. This result is consistent with the result of studies by Fisher (1993) and Gregorio (1992). They studied this issue in depth and concluded that inflation is negatively and significantly related with economic growth.
In addition to inflation, the result shows that initial GDP has a negative effect on economic growth. The result is in line with the study of Barro (1997). This result indicates convergence which means the countries with higher per capita GDP initially are the ones experiencing lower growth. The coefficient of investment variable in the model has a positive sign and it is statistically significant. This result coincides with Keynes's General theory as well as study Sala-Martin (1997). They have shown that investment played a key role in promoting economic growth. Finally the estimation result indicates that population is negatively but insignificantly related to economic growth.

The result of panel Granger causality test indicated that inflation Granger causes economic growth and that economic growth Granger causes inflation. The former causal process can be characterized as homogenous for 13 countries in the sample. The later process is heterogeneous, existing in Congo, Dep. Rep and Zimbabwe, but not for other countries. Thus, it can be argued that past values of inflation contribute to the prediction of the present value of economic growth (GDP) and vice verse.
5.3 Conclusion

The purpose of this paper is to study about the two main issues of inflation and economic growth. The first is to examine the relationship between inflation and economic growth in SSA countries. The second is to investigate the causality relationship between inflation and economic growth in SSA countries.

I have used strongly balanced panel data which is contained 13 SSA countries and covering from 1969-2009. Secondary data from World Bank and Penn world table were used for this study. The data were processed using stata for windows econometrics package.

To test the relationship between inflation and economic growth, model was formulated by having four explanatory variables (inflation, investment, population, and initial GDP). Fixed effect was used for estimation. Panel Granger causality test was used to test causal relationship between economic growth and inflation.

The estimation result has shown that inflation was negatively and significantly related to economic growth. It means that inflation has an adverse effect on economic growth. Inflation and real GDP per capita have opposite trend.

Panel Granger causality test has shown that inflation Granger causes economic growth for all countries in the sample, while economic growth Granger causes inflation for two countries (i.e. Congo, Dep. Rep and Zimbabwe). Therefore, inflation can be used in order to predict economic growth for all countries in the sample and economic growth can be also used in order to predict inflation for two countries in the sample.

Nowadays inflation of Sub Saharan Africa countries’ is increasing. So this study has a good contribution by showing the relationship between economic growth and inflation in SSA countries. Moreover testing the causal relationship between economic growth and inflation by modified panel Granger causality test has an important contribution for the economy. It is possible to study this issue by increasing number of observation and by using dynamic estimation model.
References


### APPENDIX

**TABLE A.1 Regression results of dummy variables**

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<th>Dummies</th>
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<th>Model 3</th>
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