Inflation - Growth Nexus in Ethiopia: Evidence from Threshold Auto Regressive Model[1]

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Abstract

Achieving high economic growth with stable and low inflation level has long been the macroeconomic policy objective of Ethiopia. The Ethiopian economy, however, has gone through different paths of inflation and growth relationship over the last four decades. Before 2003, Ethiopia was well-known as a low inflation country with marginal economic growth. After 2004, however, the country had been in general hovering around double digit inflation. During the same period economic growth averaged 10.7%. This seems to suggest that the two variables are positively related. Quite a large number of theoretical and empirical researches, however, suggest that there is a threshold effect in the relationship between inflation and growth such that high inflation has an adverse effect on economic growth. Against this background, this paper investigates whether there is a threshold effect between the two variables in Ethiopia for the period 1971 to 2013 using annual data and Hansen's Threshold Autoregressive (TAR) model. The empirical result does not support the existence of threshold effect between the two variables in the period. The possible reason for the non-existence of non-linearity might be related to the absence of the absence market led economic system and the low financial sector development of the study period mainly in first 25 years. As a result the informational friction that interferes with the efficiency of the financial system which finally inhibits long-run growth might be absent in the study period. Due to the small number of observations, however, this result should be interpreted with caution.

Key words: Inflation, growth and threshold autoregressive.
JEL Classification: E31, O40.

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1. Introduction

Over the last four decades, the Ethiopian economy has gone through different paths of inflation and growth relationship. In general, before 2003, Ethiopian was distinguished as a low inflation country with small economic growth. During this period the average inflation was 7.5% while the average growth rate was 2.6%. Consequently, inflation was not an issue during this period. This was mainly explained by prudent government budgets and a restrictive monetary policy. After 2004, except in 2009, and 2013, when inflation was at a single digit level, inflation was beyond the comfort zone policy makers and the country had been hovering around double digit inflation. During the same period, however, Ethiopia's economic growth, which is mainly driven by public investment in main infrastructure projects, averaged 10.7% (World Bank, 2014). This pace of growth is the fastest that the country has ever experienced and it also exceeds what was achieved by low-income and Sub-Saharan African countries in that period (World Bank, 2015). This marks not only a break from the country's past economic development trajectory, but a preeminent economic growth performance even by the standards of the fast-growing countries in African. These conditions seem to suggest that the two variables are positively related in Ethiopia.

The debate on the growth-inflation nexus has been central in the monetary policy setting. Monetary policy that ensures inflation remains low and stable over time contributes to long-run economic growth and financial stability (Bernanke, 2011). Many economists would agree that inflation has distortional effects on long-term economic growth if it gets "too high". But how high is too high? For industrialized countries, there has been an increasing consensus on inflation targets that centre around 2%. Recent empirical work by Goncalves and Salles (2008) and Lin and Ye (2009) suggest that inflation targeting in developing countries can lead to significant improvements in terms of inflation and output volatility. Many monetary authorities in developing and emerging economies are also moving towards inflation targeting. However; the appropriate level of inflation target for developing countries is still under debate. For instance, Bruno and Easterly (1998) in a cross-country regression showed that the effect of inflation on growth increases if it exceeds a critical level of 40% while Khan and Senhadji (2001) suggested the inflation threshold for developing countries is between 11 and 12 percent. Moreover, the right level of inflation may vary depending on the specific macroeconomic environment of a given country.

Despite the above facts and the availability of many empirical researches on the threshold level on inflation in the relation between inflation and economic growth, studies which focus on this issue in Ethiopia are negligible. The only study, which I am aware of, on this issue for Ethiopia was undertaken by Emerta (2012) using Khan and Senhadji (2001) approach. In theirempirical model, Khan and Senhadji (2001) interacted the indicator variables with the difference of log inflation threshold and inflation (log (π*) -log (π_{it})). The subtraction of log (π*) from log (π_{it}) is to make the relationship between growth and inflation continuous at the threshold level of inflation, π*. According to Drukker *et al.* (2005), however, Khan and Senhadji's specification does not directly fit into the (Hansen 1999, Hansen 2000) framework. Moreover, the study did not show whether there is only one threshold level or not, and nor how the relationship between inflation and growth switches in different regimes.

This paper, therefore, investigates whether there is a threshold level in the inflation and economic growth nexus using Hansen's (2000) Threshold Auto Regressive (TAR) model for Ethiopia for the period 1971 – 2013. This model assumes all regressors are exogenous. Moreover, unlike Khan and Senhadji's model the empirical specification I estimate is discontinuous in inflation at the threshold point(s). This discontinuity implies that small changes in inflation in a neighbourhood of the threshold point may have different effects depending on whether initial inflation is above or below the threshold level of inflation. In addition, the study documents the historical development of the two variables in the period 1971 to 2013.

The empirical evidence does not support the existence of threshold effect between the two variables in the period. This result contradicts the findings of Emerta (2012). The possible reason for the non-existence of non-linearity during the study period in Ethiopia might be related to the absence informational friction which interferes with the efficiency of the financial system and inhibits long-run growth is missing in the study period. This might intern be attributed to lack of market led economic system and the low financial sector development in the study period mainly in first 25 years. Due to the small number of observations, however, this result should be interpreted with caution.

The paper is organized as follows: Section two overviews the trend of inflation and growth in the period 1971 to 2013. Section three presents both theoretical and empirical literature reviews. Section four discusses the data issues and describes the variables used. The methodology used is explained in Section five. Section six presents the empirical findings of the study. Finally, Section seven concludes and highlights policy implications of the findings.

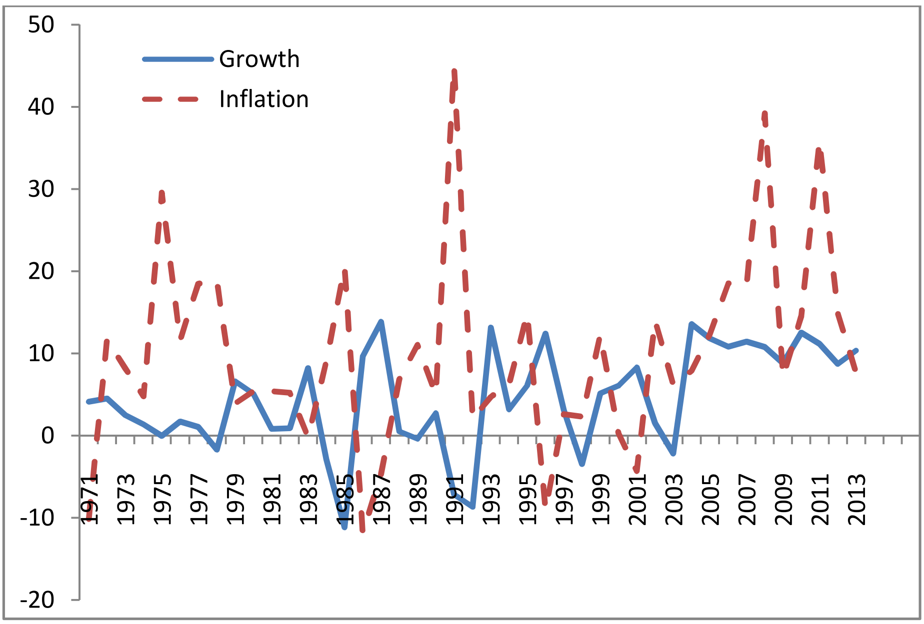
2. Trend of Inflation and Growth in Ethiopia

Examination of the historical developments of inflation and growth in Ethiopia rivals that over the last four decades the Ethiopian economy has gone through diverse phases of inflation and economic growth. These changes associated to the underplaying changes in economic policies and reaction in economic agents. Before 2003, except in the years of supply shocks and war, Ethiopia was characterized as a low inflation country with an inflation rate of single digit level. For instance, from 1971 – 2003, the inflation averaged 7.5%. In this period the highest inflation of 45% was registered in 1991, the year which marks the end of the civil war and the incumbents the Ethiopian People’s Revolutionary Democratic Front took power.

During the same period, the average growth rate was 2.7%. From 2004 to 2014, however, inflation started to rise rapidly and average inflation in this period rose to 17.7% with the highest inflation rate of 39.5% registered in 2008. Despite this high inflation, the average growth rate during the same period was 10.7%. Factors attributed to this high inflation during this period include accommodating monetary policy, agricultural supply shock and imported inflation due to the rise in international prices, (Durevall el. al., 2013).

An examination of inflation and growth year by year from 1971 to 2013 in general indicates that almost each inflation peak (bottom) is often followed by growth bottom (peak) indicating that inflation and growth are negatively related during the period (Figure 1) A close examination of these variables in the sub - periods 1971 -1990 and 1991 -2011, however, reveals a different picture, particularly in the second period. Irrespective of the change in inflation between 1972 and 1979, growth was continuously declining and even became negative in the year 1978. This may be attributed to the lack of political stability due to the takeover of power by the military regime and the resulting loss of business confidence which is important for economic growth. After 1979, the relationship becomes negative and continues till 2003.In the period between 2003 and 2008; the two variables are positively related. After 2009, however, growth seems to be less sensitive to inflation as it remains more or less stable though inflation is accelerating (Figure 1).

Figure 1: Inflation and Growth (1971 -2013)



Source: Authors' calculation.

3. Literature Review

3.1 Theoretical Literature Review

The study of inflation and economic growth has attracted extensive literature. Theoretical studies on the relationship between inflation and economic growth reached at different conclusions regarding the impact of inflation on economic growth. Nevertheless, it is widely accepted that stable macroeconomic condition is important for sustained economic growth Gregorio (1993). In the classical growth theory, economic growth depends on the stock of capital, the labour force, land and the level of technology. Though the theory does not explicitly incorporate inflation in its model, it postulated that inflation affects growth negatively. This is because inflation reduces saving and the capital accumulation process by driving up wage costs because of competition and reducing firms' profit.

Early neo-classical (Solow, 1956) believed that there exists no relationship between inflation and growth as growth was assumed to be exogenously determined. Mundell (1963) provided a mechanism through which inflation and economic growth are related. He believed that when inflation rises, it reduces the wealth of the people as the return on real money balances falls. As a result people switch other assets which raise their price and pulls down the interest rate. This boosts up the investment in the economy and growth takes place. Similarly, Tobin (1965) extended the conventional exogenous growth model with monetary framework and predicted a positive correlation between the rate of inflation and the rate of capital accumulation. He argued that an increase in the growth rate of the money supply results in higher inflation and hence in an increase in the opportunity cost of holding cash balances. This results in a reallocation of saving from money into capital and an increase in the stock of capital per worker. This change in the structure of portfolio brings a decline in the real interest rate and an increase in capital accumulation that would result in higher rate of growth.

Stockman (1981) analyzed a neoclassical growth model with inelastic labour supply and showed that the rate of money growth has only transitional effects on the growth of per-capita income if money is held to satisfy a cash-in-advance (CIA) constraint for consumption. If the cash-in-advance constraint applies to investment, he indicated that increased money growth has negative long run effects. The prediction is that when inflation rate rises it erodes the purchasing power of money. This forces firms to reduce their purchases of both cash goods and capital, resulting in a fall in the steady-state level of output. Therefore, according to Stockman (1981), money is super neutral in the long run if only consumption is subject to the (CIA). Contrary to Stockman's (1981) conclusion, Zeria (1991) found that even CIA constraint hold for consumption. According to Zeria's CIA model, higher rate of inflation raises the amount of inflation tax firms pay as firms hold money because of delayed deposit. This in turn reduces profitability; and slows down capital accumulation and growth.

Monetarists believe that the inflation has a neutral effect. It only affects the nominal variables. Thus they believed that if in an economy the prices double, nominal wages also double, thus keeping the real wages constant. Same is true for all real variables. In this way, they supported the argument money does not have any real effects. Early monetary growth models by Sidrausky (1967) and Brock (1975) investigate a similar problem in the context of a fully optimizing general equilibrium framework and introducing money in the utility function. They found that money is super neutral. In the steady states, the stock of capital per worker is independent of the growth rate of the money supply. With elastic labour supply, the Sidrausky-Brock model implies that although capital per worker (and hence the real interest rate) is independent of the growth rate of the money supply, the supply of labour is not.

Various endogenous growth models also indicate that inflation has a negative effect on economic growth. Gregorio (1993) constructs endogenous growth models that illustrate different channels through which inflation affects growth. The first model focuses on the role of money in firms' operation and its effect on the investment rate. In this model, firms use money to buy new equipment. When inflation increases, firms will be induced to economize in real balances, thereby increasing transaction costs. The increase in transaction costs will raise the shadow value of installed capital and will depress investment. In the new equilibrium, the return to capital, the rate of investment, and the rate of growth decline.

The second model emphasizes the effects of inflation on the productivity of capital and households' behaviour. The intuition for the negative effects of inflation on employment is that on the firms' side inflation increases labour costs, reducing labour demand with a consequent fall in employment and the marginal product of capital and on the households' side inflation induces substitution from consumption to leisure, reducing labour supply.

Similarly, Jones and Manuelli (1995) developed two endogenous growth models which differ in their formulation of the supply of effective labour offered to firms by workers. In the first, there is no human capital and, as a result, labour supply is zero asymptotically. In this version of the model, inflation rate has no impact on the limiting rate of interest paid on capital income and the asymptotic rate of growth of the economy but on level of economic growth. When nominally a denominated depreciation allowance is included in the tax code, the effective real marginal tax rate on investment income is altered by a change in the rate of monetary expansion. In this case, the simple model of endogenous growth predicts that different rates of monetary expansion are associated with different after tax real rates of return on investment, which in turn affects equilibrium investment decisions and growth. In the second model of endogenous growth, Jones and Manuelli (1995) showed that the steady state level of effort (i.e., number of hours supplied to the market) is determined by the relative prices of consumption and leisure and this margin is distorted by inflation. This has a direct impact on the long-run growth rate of the economy, through an effect on the marginal product of capital.

Some other theoretical studies also argued that depending on its level, inflation can either promote or harm economic growth indicating the existence of non-linearity in growth-inflation association. That is, at lower rates of inflation, the relationship is not significant or even positive; but at higher rates, inflation has a significantly negative effect on growth. In this class of models, Choi, *et al*. (1996) and Bose (2002) showed that financial market efficiency is affected by various informational asymmetries. In these models, high rates of inflation typically exacerbate informational frictions in the financial market. This friction in turn might result in credit rationing due to adverse selection and thus limit the availability of investment capital and reduce the efficiency of the allocation of savings to investment projects (the efficiency of investment). This interferes with the efficiency of the financial system and finally inhibits long-run growth. At low level of inflation Choi *et al*. (1996) models appears to possess Mundell-Tobin effect by suggesting that financial market frictions are potentially innocuous at low rates of inflation. Thus, in low inflationary environments, credit rationing might not emerge at all, and the negative link between inflation and capital accumulation vanishes.

3.2 Empirical Literature Review

Most of the empirical studies on inflation – growth nexus have used cross country regression and reached at various conclusions. Using a regression analog of growth accounting for cross-sectional and panel regressions for a set of developed and developing counties Fisher (1993) found a non-linear negative relationship between inflation and growth. In the following years many empirical studies used a large panel data across countries to investigate the threshold level of inflation in the inflation- growth nexus.

Sarel (1996) used annual data from1970 to1990 for 87 countries and found that the threshold is at 8% below which the effect of inflation on growth is negligible (or slightly positive) but beyond 8% there is a significant, extremely powerful and robust negative effect on economic growth. On similar lines, Ghosh and Phillips (1998) used a large panel data set, covering IMF member countries over 1960–1996 and found a negative relationship between inflation and growth that is both statistically and economically significant. Khan and Senhadji (2001) examined the nonlinear relationship between inflation and growth using data that cover over 140 industrial and developing countries for the period of 39 years. The result strongly suggests the existence of a threshold beyond which inflation exerts a negative effect on growth. The threshold is 1–3% and 11–12% for industrial and developing countries respectively.

Drukker *et al.* (2005) employed a non-dynamic, fixed - effects panel model and found two threshold levels of inflation for industrial countries, 2.6% and 12.6%, and one threshold value of 19.2% in non-industrial countries. Vaona and Schiavo (2007) also provided evidence about the nonlinear relationship between inflation and growth using non-parametric methods. Kremer *et al.* (2009) using a dynamic panel model with threshold for 124 countries during the period from 1950 to 2004found that for industrialized countries, the estimated inflation threshold is about 2.5%. For non-industrialized countries, however, inflation hampers growth if it exceeds 17%. Below this threshold, however, the impact of inflation on growth remains insignificant. Espinoza *et al.* (2010) estimate the inflation-growth nexus using a smooth transition regression model. They estimated a threshold of about 10% for all country groups above which inflation quickly becomes harmful to growth. However, for the advanced economies, threshold was much lower.

There has been also a surge in country specific studies of threshold level of inflation in developing countries. Mubarik (2005), for instance, estimates the threshold level of inflation for Pakistan using annual dataset from 1973 to 2000. The estimated model suggests 9 percent threshold inflation level above which inflation is inimical for economic growth. Lee and Wong (2005) estimated the threshold levels of inflation using TAR model for quarterly data set from the period between 1965- 2002 for Taiwan and 1970-2001 for Japan. Their estimation of the TAR models suggests that an inflation rate beyond 7.25% is detrimental for the economic growth of Taiwan. For Japan, however, they found two threshold levels, which are 2.52% and 9.66% suggesting that in the moderate inflation regime, between 2.52 and 9.66% inflation rate, inflation is favourable to economic growth and beyond this threshold value it is inimical for the economic growth.

Some country specific studies were also undertaken in some African countries. Salami and Kelikume (2010) uses annual data spread over two periods 1970-2008 and 1980-2008 to determine the threshold level of inflation for Nigeria and to examine whether there is significant change in the threshold level for the two periods. They established an inflation threshold of 8% and 7% for Nigeria over the first and second sample period respectively; but the latter fail the test of significance. The study by Phiri (2010) investigates the level at which inflation is least detrimental towards finance-growth activity in South Africa and the least adverse effects of inflation on finance-growth activity are established at an inflation level of 8%.

Using quarterly data for the period of 1997 to 2011, Mohanty *et al.* (2011) suggests that the structural break in the relationship between output growth and inflation in India occurred between 4.0 and 5.5% of inflation above which inflation retards growth. Below this threshold level, however, there is a statistically significant positive relationship. Frimpong and Oteng-Abayie (2010) estimated the threshold effect of inflation on economic growth in Ghana for the period 1960-2008 using threshold regression and found inflation threshold level of 11% at which inflation starts to significantly hurt economic growth in Ghana. Below the 11% level, inflation is likely to have a mild effect on economic activities.

4. Estimation Methodology

The econometric model I used is based on various empirical cross country analysis of inflation-growth nexus (See: for instance: Kormendi and Meguire, 1985 and Barro 1991; 1995. This approach can be extended to country specific time series analysis as follows:

$$gdp_t = \alpha + \beta_i X_i + \varepsilon_t \ \ldots \qquad \textbf{(1)}$$

Where gdp_t is the growth rate of real GDP ($\Delta \log Y$) and ε_t is iid distributed error term with *(0, σ2)*. X_i is a matrix that denotes explanatory variables discussed above including inflation. The empirical model of equation (1) represents the conventional linear growth model. As stated in the literature review, however, the relationship between inflation and economic growth may exhibit a non-linear relationship. I, therefore, used a TAR model suggested by Hansen's (1996, 2000). In the TAR model, the classification of the variable across regimes is based on an estimate of the time series behaviour that is consistent with reaching the threshold that separates the regimes.

Consider a two-regime TAR model proposed by Hansen (1999, 2000):

$$gdp_t = \theta_1' X_t + u_t, \quad \text{if } q_t \leq \gamma \qquad \textbf{(2)}$$

$$gdp_t = \theta_2' X_t + u_t, \quad \text{if } q_t > \gamma \qquad \textbf{(3)}$$

Where, q_t denotes the threshold variable, inflation, splitting all the observed values into two regimes, γ is the threshold level of inflation. If I knew γ the model would be easily estimated by OLS. Since the threshold is unknown a *priori* so it should be estimated in addition to other parameters. When the inflation is smaller than the threshold parameter, the model estimates equation (2). Similarly, when inflation is larger than the threshold parameter, the model estimates equation (3). Let $I_t(\gamma) = \{q_t \leq \gamma\}$ and {.} as an indicator function with I = 1 if occurs $q_t \leq \gamma$, or I = 0 otherwise. Moreover, when I let $X_t(\gamma) = X_t I(\gamma)$, then Equations (2) and (3) can be revised as follows:

$$gdp_t = \theta' X_t + \delta_n' X_t(\gamma) + e_t \quad e_t \sim \text{i.i.d. } (0, \delta_t^2) \qquad \textbf{(4)}$$

Where, $\theta = \theta_2$, $\delta = \theta_1 - \theta_2$, and θ, δ, and γ are the regression parameters to be estimated. Equation (4) allows all the regression coefficients to differ between the regimes. The resulting sum of squared error as a result of estimating these parameters θ, δ, and γ can be expressed as follows:

$$S_1(\gamma) = \hat{e}_t(\gamma)' \hat{e}_t(\gamma) \qquad \textbf{(5)}$$

Hansen (1999; 2000) recommends estimating γ by least squares technique. The easiest way to implement this procedure is through minimization of the sum of squared residuals as a function of expected threshold value. Therefore, the optimal threshold value is given by:

$$\hat{\gamma} = \text{argmin} S_1(\gamma) \qquad \textbf{(6)}$$

Once the threshold level of inflation is obtained, the vectors of the slope coefficient estimated are $\hat{\theta} = \hat{\theta}(\hat{\gamma})$ and $\hat{\delta} = \hat{\delta}(\hat{\gamma})$. According to the foregoing process, the linear Equations, Equation (2) and (3), can be expressed as a nonlinear equation under a two-regime TAR model as follows:

$$gdp_t = \theta_0' + \theta_1' X_i I(q_t \leq \gamma) + \theta_2' X_t\, I(q_t > \gamma) + \varepsilon_t^* \qquad \textbf{(7)}$$

Where, q_t denotes the threshold variable, inflation, splitting all the observed values into two regimes, γ is the threshold level of inflation. *I (·)* is the indicator function indicating the regime defined by the threshold variable q_t, and the threshold level *γ*. The threshold value is determined by searching the threshold value of inflation that minimizes the sum of the squared error given by equation (6) through the estimating equation (7). The main question in equation (7) is whether or not there is a threshold effect, i.e., to determine whether the estimate is statistically significant. This requires the examination between the linear model (equation 1) vis-à-vis the two-regime model (equation 7). That means, once the threshold value γ is determined through the grid search by estimating equation (7), the null hypothesis of no threshold effect, equation (1), is tested against its alternative hypothesis threshold effect, equation (7), exists, using the maximum likelihood ratio test. The null hypothesis of no threshold effect and its alternative by estimating equation (7) are:

H_0: $\theta_{1i}' = \theta_{2i}'$, and

H_1: $\theta_{1i}' \neq \theta_{2i}'$, where i= 0,…,n) **(8)**

To accomplish this test whether the coefficients in the two regimes are the same or not will be undertaken using the F-test based on:

$$F_1 = \frac{S_0 - s_1(\hat{\gamma}))}{\hat{\sigma}^2} \qquad \textbf{(9)}$$

Where S_0 and s_1 are the residual sum of squares under the nullhypothesis of no threshold effect and alternative discussed above, respectively and $\hat{\sigma}^2$ is the estimated residual variance from the estimated threshold model. Since the threshold parameter γ is unknown under the null hypothesis of no threshold effect exits, the traditional F - test will have non-standard distributions and strictly dominates the Chi-square distribution, and thereby cannot be applied (Hansen, 1999). Therefore, as suggested by Hansen (1999) the study uses a standard Lagrange Multiplier (*LM*) fixed bootstrap method to calculate the asymptotic critical value and the p-value. The bootstrap sampling produces asymptotically valid p-values Hansen (1996). The null hypothesis is rejected when the statistic F_1 is greater than the critical value at standard significance level.

Once the existence of threshold is known, the next question is whether or not the estimate can be known precisely. When there is a threshold effect ($\theta'_{1t} = \theta'_{2t}$) Hansen (2000) have shown that the threshold estimate, $\hat{\gamma}$, is consistent for the true value of γ, say γ_0. However, the asymptotic distribution of the least square estimate of the threshold parameter, $\hat{\gamma}$, is highly non-standard. Therefore, Hansen (2000) uses the likelihood ratio (LR) statistic to form confidence intervals for the estimated threshold values, $\hat{\gamma}$. The null hypothesis of the threshold value is H_0: γ= $\hat{\gamma}$and the likelihood ratio statistic is given by:

$$LR_1(\gamma) = \frac{S_1(\gamma) - S_1(\hat{\gamma})}{\hat{\sigma}^2} \quad \textbf{(10)}$$

Where $S_1(\gamma)$and $S_1(\hat{\gamma})$ are the sums of the squared residuals from equation (7) given the true and estimated value, respectively.The no-rejection region, c(α), α is a given asymptotic level (1 – α is no rejection region confidence level)is the set of values of γsuch that , $LR_1(\gamma) \leq c(\alpha)$where $c(\alpha) = -2\ln(1-\sqrt{1-\alpha}\,)$. This is easiest to *find* by plotting $LR_1(\gamma)$ against $q_t$and drawing flat line at c (α) Hansen (1999).

5. Data Issues and Description of Variables

The study used annual time series data for the period of forty three years, 1971 – 2013, obtained from various international and domestic sources. These sources include World Bank World Development Indicator (WDI) for real GDP and Gross Investment in 2011 constant local currency prices, Central Statistical Agency (CSA) for CPI and population, National Metrological Agency (NMA for annual average rainfall data and NBE for private sector credit.

The control variables in the model are based on empirical literature. Kremer *et al.* (2009) suggested that any empirical analysis of the impact of inflation on economic growth has to control for the influence of other economic variables that are correlated with the rate of inflation. Thus, following Khan and Senhadji (2001) and Drukker *et al.* (2005) and Kremer *et al.* (2009), the explanatory variables in the model includes inflation (*inf*) which is based on CPI, investment as a share of GDP growth *(igdp*), the growth rate of population (*pop*) and the annual percentage change in the terms of trade (*tot*) measured as exports divided by imports. In addition to the above variables, I include rainfall, *rain*, real private sector credit growth, *pcg*, second lag of inflation, *l2inf*; and first lag of real GDP growth, *lgdp* in the model. This is because first, the Ethiopian economy is highly dependent on agriculture, which is in turn depends on rainfall. For instance in 2012/13 fiscal year, agriculture constituted more that 47% of GDP, of which crop production accounts 30 percent of GDP (World Bank, 2014).

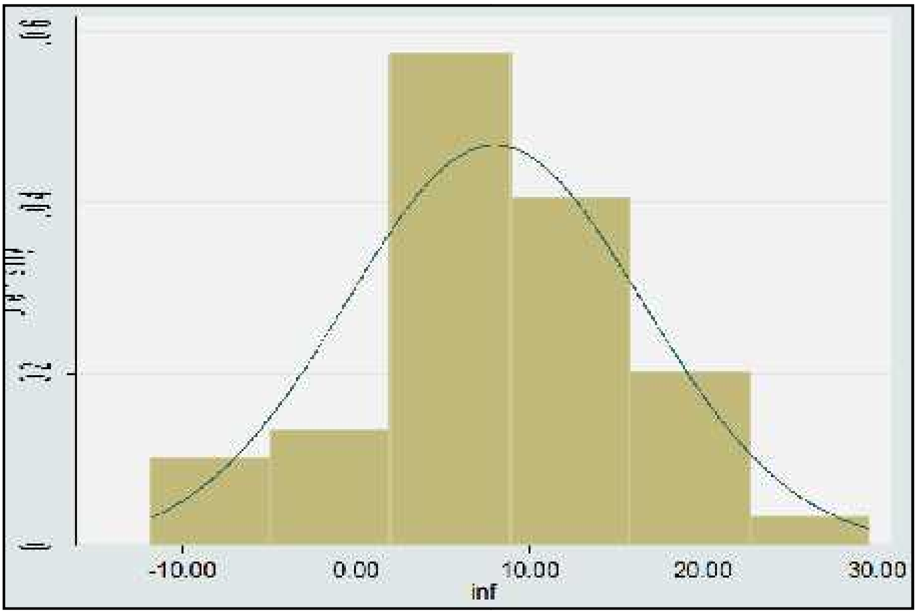
Second, empirical and theoretical literature suggests that financial markets play an important role in the growth process. Changes in inflation do affect activity in financial markets. High inflation exacerbates informational frictions in the financial market that would lead to credit rationing due to adverse selection. This in turn reduces the availability of investment capital and the efficient allocation of savings to investment projects. This interferes with the efficiency of the financial system and finally inhibits long-run growth. Thus, and real domestic credit growth is included as a measure financial sector development[3]. Finally, the second lag of inflation, *l2inf*, and the first lag of real GDP growth, *lgdp, was* included in the model due to the presence of Granger Causality and to account for possible serial correlation and omitted variable bias.

The question now is should the level or log of inflation be related to growth. A regression of real GDP growth on the level of inflation would give much weight to the extreme inflation observations, even though the bulk of the observations may correspond to low and medium inflation rates (Khan and

[3]There is no a single indicator of financial development. In the estimation, I tried to use real domestic credit and broad money growth as a proxy for financial sector development. But they led to the misspecification of the model. So, I used real private sector credit growth (ratio of claim on other sectors to GDP growth).

Senhadji, 2001). Sarel (1996) suggested that the log transformation avoids the extreme observations that distort the regression results and produces symmetrical distribution in inflation. Thus, I first examined the distribution of inflation for the period 1971 – 2013. As indicated in the Figure 2 below, the examination of the distribution of inflation appears to be normal. The statistical test also shows the same.[4] The log transformation, Figure 3, however, failed to produce a normal distribution of inflation. Therefore, I used the level of inflation in the regression analysis.

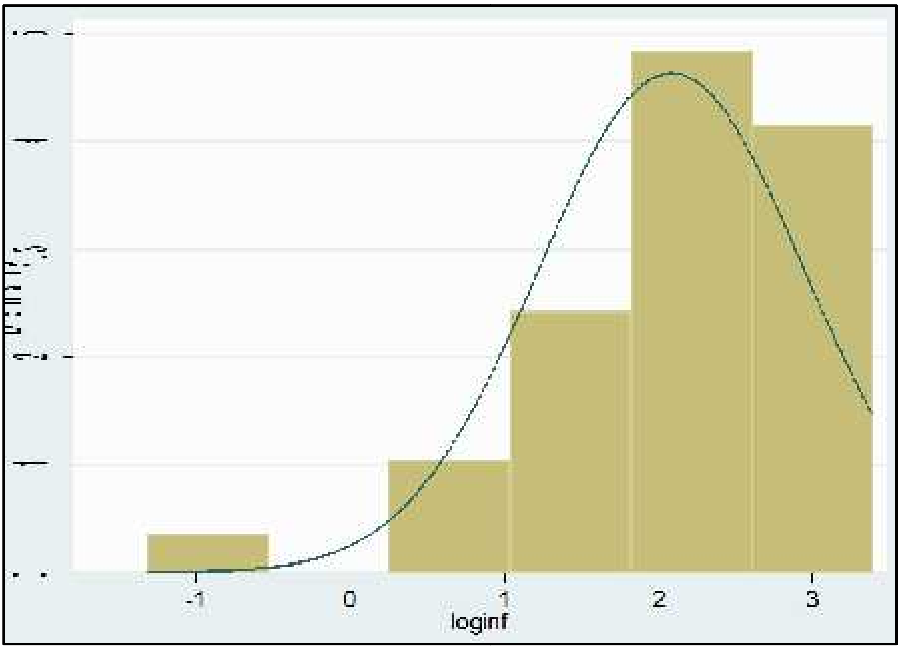
Figure 2: Distribution of Inflation



Source: Author's calculation.

[4] The p-value of swilktest on inflation is 0.54297 indicating that inflation is normally distributed.

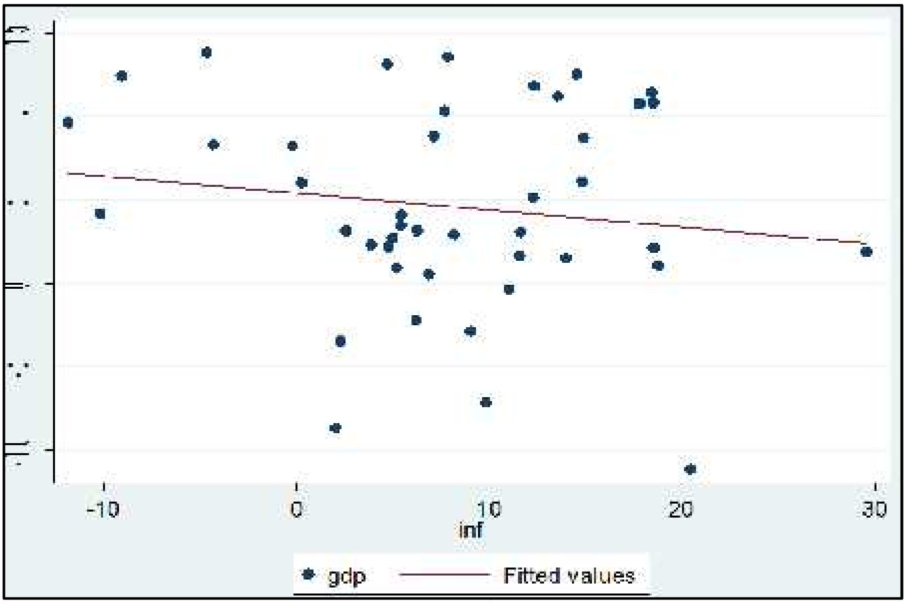
Figure 3: Distribution of Log of Inflation



Source: Author's calculation

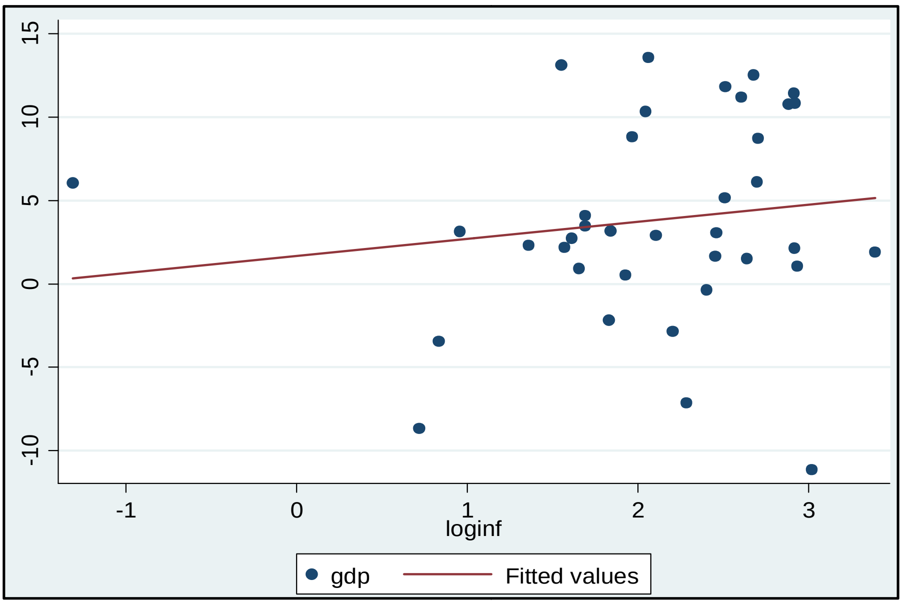
I also examined the simple relationship between inflation and economic growth using a line plot. Figure 4 shows that the relationship between real GDP growth and the level of inflation is negative for all levels of inflation. Looking at this relationship using the log of inflation, however, produces a positive relationship (Figure 5). This result contradicts with the findings of Ghosh and Phillips (1998), and Khan and Senhadji (2001) who found that the relationship between real GDP growth and the log of inflation is slightly positive for low levels of inflation and becomes negative for higher inflation levels. But this simple analysis may obscure the true relationship between the two variables.

Figure 4: Relationships between inflation and real GDP growth



Source: Author's calculation.

Figure 5: Relationship between log of inflation and real GDP growth



Source: Author's calculation.

6. Empirical Results

6.1 Linear Model

Before I undertake the simple linear relationship of inflation and growth, I investigated whether the variables used in the models are stationary or not to ensure consistency of results and avoid spurious regression. To this end, we employed the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) units root tests with "constant" and "constant and trend". The PP generalizes the ADF test and provides robust estimate in the presence of serial correlation, time dependent hetroskedasticity and structural break in time series. The results are presented in Table 1 below. The estimation results of ADF and PP unit root test show that the variables are stationary at 1%significance level except for *igdp* and *pop*. Since first differencing of these variables makes them stationary, I used their first difference, *igdpD1* and *pop.D1,* in the regression analysis.

Table 1: Unit root test results

Variables	ADF test		PP test	
	Constant	Constant and trend	Constant	Constant and trend
Gdp	-4.585*	-5.581*	-4.565*	-5.522*
Inf	-5.926*	-5.825*	-5.953*	-5.863*
igdp.D1	-4.462*	-5.546*	-4.510*	-5.585*
pop.D1	-2.618***	-2.597	-2.642***	-2.597
Tot	-6.830*	-6.924	-7.015*	-7.216*
rain	-4.468*	-4.568*	-4.509*	-4.588*
pcg	-4.997*	-5.109*	-4.927*	-5.038*
l2inf	-5.788*	-5.697*	-5.816*	-5.733*
lgdp	-4.617*	-5.51*	-4.588*	-5.452*

Source: Author's calculation.

Note: ***and * indicate significant at 1% and 10% levels respectively.

The t-statistics are computed using MacKinnon (1996).

To understanding the direction of causality between inflation and growth and to decide the number of lags of inflation to be included in the regression for threshold inflation search, we used Granger-Causality test. Thus, Irun a VAR model in order to know whether inflation "Granger-causes" growth or vice versa. Inflation is said to Granger-cause growth if, given the past values of growth, past values of inflation are useful for predicting growth. As indicated in Table 2 the Wald test in the first equation is that the coefficients on the two lags of inflation that appear in the equation *gdp* are jointly zero. Therefore, the null hypothesis that inflation does not Granger-cause growth is rejected at 5% significant level. Similarly, in the second test the null hypothesis that growth does not Granger-cause inflation is rejected at 5% significant level indicating the existence of reverse causation from output growth to inflation.

Table 2: Granger causality Wald tests

Equation	Excluded	chi^2	Df	Prob>chi^2
gdp	**inf**	8.6077	2	0.014
Inf	**gdp**	8.5288	2	0.014

Source: Author's calculation.

Once the threshold value which minimizes the sum of squared residuals given by equation (6) is determined through the grid search, determining whether or not there is a threshold effect requires the comparison between the linear model vis-à-vis the two-regime model.

Thus, I first established the linear model for inflation and growth nexus for the period 1971 to 2013 by employing a general to specific modelling approach. For that, first I estimated a liner distributive lag growth model of equation (1) using the explanatory variables discussed above using OLS estimation technique[5]. Nevertheless, the model suffers from omitted variable bias and multicollinearity. Then, I removed the insignificant predictors with the highest variance inflation factor[6] one by one and re-estimated the model for the remaining regressors. When I drop the insignificant variables from

[5]But it should be noted that OLS estimation of a dynamic model such as this produces based estimate.

[6] First lag of inflation and second lag of real GDP growth were the one taken out of the model.

the mode step by step, the significance of some variables changed with a very small decline in the calculated value of R^2 for the overall regression. The final linear model estimated is presented in the Table 3 below[7].

Table 3: OLS Estimates Inflation - Growth

Dependent Variable: Real GDP Growth				
Variables	**Coefficient**	**Std. error**	**t-Statistic**	**Prob.**
Inf	-0.19	0.11	-1.79	0.08
igdp.D1	0.50	0.33	1.53	0.14
pop.D1	-0.44	7.05	-0.06	0.95
Tot	0.07	0.04	1.72	0.10
rain	2.95	15.39	0.19	0.85
pcg	-0.04	0.06	-0.69	0.50
l2inf	0.26	0.10	2.50	0.02
lgdp	0.26	0.17	1.57	0.13
_cons	-17.03	104.66	-0.16	0.87
Number of obs = 41		Breusch-Godfrey LM test: 1.001 (0.3171)		
Adj R-squared = 0.2710		Breusch-Pagan: 0.12 (0.7345)		
Ramsey RESET test: 1.74 (0.1802)				

Source: Author's calculation.

Note*:* The numbers in the brackets are t- statistics

6.2 Tests for the Existence of Inflationary Threshold Effect

After establishing the linear model, I proceed to the investigation of the inflationary threshold effect. The threshold value is determined by searching the value of inflation that minimizes the sum of the squared error (RSS) given by equation (7) through the estimating equation (9). I start the search for threshold level of inflation by estimating equation (9) for a range of inflation starting from 3% to 18%[8]and use the level of inflation as the threshold variable that minimizes RSS.

[7]The insignificance of rainfall might be due to the small sample size and the resulting low statistical power of the regression that prevents any potential association of reasonable size to be statistically significant.

[8] Because of the small number of observation and the resulting multicollinearity problem, it is not possible to look for a threshold level of inflation beyond 18% of inflation

To see the stability of the inflation level which minimizes the RSS, I started the search with the basic mode i.e., without *rain*, pcg, *lgdp and l2inf*. In this search, the minimum RSS found to be at inflation rate of 15%, 16% and 17%. When rainfall and real private sector credit growth added the model one by one, the threshold level of inflation remains the same. Adding *lgdp* further to the model, nonetheless, produces a threshold level of inflation at 14%. In the final model, which includes all variables, including *l2inf*, which appeared is part of the final linear model, the threshold level of inflation remains the same at 14%.Though the threshold level remains in the final two models remains at 14%, it happens to be in the range of 14% to 17%. This indicates the threshold level of inflation is unstable.

Having found the threshold level is 14%,I should test whether this threshold level is statistically significant or not. To do this, I need to test the null hypothesis that $\theta_{1t}^{'} = \theta_{2t}^{'}$. If the null hypothesis is true, it allows us to conclude a threshold exists in the inflation-growth relationship in Ethiopia for the period 1971 to 2013. The problem in testing the significance of a threshold is that the threshold γ is not identified under the null hypothesis. This implies that the classical tests do not have standard distributions and critical values cannot be read off standard distribution tables. Thus, I follow Hansen (1996) recommendation and used bootstrapping procedure to obtain the p-value for the test of a significant threshold. Table 4 below shows the result from bootstrapping procedure.

Table 4: Threshold effect test results for the period from 1971 to 2013

Test Hypothesis	F_1 test	Bootstrap p-value	Threshold Estimate (%)
Ho: No threshold Effect	5.60	0.35	14

Source: Author's calculation.

Note: Estimation period is 1971 to 2013. The threshold is obtained by the minimum of sum of squared residual.

The F-test and the asymptotic p-values obtained through 462bootstrap replications[9] to test the equality of the coefficients in the two regimes are reported in Table 4 above. The F- statistics of 5.60 for specification (7)

[9]The bootstrap replication was undertaken 1000 times. But, one or more parameters could not be estimated in 538 bootstrap replicates.

exceeds the critical values even at the 10% significant level, suggesting that coefficients in the two regimes are the same. Therefore, I fail to reject the hypothesis that there is no threshold effect in the relationship between inflation and growth in Ethiopia for the period 1971 - 2013[10].

Given the insignificance of the threshold estimate, the result is contrary to the result obtained by Emerta (2012), who found 11% inflation threshold for the period 1970-2011. The possible reasons for this difference might be related to the difference in model specification and the use of different explanatory variables. Emerta (2012) used Khan and Senhadji's (2001) model specification. But, as indicated in Drukker *et al.* (2005), this speciation does not directly fit into the (Hansen 1999, Hansen 2000) TAR framework. In addition, Emerta (2012) modelled drought using dummy variable. In the model, however, I modelled rainfall explicitly to see how rainfall affects growth.

The possible reasons for the non-existence of non-linearity in Ethiopia for the stated period might be due to the absence of market led economic system and the low financial sector development of the study period mainly in first 25 years. In the period 1971 to 1991, the financial sector was fully controlled by government. In this period, the allocation of credit was not based on price signal. Consequently, the public sector was favoured in loan provision while the private sector was disparaged to have access to credit. Though government monopoly of financial institution was ceased in the early 1990s[th] when NBE allowed private ownership of financial intuitions, the financial sector is at its early infancy stage. Bank deposit real interest rate does not respond to inflation and has long been negative (IMF, 2013).

The recent economic growth is driven by the heterodox public investment which is implemented over the national budget and through State Owned

[10]As a robustness check I estimated a quadratic specification of inflation as this method is used by many to find a threshold level of inflation in the inflation – growth nexus. Though this model speciation assumes the existence of non-linear relationship between the two variables, the result reveals the absence of this non-linear relationship between inflation and growth in Ethiopia in the period 1971 to 2013. The result for this can be available up on request.

Enterprises (SOEs) using domestic and external sources of financing (World Bank, 2016). The main sources of domestic finance include Treasury bill (T-bill), bond, and direct advances form NBE. The bond purchase is undertaken by state-owned banks to finance SOE projects at low interest rate, 6%. Given the dominance of state-owned banks which accounts more than three forth of banking system assets and loan and advances (World Bank, 2015), and credit rationing in the presence of negative real interest rates provides cheap sources of financing for public projects. This implies the existence of financial repression that kept interest rates and borrowing cost of the government low that.

Moreover, the private sectors which are identified as priority areas and expected to increase export performance and generate a large foreign exchange earnings and import substituting industries were given generous credit schemes (Mulu, 2013). As a result, Mulu mentioned that real interest rate was virtually negative over most of the years since 2002/03 as the interest rate was deliberately kept low even in the period of high inflation.

All these shows that market forces do not play a prominent role in the allocation of credit in Ethiopia. This may indicate that the credit rationing and reduction of credit availability due the information friction created by high inflation which in turn inhibits long-run growth may not take place properly in Ethiopia for the stated period.

7. Conclusions and Policy Implications

The conventional view advocated mostly by the short run Phillips Curve states that higher inflation tolerance could yield higher growth. However, substantial body of evidence suggests that sustained high rates of inflation can have adverse consequences for real economic growth in the long run. The classical growth theory and the early monetary growth models by Stockman (1981) and Zeria's (1991) postulate a negative relationship between inflation and growth. The neoclassical growth theory which is championed by Mundell (1963) and Tobin (1965), however, predicted a positive correlation between the rate of inflation and the rate of capital accumulation.

The new class of endogenous growth models, however, shows that inflation and growth have non-linear relationship. In the theoretical models of Choi, *et al.* (1996) and Bose (2002) high rates of inflation exacerbate informational frictions in the financial market. This friction in turn might result in credit rationing due to adverse selection and thus limit the availability of investment capital and reduce the efficiency of the allocation of savings to investment projects (the efficiency of investment). This interferes with the efficiency of the financial system and finally inhibits long-run growth.

Quite large number of country and country specific empirical works also suggests the existence of non-linear relationship between inflation and growth. Therefore, this paper examines the existence of the non-linearity in the relationship between inflation and growth for Ethiopia. To this end, I used TAR econometric model developed by Hansen (1996, 2000). The investigation was undertaken using annual CPI growth rate, inflation, as a threshold variable for the periods 1971 to 2013. The estimation result for the period does not support the existence of non-linear relationship between the two variables. The possible reason for the absence of non-linearity during the study period in Ethiopia might be related to the absence informational friction which interferes with the efficiency of the financial system and inhibits long-run growth is missing in the study period. This might intern be attributed to lack of market led economic system and the low financial sector development in the study period mainly in first 25 years. Due to the small number of observations, however, this result should be interpreted with caution.

Even though there is no threshold level of inflation in the period 1971 to 2013, the empirical result from the linear model suggests that current inflation is negatively related to economic growth; and inflation has a long run positive impact for the economy in the sense that current inflation affects economic growth positively after two years. This might be due to the existence of financial repression which keeps borrowing cost low irrespective of the change in inflation. Even so, it should be noted that inflation has a negative effect on standard of living and macroeconomic stability. Therefore, policy makers should balance this positive effect with its negative impact on the standard of living and poverty especially given the high level of poverty in country. The problem would be how to strike the balance. To this end, both monetary and fiscal authorities strengthen their coordination effort and continue to work together to avoid the setting of conflicting macroeconomic objectives. Moreover, continuous assessment of the inflation threshold in the inflation growth nexus using different models and other determinants of growth in addition to the one used by Khan and Senhadji (2001) is important. This would help to design more appropriate monetary and fiscal policy, and put the economy under sustainable development path.

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Appendix:

Appendix1: Correlation matrix of the variables

Variables	***gdp***	***inf***	***igdp.D1***	***pop.D1***	***tot***	***rain***	***pcg***	***l2inf***	***lgdp***
gdp	1.00								
Inf	-0.15	1.00							
igdp.D1	0.30	0.18	1.00						
pop.D1	-0.11	-0.05	-0.02	1.00					
Tot	0.31	0.01	0.00	-0.36	1.00				
rain	0.25	0.08	0.20	-0.04	0.08	1.00			
pcg	0.03	0.25	0.32	0.12	-0.02	0.19	1.00		
l2inf	0.42	0.07	0.21	0.05	0.05	0.24	0.05	1.00	
lgdp	0.30	0.22	0.28	-0.07	0.14	0.40	0.44	0.08	1.00