INFLATION AND ECONOMIC GROWTH: AN ESTIMATE OF THE THRESHOLD LEVEL OF INFLATION FOR ETHIOPIA

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Abstract

Although Ethiopia has been a low inflation country, recently, double digit inflation has become one of the main macroeconomic concerns of policy makers and the society. By adopting the threshold approach, this paper is primarily meant to estimate the optimal level of inflation in Ethiopia around which inflation affect economic growth optimally. Applying this modeling technique on the data from 1971-2010, this paper established that inflation level of about 8-10 percent is optimal for Ethiopia. Any inflation level significantly above or below this level may be a deterrent to long-term and sustainable economic growth. Hence, the monetary authority (National Bank of Ethiopia) should work to maintain the inflation level close to the threshold level. Good monetary and fiscal policy coordination is also needed to maintain the inflation level around the desirable range. The inflation target of 6 percent set in the GTP may not only be so ambitious, given the current context of the Ethiopian economy, but also is a little bit below our threshold estimate. The estimation result is robust to alternative specifications.

Keywords: threshold, inflation, economic growth, optimal

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1. Introduction

The major macroeconomic objectives of countries are achieving high and sustainable economic growth coupled with stable price level. Likewise, these have been the principal objectives of policy making institutions in Ethiopia. The National Bank of Ethiopia (NBE) has been following single digit inflation targeting sort of monetary policy for the past couple of decades. Price stability is viewed as one of the mechanisms by which the bank can support economic growth in the country. Despite the global concern on economic growth and price stability as main macroeconomic objectives, the economic literature so far is inconclusive on the impact of inflation on growth, and the issue remained at the forefront on the economic debate. Among the existing variations in the research is the sign and significance of the linear relationship between inflation and growth, although the majority of the study supports a negative one. Despite the considerable disagreement in the literature, a recently emerging research agreed on some aspect of their relationship. Specifically, the non-linear relationship is becoming obvious. However, the level of inflation which is growth discouraging is inconclusive and depends on country specific characteristics.

Although there is a large volume of discussion on the issue at the global level, inflation has not been a point of dialogue among researchers in Ethiopia. The country has been a low inflation country, where double digit inflation is observed only during periods of war and drought. Deflationary tendencies were observed in years of bumper harvest. However, since 2004, the country started to exhibit a continued inflationary dynamics, despite a paralleled and sustained growth performance. Apart from efforts to explain the causes of inflation, stakeholders are now deeply concerned that the accelerating inflation may terminate the growth momentum experienced since the recovery in 2004. As a result, various direct and indirect interventions were executed for the past couple of years to keep inflation within "an admissible level"[2]. The government increased the reserve requirement, controlled credit creation through credit caps, raised the deposit rate, and installed price caps on selected commodities. There are also paralleled interventions by the fiscal authority. Some of these contractionary interventions could cost the economy in terms of lost output and growth, at the expense of price stability. Sometimes, policy interventions may fail to meet any of the growth and stability targets. Moreover, these policy responses were carried out without a detailed study on the

[2] By "admissible level" of inflation, policy makers meant a single digit level of inflation. There was no an exact target for inflation in the country.

optimal inflation target. In an effort to establish the impact of inflation on growth and provide an estimate of the inflation level that can support the growth process, this paper intends to estimate an optimal inflation level that is consistent with a high growth performance. After confirming the robustness of the estimation result using alternative approaches, the economy could benefit if the monetary authority target inflation around this threshold level.

The rest part of the paper is organized as follows. Section two looks at both the theoretical and empirical evidence on the relationship between inflation and economic growth. In this section, the theory and empirics on the relationship between inflation and economic growth is looked at. In addition, historical overview of inflation and economic growth in Ethiopia is also assessed. Model specification and data is presented in section three. This section deals with the data, methodology and technique adopted in carrying out the research. Estimation results of the model are presented in section 4. Section five concludes the paper and gives policy recommendations.

2. Inflation and Economic Growth: Theory and Evidence

2.1. Theoretical review

Since inflationary situations in the 1940's and earlier (Bronfenbrenner and Holzman, 1963), the issue of inflation and its impact on the real economy has been a target for theoretical and empirical investigation. The normal step in theorizing the link between output fluctuation and inflation is identifying the fundamental sources of inflationary tendencies. The literature viewed the sources of inflation into two broader groups: demand side factors (in the goods, factor, and asset markets) or from the supply side. Synthesis of the two extreme views implies that inflationary tendencies can also emerge from some combinations of the two. While the answer on this issue may differ across countries depending on the structure of their economies (developing versus developed and highly managed versus highly free market) and the period under consideration (short- or long-run), this is not, however, the direct concern of this paper and in the interest of space, we directly move into relating inflation and output.

A concise review of the theoretical literature is provided below. Although there is a general shortage of theoretical models explicitly addressing the issue of the effects of inflation on economic activity (Andres and Hernando, 1999), the existing theoretical stories on the relationship between growth and inflation are largely ambiguous (Temple, 2000; Grier and Grier, 2006; Fountas and Karanasos, 2007). Grier and Grier (2006) also stressed that economic theory can predict either a positive, negative, or zero effect of trend inflation on output growth, depending on the specific assumptions of the model.

Classical theory The traditional way of analysing inflation and growth has been to setup a (neo)classical growth model and consider the effect of monetary changes on the level of physical capital stock (Temple, 2000). Classical thinking on the relationship between price and output is rooted in a world of price takers and in an economy believed to face only transitory departures from full-employment equilibrium (Perry, 1980). The assumption of rational expectation of economic agents can also affect the real impact of nominal changes such as price change. Although the classical growth theory does not explicitly assume the impact of inflation on growth, the theory and its basic assumptions implicitly imply a negative relation between the two. According to the classical growth theory, saving is a creator of investment, hence, growth. Inflation affects this process by reducing firms' profits through higher wage costs.

Keynesian theory Keynesian view assumes an economy with quantity-adjusting markets and involuntary cyclical unemployment. According to Kibritçioglu (2002), Keynes (1940) tried to explain inflation using an inflationary gap model, a demand side model with rigid wage rate allowing for a short term impact of inflation on economic activity. According to this model, given the short-run aggregate supply curve (which is up-ward sloping), price surges caused by demand side factors creates unanticipated profits for firms while nominal wages remain temporarily constant. This process affects output positively at least in the short run. The reason that nominal shocks matter is that nominal wages and prices are not fully flexible (Ball et al, 1988). Rigidity of nominal prices could be due to contracts and costs involved in relation to adjusting prices frequently. The real effects of nominal demand shocks can be large even if the frictions preventing full nominal flexibility are slight (Ball et al, 1988). The possible positive impact of inflation on real investment during times of inflation can also be justified by the fact that rational economic agents tend to put their financial assets in terms of real assets leading to high economic activity.

Latter developments of the Keynesian view such as synthesis of Keynesian and classical views (*Keynesian neoclassical synthesis*) proposed income distribution mechanism due inflation (Kibritçioglu, 2002) implying a sort of real impact in the economy. These economists based their explanation on inflation on the famous *IS-LM*, *Philips curve* and

Fleming-Mundell (F-M) frameworks. This is reinforced by the issue of cost-push arguments for inflation where the real incomes of fixed income earners will be significantly affected during periods of inflation while those with adjusting incomes may not be affected. Economic agents investing in assets are also mostly likely to benefit during periods of inflation.

Such a positive relationship between inflation and economic growth was also supported by what is known as the Mundell-Tobin effect. As briefly summarised in Gregorio (1996), Mundell and Tobin independently predicted a positive correlation between the rate of inflation and the rate of capital accumulation, which was latter referred as the Mundell-Tobin effect. It relies on the substitutability between money and capital, by which an increase in the rate of inflation results in an increase in the cost of holding money and a portfolio shift from money to capital, the increase in the rate of capital accumulation inducing a higher rate of growth. Tobin has supported this view by constructing a theoretical model where inflation reduces accumulated wealth, which in turn raises current savings, investment, and growth (Grier and Grier, 2006).

*Monetarist*s An alternative view on the role of prices and inflation comes from monetarists. Building on the famous quantity theory of money, monetarists suggest that in the long-run, prices are mainly affected by growth rate in money, while having no real effect on growth. According to Fountas and Karanasos (2007) the principal proponent of monetarist view, Friedman (1977), argues that a rise in the average rate of inflation leads to more uncertainty about the future rate of inflation, it distorts the effectiveness of the price mechanism in allocating resources efficiently, and thus it creates economic inefficiency and a lower growth rate of output.

Gregorio (1996) has also seen that monetarists have linked inflation with loss of welfare since inflation can force people to hold less cash balances. As a result, this school of thought (principally Friedman) has proposed zero nominal interest rate to achieve full liquidity. The conclusion from the monetarists view is that a comprehensive empirical study that tests for the real effects of inflation should control for the impact of inflation uncertainty on output.

Endogenous growth theories Apart from these older theories in economics, a review on the impact of inflation on economic activity can be deduced from the recent theories of growth such as endogenous models. The endogenous growth theory assumes that growth is mainly the result of technological change and knowledge, which itself depends on the size of return on human and physical capital. Inflation acts as a tax and hence reduces the return on all types of capital and affect growth rate negatively. Andres and Hernando (1999) also suggested that inflation can affect the accumulation of other determinants of growth such as human capital or investment in R&D; this channel of influence is known as the accumulation or investment effect of inflation on growth.

Technological change and research and development are also influenced by access to financial resources. Several researchers have suggested that inflation may affect real deposit rates, and thereby affect saving ratio (Temple, 2000). In a world of imperfect international capital mobility, these changes in savings could affect the domestic user cost of capital and hence the domestic volume of investment. However, as Grier and Grier (2006) pointed out, simulations following endogenous growth models did not showed a strong relationship between growth and inflation.

Despite the views of the mainstream schools of thoughts in economics, since the early 1990s, the sharp difference between economic theorists on the relationship between price and output fluctuations has been increasingly softening, and a *new neoclassical synthesis (NNS)* is now on the agenda of macroeconomics (Kibritçioglu, 2002). The systematic application of intertemporal optimization behaviour of firms and households and rational expectations, and incorporation of imperfect competition and costly short-run price adjustments into dynamic macroeconomics has played for the growing theoretical consensus on how real and nominal fluctuations might be linked avoiding corner solutions.

The relationship between inflation and economic growth will be a much more complex issue if price volatility and inflation uncertainty is taken into account. A further complicating factor is that there may be a relationship between average inflation and the degree of uncertainty about future inflation. As underlined by Gregorio (1996), Grier and Grier (2006) and Temple (2000), price variability most likely affect long-run economic growth negatively through its impact on firms profit, financial sector development, and investment. Uncertainty related to inflation can also affect adversely the public's ability to make their best decisions. Apart from the anticipated component of price volatility that creates uncertainty, inflation can also cause significant uncertainties due to its unanticipated components (Temple, 2000). This uncertainty is also damaging to resource allocation. This issue of inflation uncertainty and its impact on growth was also raised by monetary economists.

On the other hand, the theoretical literature on the relationship between inflation and economic growth tends to establish a linear relation between the two variables, which is confronted highly by the recent empirical literature. The existence of non-linearity in the relationship between inflation and output will also be tested empirically on the case of Ethiopia upon which we can judge the mainstream theoretical development.

2.2. Empirical review

Alike the contrasting theoretical views on the relationship between inflation and economic growth, the empirical literature is also decorated with conflicting results: there are many works establishing a negative relationship, while a few others found a positive long-run relationship. For example, Khan (2002), Boyd & Champ (2006), and Rousseaua and Wachtelb (2001) are among the very few who found a significant negative relationship between inflation and economic growth. Those studies that identified a negative long-run impact of inflation on growth provided various explanations on the transmission mechanism. Khan (2002) and Boyd & Champ (2006) argued that inflation affects economic growth through its adverse impact on financial deepening. These studies assume that financial sector deepening retards during periods of high inflation. Rousseaua and Wachtelb (2001) also supported this and added that inflationary episodes may trigger policy interventions that erode the business environment.

Although the text that inflation retards long-run growth is dominating, others such as Arai et al (2002), Dotsey and Sarte (2000), Mallik and Chowdhury (2001), Seleteng (nd), and Charemza et al (2010) found a positive relationship between inflation and economic growth. The positive impact of inflation on growth is through active precautionary savings motive by economic agents during inflationary periods. Moreover, when inflation is high, wealth could be allocated away from money and into physical assets which are related to investment. Also, on economies with initially low rates of inflation, modest increases in the rate of inflation may not negatively affect long-run rates of real economic growth (see Seleteng, nd) as firms will be better off as prices rise (Sargsyan, 2005). Likewise, even though they found a negative long-run impact of inflation, Rousseaua and Wachtelb (2001) stress that inflation becomes undesirable only when it is significantly high.

Despite the conflicting result on the long-run linear relationship between inflation and growth, most of the empirical research accepts the existence of threshold level of inflation significantly below and above which inflation becomes a deterrent to economic growth. Nevertheless, there is no consensus on the rage of inflation which is favorable for economic growth. The result generally varies across countries depending on their income groups and structure of their economies, with developing countries experiencing higher threshold level of inflation compared to industrialized ones. We will build our empirical literature around recent studies which adopted the most advanced econometric techniques in search for a true relationship between inflation and economic growth.

Applying threshold estimation technique, Khan and Senhadji (2001) tested for the existence of threshold effects in the relationship between inflation and growth for a set of developed and developing countries. They found that the threshold level of inflation above which inflation significantly slows growth is around 1–3 percent for industrial countries and 11–12 percent for developing countries. They found a negative and significant relationship between inflation and growth for inflation rates above the threshold levels.

Drukker et al (2005) applied related econometric methods for estimation and inference in non-dynamic, fixed-effects, and panel-data models for a sample of 138 countries over the period 1950-2000. They find one threshold that is well identified by the data when the full sample is considered. The estimated value of the threshold is 19.16 percent. For the industrialized sample, their results indicate that there are two threshold points at 2.57 percent and 12.61 percent. They also find that, in the full sample, if the initial inflation rate is below 19.16 percent, increases in inflation do not have a statistically significant effect on growth. In contrast, when the initial inflation is above 19.16 percent, a further increase in inflation is observed to decrease long-run growth.

Hussain (2005) also attempted to estimate threshold level of inflation in Pakistan using annual data for the period 1973-2005. The study suggests that the central bank in Pakistan should keep the inflation level within the range of 4 – 6 percent to achieve sustained growth. However, this was significantly low as compared to a 9 percent level of threshold obtained by Mubarik (2005).

Moreover, according to Sargsyan (2005), the optimal level of inflation in Armenia is 4.5 percent annually vis-à-vis the already set target of an inflation level higher than 3 percent by Central Bank of Armenia. The author conclude that targeting a level of inflation higher than the set amount but not exceeding calculated threshold level might be beneficial for Armenia.

There are also few attempts to examine whether there is a threshold relationship between inflation and economic growth in various African countries. The attempts also estimated the threshold levels for the respective countries. For example, Frimpong & Oteng-Abayie (2010) studied the threshold effect of inflation in Ghana for the period 1960-2008 using threshold regression. They found an evidence for a threshold effect of inflation on economic growth in Ghana. The estimation result indicates an inflation threshold level of 11 percent, above which inflation starts to significantly hurt economic growth. Below the 11 percent level, inflation is likely to have a mild effect on economic activities.

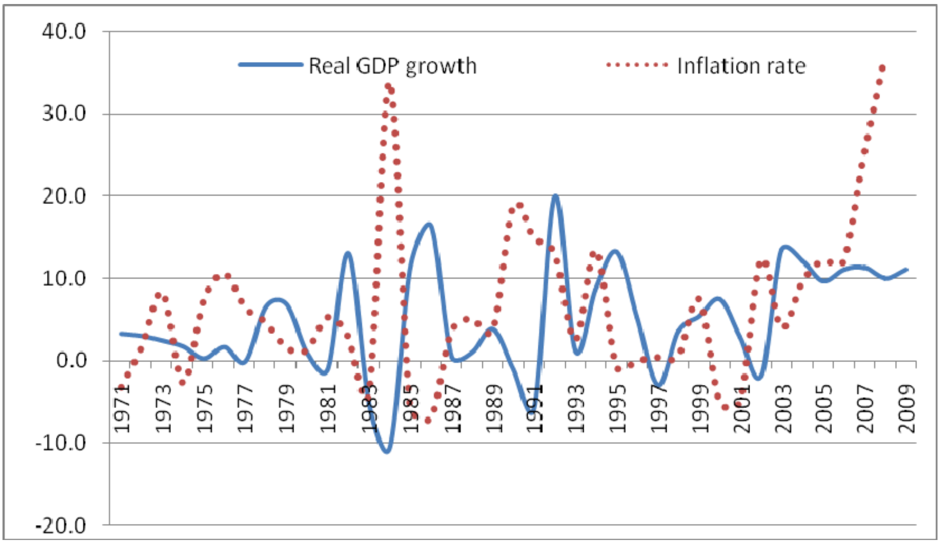
Likewise, Salami and Kelikume (nd) examined the annual time series data of Nigeria spread over two periods of 1970-2008 and 1980-2008 to determine the inflation threshold for the country, and to establish whether there is significant change in the threshold level for the two periods. Using a non-linear inflation-growth model, they established an inflation threshold of 8 percent for Nigeria over the sample period 1970-2008. For the period 1980-2008 they estimate an inflation threshold of 7 percent. This result is essential for monetary policy formulation in Nigeria given the single digit inflation target by the Central Bank without necessarily targeting the optimum point in which inflation becomes inimical to growth.

Following the approach suggested by Khan and Senhadji (2001), Seleteng (nd) estimated a threshold level of inflation for Lesotho so as to guide monetary policy making in the country. The model recommends a 10 percent optimal level of inflation, which is conducive for economic growth. The implication is that any inflation rate above this level is not optimal for growth in the country.

2.3. Historical overview of inflation and economic growth in Ethiopia

Following the theoretical and empirical view that inflation may affect economic growth, we present the historical overview of inflation and economic growth in Ethiopia. A graphical presentation of the inflation-growth relationship is given in Figure 2.1a and 2.1b. Although years of high inflation were generally labelled as years of poor agricultural performance in Ethiopia, one can identify two regimes on the relationship between these two variables in the economy. The data shows that there was an inverse relationship between inflation and output growth in the years prior to the mid 1990's. This is visible in the first part of Figure 2.1a and the first panel of Figure 2.1b.

Figure 2.1a: Growth and inflation in Ethiopia (1971-2010)[3]

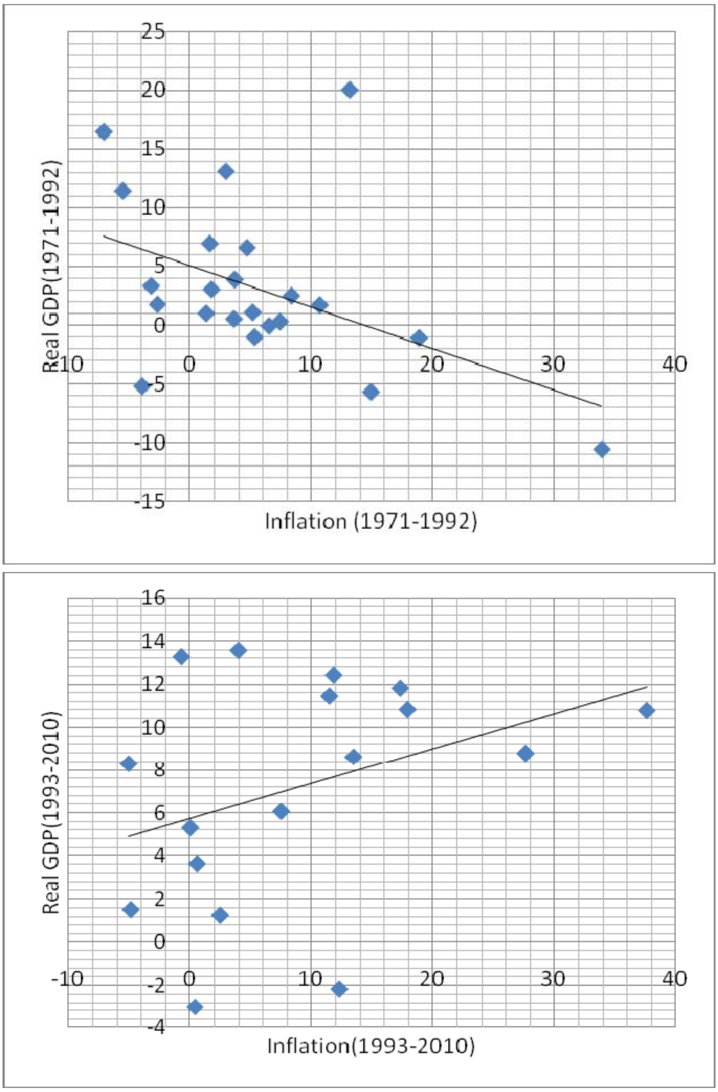


Nevertheless, in the latter period, inflation and output tend to move together with a closer relationship between inflation and output except the most recent years where inflation accelerates with stable growth performance. Hence, it is not clear to draw any conclusion about the long-run relationship between inflation and output growth in Ethiopia by mere inspection of the lines. Moreover, the recent phenomenon of high inflation and good agricultural and non-agricultural production points a doubt on the naively established relationship between inflation and economic growth. It also raised a concern by many that the current growth performance cannot be sustained in the face

[3] Note that the output growth and inflation rates are annual percentage changes of the untransformed variables.

of high inflation. On the other hand, others stressed the need for moderate level of inflation in the country to frequently ignite growth by motivating producers.

Figure 2.1b: Growth and inflation in Ethiopia (1971-2010)



Source: Own computation based on MoFED and NBE

To understand the long-run relationship between inflation and economic growth in Ethiopia in a more scientific way, the study will move this attempt forward using vector-autoregressive (VAR) based granger causality and threshold regression introduced to the growth analysis by Khan and Senhadji (2001).

3. Model Specification and Data

Our main purpose is to estimate the threshold level of inflation in Ethiopia. This requires us first test whether there is causality between inflation and economic growth, and whether the causality is uni-directional or bi-directional. The conventional model for testing causality is VAR based Granger causality test. This test is presented in the two-variable VAR (k) system of equations as provided in (3.1).

$$\left.\begin{aligned} growth_t &= \alpha_{10} + \alpha_{1j}\sum_{j=1}^{k}\pi_{t-j} + \lambda_{1j}\sum_{j=1}^{k} growth_{t-j} + \eta_{1t} \\ \pi_t &= \alpha_{20} + \alpha_{2j}\sum_{j=1}^{k}\pi_{t-j} + \lambda_{2j}\sum_{j=1}^{k} growth_{t-j} + \eta_{2t} \end{aligned}\right\} \quad \textbf{(3.1)}$$

where $growth_t$ and π_t are growth rate of real GDP *(d(log(RGDP)))* and the inflation level *(d(log(CPI)))*, respectively. Once we determine the existence of causation, we will move on to determine the threshold level of inflation in Ethiopia that can stimulate growth.

The long-run relationship between growth and inflation can be derived following the developments in standard growth analysis. The conventional growth models assume the growth function specified in Equation (3.2).

$$growth_t = XB + \varepsilon_t \quad \textbf{(3.2)}$$

where $growth_t$ is as defined above, *X* is a vector of explanatory variables, B is vector of slope coefficients attached with the vector of explanatory variables, and ε is the error term.

Equation (3.2) is expanded to capture the link between inflation and economic growth as in Equation (3.3):

$$growth_t = \alpha_0 + \alpha_1\pi_t + XB + \varepsilon_t \quad \textbf{(3.3)}$$

Conventional growth models including neoclassical growth model start with investment and population growth in the growth analysis. Most similar attempts also include inflation, openness, monetization, and access to credit, among others, in the growth regression. We would follow a different strategy and statistically identify the most important variables for inclusion in the modeling while keeping inflation in all cases. Following this procedure, we choose investment-to-GDP ratio, credit-to-GDP ratio, and a dummy variable for drought in our baseline regression. We include an indicator for drought given the agrarian nature of the economy. The data are obtained from official sources including Central Statistical Agency (CSA), National Bank of Ethiopia (NBE), and Ministry of Finance and Economic Development (MoFED).

Hence, incorporating the right-hand-side variables to the growth equation, we arrive at the following linear regression equation:

$$growth_t = \alpha_o + \alpha_1 \pi_t + \alpha_2 invest_t + \alpha_3 credit_t + \alpha_4 ddrought_t + \varepsilon_t \quad (3.4)$$

where $invest_t$ is investment-to-GDP ratio, $credit_t$ is total credit-to-GDP ratio, and $ddrought_t$ is an index of years of drought.

Nevertheless, recent studies are increasingly establishing that the relationship between inflation and economic growth does not follow a single pattern, motivating the threshold level application in such relationship. The most common model for threshold analysis is the one developed by Khan and Senhadji (2001). Since then, different variants of the model emerge and are frequently used to determine the threshold level of inflation for industrialized and developing countries. For example, Seleteng (nd), Frimpong & Oteng-Abayie (2010) and Salami & Kelikume (nd) used some variant of the model on the case of Lesotho, Ghana, and Nigeria among African countries, respectively. We join such efforts using similar approach to determine whether there is a threshold level of inflation in Ethiopia which is optimally related to economic growth.

The threshold level of inflation with respect to economic growth, under the assumption of two inflation regimes, can be estimated using the form in (3.5).

$$growth_t = \beta^{\pi}{}_o + \beta^{\pi}{}_1 (1 - D_t^{\pi^*}).(\pi_t - \pi^*) + \beta^{\pi}{}_2 D_t^{\pi^*} (\pi_t - \pi^*) + \beta^{\pi}{}_3 invest_t + \beta^{\pi}{}_4 credit_t + \beta^{\pi}{}_5 ddrought_t + \varepsilon_t \quad \textbf{(3.5)}$$

where $\pi = \underline{\pi},\ldots\ldots,\overline{\pi}$, and

$$D_t^{\pi^*} = \begin{cases} 1\ if\ \pi_t \succ \pi^* \\ 0\ if \pi_t \le \pi^* \end{cases}, t = 1,\ldots\ldots T$$

where π^* is the threshold level of inflation, and $D_t^{\pi^*}$ is a dummy variable that takes a value of 1 for inflation levels greater than π^* percent and 0 otherwise. Note that $\beta's$ are indexed by π to show their dependence on the threshold level of inflation, its range[4] is between $\underline{\pi}$ & $\overline{\pi}$. Variables are as defined above. We will also use other variables including $openness_t$, which is defined as the logarithmic growth of the sum of imports and exports to measure the rate of openness, and $money_t$, which is a measure of monetization (money/GDP) for the robustness analysis.

According to Sergii (2009), and Ghosh and Phillips (1998), it is advised to use the log version rather than level of the variables for couple of reasons. Firstly, this transformation eliminates strong asymmetry in initial distribution of variables. Secondly, log transformation provides the best fit among non-linear models. Hence, we use the log transformation of CPI based inflation (i.e., *d(log(CPI))* and output growth.

In addition, Khan and Senhadji (2001) proposed to use the following transformation and estimable model in order to deal with negative values of inflation:

$$\begin{aligned} growth_t = \beta o + \gamma_1 (1 - D_t^{\pi^*})\{(\pi_t - 1) I(\pi_t \le 1) + [\log(\pi_t) - \log(\pi_t^*)] I(\pi_t \succ 1)\} + \\ \gamma_2 D_t^{\pi^*}\{(\pi_t - 1) I(\pi_t \le 1) + [\log(\pi_t) - \log(\pi_t^*)] I(\pi_t \succ 1)\} + \\ \beta_3 invest_t + \beta_4 credit_t + \beta_5 ddrought_t + \varepsilon_t \end{aligned}$$

(3.6)

where $I(\pi_t \le 1)$ and $I(\pi_t \succ 1)$ are indicator functions- that is, functions that take the value of 1 if the term between parenthesis is true and 0 otherwise. The effect of inflation

[4] This range can be determined depending on the researcher's discretion on the range where the threshold level of inflation can lie.

on GDP growth is given by γ_1 when inflation is less than or equal to π^* percent, and γ_2 when inflation rates are higher than π^* percent. The strategy adopted above generates a hybrid function of inflation which is linear for values of inflation rates below or equal to one and logarithmic for inflation rates greater than one. That function is:

$$f(\pi_t) = (\pi_t - 1)I(\pi_t \leq 1) + \log(\pi_t)I(\pi \succ 1) \quad \textbf{(3.7)}$$

The first part of (3.7) is a linear component of the function for the inflation level less than or equal to 1, given the indicator function. The second one is a logarithmic component for all level of inflation disregarding inflation less than or equal to 1 as defined by the associated indicator function.

We subtract one from the first term to allow *f(*π_t*)* to be continuous at unity, when the function changes from being linear in π_t to being log linear in π_t. The function *f(*π_t*)* is also continuously differentiable. Consequently, *f(*π_t*)* allows us to take into account all observations, including observations with negative inflation rates. The subtraction of *log(*π^**)* from *log(*π_t*)* makes the relationship between growth and inflation, described by Equation (3.6), continuous at the threshold level, π^*.

If the threshold were known a priori, the model could be estimated by ordinary least squares (OLS). Since π^* is unknown, it has to be estimated along with the other regression parameters[5]. The appropriate estimation method in this case is nonlinear least squares (NLLS). Furthermore, since π^* enters the regression in a nonlinear and non-differentiable manner, conventional gradient search techniques to implement NLLS are inappropriate. Instead, estimation has to be carried out with method called *conditional least squares* which can be described as follows[6]. By estimating the model in (3.6) by OLS, as suggested by Hansen (1997), for different values of π which is chosen in an ascending order (that is 1, 2, 3 and so on), the optimal value of π (i.e., π^*) is obtained by finding the value that maximizes the adjusted-R^2 or minimizes Residual Sum

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[5] Notice that when the threshold variable is smaller than the threshold parameter, the model estimates the first part of equation (3.6). Similarly, when the threshold variable is larger than the threshold parameter, the model estimates the second part of equation (3.6).
[6] The main idea of this method is to find the level of inflation that minimizes the sum of squared residuals.

of Squares (RSS) from the respective regressions. More specifically, the optimal threshold level is identified as:

$$\pi^* = \arg\max_{\pi} \left\{ adjR^2(\pi), \pi = \underline{\pi}, \ldots, \overline{\pi} \right\}$$

Or, alternatively,.......(3.8)

$$\pi^* = \arg\min_{\pi} \left\{ RSS(\pi), \pi = \underline{\pi}, \ldots, \overline{\pi} \right\}$$

If the threshold value, π^*, was known, then to test for threshold behavior, all one needs is to test the hypothesis $H_o : \gamma_1 = \gamma_2$, with H_o of no threshold effects. Unfortunately, the threshold value is typically unknown and, under the null hypothesis, parameter π^* is not identified, so classical tests, such as t-tests, have nonstandard distribution. As a way out, our model specification and inference will closely follow Hansen (1997) who (a) provides a bootstrap procedure to test H_o, (b) develops an approximation to the sampling distribution of the threshold estimator free of nuisance parameters and (c) develops a statistical technique that allows confidence interval construction for π^*. The basic procedure is available in Hansen (1997) and summarized in Annex 1.

4. Estimation and Results

4.1. Data Examination

We examine the basic statistics on real GDP growth and inflation rate (i.e., the changes in logarithm) data. In an effort to explore the bivariate relationship between the variables, Table 4.1 depicts the joint frequency distribution of the two variables in various ranges of inflation. The table provides us with interesting results: annual average inflation appears to exhibit a positive relationship with growth, where the mean and median growth rates rise as inflation rises.

Table 4.1: Basic statistics

	Inflation			GDP growth		
	Number of observation	Mean	Median	Number of observation	Mean	Median
All Observations	39	6.4	4.6	39	2.6	1.7
$-\infty < \pi < 3$	16	-1.3	-0.3	23	-3.0	-2.2
$3 < \pi < 5$	4	4.0	3.9	2	3.7	3.7
$5 < \pi < 10$	6	6.5	6.7	5	8.1	8.5
$10 < \pi < \infty$	13	16.7	13.9	9	13.5	11.8

Source: Own computation based on CSA and MoFED data

On the other hand, the long-run correlation between inflation and real GDP growth is not so strong. The long-run correlation coefficient is -0.17 showing a not so strong but negative contemporaneous relationship between them.

An important exercise in time series analysis is the test of whether the macroeconomic variables we are considering in the modeling exercise are stationary or not. Augmented Dickey-Fuller test for unit roots is conducted on the variables to be included in the inflation threshold estimation model. The result shows that variables except investment, money and credit to GDP ratios were stationary. We included investment and credit to GDP ratios in the models after a test for long-run co-integration showed that the two variables are actually co-integrated. We followed the same procedure always we get two non-stationary variables. The unit root test result is shown in Table 4.2.

Table 4.2: Unit root test

Variable	In levels				Level of integration
	Test statistics	1%	5%	Prob.	
Growth	-7.386	-4.227	-3.537	0.000	I(0)
π	-4.888	-4.219	-3.533	0.002	I(0)
Invest	-2.828	-3.910	-2.938	0.054	I(1)
Credit	-1.900	-3.610	-2.938	0.321	I(1)
Money	-1.964	-3.610	-2.938	0.300	I(1)
openness	-6.256	-4.219	-3.533	0.000	I(0)

Source: Authors estimation based on CSA, NBE and MoFED data

4.2. Estimation of Threshold Level of Inflation

i) Causation between growth and inflation

Before estimating the optimal level of inflation which is desirable for long-run economic growth in Ethiopia, we undertook a little exercise on VAR based causality analysis between inflation and output growth. We use log-differenced values of CPI and output to compute inflation and growth for reasons we discussed previously. The likelihood ratio test statistics (LR), final prediction error (FPE) and Akaike information criterion (AIC) show that lag length of 2 is appropriate for the VAR model. The VAR based Granger Causality test statistics based on the estimated two-variable VAR model indicates the existence of bi-directional causality between the two variables. The null hypothesis that one variable does not cause the other is rejected. The existence of Granger-causality between inflation and output also implies that there is a long-run relationship between the two variables and, hence, the variables are co-integrated. See Table 4.3.

Table 4.3: VAR based granger causality/weak exogeneity test

Dependant variable		π	
Excluded	Chi-sq	df	Prob.
Growth	10.957	2	0.004
Dependant variable		***growth***	
Excluded	Chi-sq	df	Prob.
π	8.194	2	0.017

Source: Authors estimation

ii) Baseline linear growth regression

A simple linear model on the long-run relationship between output growth and inflation was first estimated following Equation (3.4) before a non-linear model is used. Inflation was entered in the growth model lagged two periods due to the existence of strong causality moving from the second period lag inflation to output growth. The result indicates that inflation has a positive and strong impact on long-run growth (see Table 4.4). This can be convincing due to couple of reasons. First, Ethiopia has been a low inflation country with average inflation rate of just above 6 percent over the period 1971-2010[7]. Second, given the low level of average inflation for the period covered, any additional inflation may stimulate economic activity. Moreover, investment and credit as

[7] This can be compared with an average (1971-2009) inflation of close to 12 percent for about 45 African countries, after canceling out countries with outlier average inflation of above 50 percent.

a ratio of GDP have positive and statistically significant impact on economic growth. On the other hand, drought, a proxy for how rainfall is important for the Ethiopian economy, has a statically significant negative coefficient.

Table 4.4: OLS estimates of inflation and economic growth: Without threshold effect[8]

	Dependent variable: *growth*			
Variable	**Coefficient**	**Std. error**	**t-statistic**	**Prob.**
C	-20.565	5.349	-3.84	0.001
$\pi(-2)$	0.357	0.129	2.76	0.010
invest	0.777	0.326	2.38	0.023
Credit	0.260	0.133	1.96	0.059
ddrought	-8.949	4.021	-2.230	0.033
Adjusted r-squared	0.49	Ramsey RESET test		0.47(0.70)
Sum squared resid	1287.65	Autocorrelation LM test		1.79(.18)
Durbin-Watson stat	2.34	Het. Test		0.09(0.76)

Source: Authors estimation

Although the positive long-run linear relationship between inflation and economic growth in Ethiopia may seem a little bit strange, the result is consistent with some similar studies. For example, Arai et al (2002) found a positive and significant relationship between average inflation and average growth for OECD countries. In addition, Dotsey and Sarte (2000) find that variability increases average growth through a precautionary savings motive. Mallik and Chowdhury (2001) also found a similar positive long-run relationship between inflation and economic growth for Bangladesh, India, Pakistan and Sri Lanka. One explanation for this is that when inflation is high, wealth could be allocated away from money and into physical assets which are related to investment.

Similar positive long-run relationship between inflation and economic growth was obtained by Seleteng (nd) on the case of Lesotho. Seleteng (nd) also stated that for economies with initially low rates of inflation, modest increases in the rate of inflation do not affect long-run rates of real economic growth. Charemza et al (2010) also observed positive real effects in periods after increased inflation in Malaysia. Likewise,

[8] The post estimation tests show that the model fits the data well, and that there are no serious problems on our model.

Rousseaua and Wachtelb (2001) stress that inflation becomes undesirable only when it is significantly high, although it can not a priori be possible to decide how high it is.

Although high inflation rate was observed to stimulate economic growth in some countries, many studies advise that the inflation rate should be kept as low as possible since high inflation is inherently unstable due to inflation inertia.

iii) Baseline non-linear threshold estimation

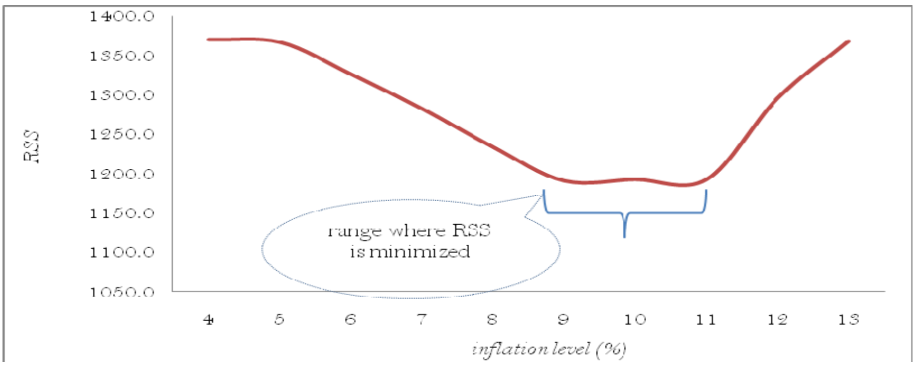
Not all level of inflation is desirable as hastily established by the linear model. Unlike the linear regression modeling technique, the threshold estimation assumes that inflation level only around some range is optimal for economic growth. Significantly lower and significantly higher levels of inflation may be harmful. In an effort to identify the optimal level of inflation that can support the growth process, we estimated the non-linear model mentioned in Equation (3.6).

Testing for existence of threshold level of inflation in Ethiopia

Building on the procedure stated above, the test for existence of threshold level of inflation requires us i) estimate the non-linear model in (3.6), ii) identify the level of inflation that minimizes the *RSS* or maximizes the *Adjusted* R^2, and iii) test the null of no threshold effects based on the bootstrapped LR_o.

Accordingly, we estimated (3.6) for a range of inflation from $\bar{\pi}$=4 to $\underline{\pi}$=14 to determine the level of inflation that minimizes the *RSS*. The procedure shows that π=9 is the level of inflation that minimizes the *RSS* within the stated range. See Figure 4.1.

Figure 4.1: Estimation of the threshold level of inflation

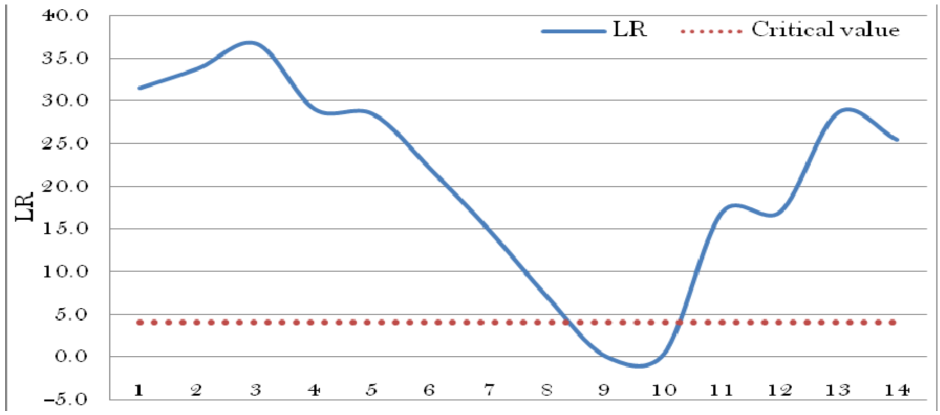


Source: Authors estimation

Once we identify the suspected level of threshold inflation, we check whether this level is actually a threshold level using bootstrap procedure. The likelihood ratio test shows that the null hypothesis of no threshold effect can be rejected at 5 percent significance level (bootstrapped p-value=0.02)-with observed value of LR_o of 15.71 vis-à-vis a critical value of 4.96. Thus, the Ethiopian macroeconomic data strongly suggests the existence of threshold level of inflation on the relationship between inflation and economic growth.

To construct the confidence interval for the threshold level, we followed the procedure stated in Hansen (1996). For this purpose, we calculate the critical value and the corresponding likelihood ratio. We computed the 90 percent confidence interval by plotting the "no-rejection region" as in Figure 4.2. The "no-rejection region" is tight and between [8.5, 10.5].

Figure 4.2: Confidence interval



Source: Authors computation

Discussion of estimation results

Unlike the linear OLS result provided in Table 4.4, Table 4.5 shows the conditional OLS estimation result for Equation (3.6) associated with the threshold level of inflation of 9 percent. At the optimal level of inflation, the coefficient of inflation below the threshold level (γ_1) is not significant. On the other hand, γ_2 is statistically significant and positive showing that inflation above 9 percent is desirable for economic growth. Moreover, the conditional coefficients of other control variables are as theoretically expected. While the coefficients of investment and credit variables are positive and significant, the dummy variable for drought is negative showing that growth is negatively affected by the level of rainfall.

Table 4.5: OLS estimates on the threshold level of inflation of $\pi^* = 9$

	Dependant variable: *growth*			
Variable*	**Coefficient**	**Std. error**	**t-statistic**	**Prob.**
C	-18.456	5.132	-3.600	0.001
γ_1	0.084	0.474	0.180	0.859
γ_2	4.361	1.422	3.070	0.004
invest	0.674	0.325	2.070	0.047
Credit	0.253	0.130	1.950	0.061
ddrought	-8.615	3.959	-2.180	0.037
Adjusted R-squared	0.451	Sum squared residual		1190.541

*The inflation was lagged two periods as informed by the causality test.
Source: Authors estimation

An estimation result for different levels of inflation is provided in Annex 2. One can also draw interesting observations from the annex. For inflation level below threshold, the significance and size of coefficient of high inflation is increasing as we approach the threshold level. However, above the threshold level, as inflation increases, there is a general trend of declining significance and magnitude of the inflation coefficient. See Annex 2.

Although the study shows that inflation and output growth in Ethiopia are positively correlated, an inflation level of 8-10 percent seems optimal. Allowing the inflation level to significantly exceed from this range may invite unprecedented consequences of galloping and uncontrollable inflation. Letting inflation to significantly fall below the threshold level may also slow down economic activity.

4.3. Stability and Diagnostic Tests

Sensitivity to change in model variables

To check for the robustness of our results, keeping the specification in Equation (3.6), we estimated Equations (4.1), (4.2), and (4.3) below using the same procedure including indicators of openness (log growth rate of sum of imports and exports), and monetary depth (M2/GDP) as control variables. π is defined as given in (3.6). The new specifications do not result in significant change in our results, and support the result that the optimal level of inflation in Ethiopia is around 8-10 percent. Also, there are no changes in terms of interpretation of coefficients of inflation. The sign and significance of coefficients of the control variables are consistent with the theory.

$$growth_t = \beta o + \gamma_1 (1 - D_t^{\pi^*}) \pi + \gamma_2 D_t^{\pi^*} \pi + \beta_3 invest_t + \beta_4 openness_t + \beta_5 money_t + \beta_6 ddrought_t + \varepsilon_t \quad (4.1)$$

$$growth_t = \beta o + \gamma_1 (1 - D_t^{\pi^*}) \pi + \gamma_2 D_t^{\pi^*} \pi + \beta_3 invest_t + \beta_4 openness_t + \beta_5 credit_t + \beta_6 ddrought_t + \varepsilon_t \quad (4.2)$$

$$growth_t = \beta o + \gamma_1 (1 - D_t^{\pi^*}) \pi + \gamma_2 D_t^{\pi^*} \pi + \beta_3 invest_t + \beta_4 money_t + \beta_5 ddrought_t + \varepsilon_t \quad (4.3)$$

Diagnostics tests

To check for the reliability of the baseline estimation, we undertook various diagnostics tests based on the conditional estimation consistent with the threshold level of $\pi^* = 9$. The DW statistics suggests that there is no serious autocorrelation problem. The Ramsey RESET test of no omitted variables was also conducted but we were unable to reject the null (Table 4.6). We also undertook misspecification and autoregressive conditional hetroskedasticity tests. The test result in Table 4.6 reveals that there are no misspecification and hetroskedasticity problems. Similar diagnostic tests were also done on the alternative specifications in (4.1), (4.2) and (4.3). No evidence of specification problem was observed.

Table 4.6: Post estimation tests

Test type	Test result	Test type	Test result
ARCH LM test	0.31(0.57)	Breusch-Pagan	1.13(0.28)
Ramsey RESET test	0.18(0.90)	Durbin-Watson (DW)-statistic	2.26

Source: Authors estimation

Sensitivity to an estimation approach

One of the potential problems in growth regression is the possible endogeneity of right hand side variables (mainly inflation and investment). To check for a specification bias due to endogeneity, Equation (3.6) is re-estimated using the two-stage least squares (2SLS) - instrumental variable (IV) estimation method. We used lagged values of inflation, investment, credit, and drought as instrumental variables in the estimation process. All instruments are significantly defined with one lag, with the exception of inflation in which three lags were found as being compatible. The comparison of OLS and

2SLS-IV estimated models depict a similar threshold level of inflation. The associated coefficients in both models are not significantly different from each other. The coefficients of the 2SLS-IV estimation can be interpreted analogously as the conditional OLS. Hence, an inflation rate of 8-10 percent can be deemed as a robust threshold estimate. The 2SLS-IV estimation output on the threshold level is given in Table 4.7. The detailed 2SLS-IV result for range of inflation levels is presented in Annex 3.

In relation to the theoretical literature, the finding on the Ethiopian data showed that inflation and economic growth are positively but non-linearly related.

Table 4.7: 2SLS-IV estimation result at the threshold inflation ($\pi^* = 9$)

	Dependant variable: *growth*			
Variable*	**Coefficient**	**Std. error**	**t-statistic**	**Prob.**
c	-19.674	5.226	-3.760	0.001
γ_1	0.211	0.486	0.430	0.668
γ_2	4.379	1.417	3.090	0.004
invest	0.643	0.326	1.980	0.057
credit	0.313	0.140	2.230	0.033
ddrought	-8.375	3.949	-2.120	0.042
Adjusted R-squared	0.467	Sum squared residual		1142.680

*The inflation was lagged two periods as informed by the causality test.
Source: Authors estimation

5. Conclusion and Policy Implications

Although Ethiopia has been a low inflation country with average inflation of around 6 percent for the past four decades, inflation has become a growing challenge for policy makers and researchers recently. Similar to the conflicting empirical and theoretical literature on the relationship between inflation and long-run growth, stakeholders are unclear on the impact of various levels of inflation on the current growth experience in Ethiopia. Building on the recently growing approach of threshold estimation on growth-inflation relationship, this specific paper intends to estimate the optimal level of inflation for Ethiopia. The estimation procedure gave us some interesting results. First, only the second period lag of inflation affects economic growth significantly. Second, we found a non-linear relationship between growth and inflation in Ethiopia over the period 1971-

2010. Third, inflation level within the range of 8-10 percent is optimal for economic growth. The estimation result is robust to choice of variables and estimation technique.

The findings also have important policy implications. First, inflation is not generally harmful for growth in Ethiopia. Second, the monetary authority should keep the inflation level with in the single digit level, but not significantly lower than our estimate. Third, the inflation target of 6 percent for the period of the GTP plan is not only very low, but also ambitious given the recent state of the economy and the planned projects. Fourth, the policy advice of the international lending agencies of reducing the inflation level to a very low level (close to zero) are likely to adversely affect economic growth.

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Annex 1: Inference and testing of threshold effects: Hansen's procedure

Testing for a threshold (bootstrap procedure)

Testing the existence of threshold levels simply amounts to testing $H_o : \gamma_1 = \gamma_2$. Under the null hypothesis, the threshold $\pi *$ is not identified, so classical tests, such as the *t*-test, have nonstandard distributions. Hansen (1997) suggests a bootstrap method to simulate the asymptotic distribution of the following likelihood ratio test of H_o .

$$LR_o = \frac{S_o - S_1(\pi *)}{\hat{\delta}^2} \qquad \text{(i)}$$

where S_o and $S_1(\pi *)$ are the sums of squared residuals under the null and alternative hypothesis and $\hat{\delta}^2$ is variance of the residuals under the alternative hypothesis for our growth regression (3.6) without and with threshold. The asymptotic distribution of LR_o is non-standard, and strictly dominates the χ_k^2 distribution. The distribution of LR_o depends in general on the moments of the sample; thus critical values cannot be tabulated. In order to solve this problem Hansen (1997) suggested a bootstrap technique to stimulate the likelihood ratio (LR_o), so p-values constructed from this are asymptotically valid.

He recommends the following procedure for the bootstrap. Fix the repressors and the threshold level of inflation, holding their values fixed in repeated bootstrap samples. Take the regression residuals, and treat them as the empirical distribution to be used for bootstrapping. Draw (with replacement) a sample of size n from the empirical distribution and use these errors to create a bootstrap sample under H_o . Using the bootstrap sample, estimate the model under the null and alternative, and calculate the bootstrap value of the likelihood ratio statistic LR_o in (i). Repeat this procedure a large number of times and calculate the percentage of draws for which the simulated statistic exceeds the actual. This is the bootstrap estimate of the asymptotic p-value for LR_o under H_o . The null of no threshold effect is rejected if the p-value is smaller than the desired critical value.

Asymptotic distribution and construction of the confidence interval

To construct confidence interval for the threshold level we will use the concept of "no-rejection region" using the likelihood ration statistic. In the case of threshold effect ($\gamma_1 \neq \gamma_2$) our estimated threshold (π^*) is consistent with "true value of π" (π_o) and its distribution is highly non-standard.

Hence, to test the hypothesis that $\pi = \pi_o$, we should calculate the likelihood ratio and compare it with the critical value:

$$LR(\pi) = \frac{S(\pi) - S_1(\pi^*)}{\hat{\delta}^2} \quad \text{(ii)}$$

$$c(\alpha) = -2\log(1 - \sqrt{1-\alpha}) \quad \text{(iii)}$$

where $LR(\pi)$ is a likelihood ratio function of threshold level, $S(\pi)$ is residual sum of squares for given threshold π (where π is from 1-14), $S_1(\pi^*)$ is sum of residuals' squares for threshold π^*, which can be computed in (3.8), $\hat{\delta}^2$ is the variance of the residuals for threshold π^*, $c(\alpha)$ is a critical value, and α is the significance level.

In order to construct a "no-rejection region" we will find the set of π, which satisfies the following inequality:

$$LR(\pi) \leq c(\alpha) \quad \text{(iv)}$$

where $LR(\pi)$ and $c(\alpha)$ are defined in (i) and (iii) correspondingly. The most convenient way to find the "no-rejection region" is by drawing $LR(\pi)$ function and intersect it by line $c(\alpha)$.

Annex 2: Conditional OLS estimation of the threshold level of inflation for Ethiopia*

π	growth	Regression variables γ_1	γ_2	invest	Credit	ddrought	_cons	RSS	R^2
$\pi = 5$	Coefficient	0.218	2.279	0.726	0.283	-9.660	-19.880	1370.35	0.454
	Std. Error	0.532	0.532	0.532	0.532	0.532	0.532		
	t statistics	0.410	0.410	0.410	0.410	0.410	0.410		
	Probability	0.685	0.685	0.685	0.685	0.685	0.685		
$\pi = 6$	Coefficient	0.174	2.786	0.680	0.292	-8.759	-19.490	1326.35	0.471
	Std. Error	0.513	1.253	0.348	0.138	4.188	5.457		
	t statistics	0.340	2.220	1.960	2.110	-2.090	-3.570		
	Probability	0.737	0.034	0.059	0.043	0.045	0.001		
$\pi = 7$	Coefficient	0.122	3.310	0.676	0.280	-8.666	-19.227	1282.18	0.489
	Std. Error	0.502	1.317	0.340	0.135	4.116	5.348		
	t statistics	0.240	2.510	1.990	2.070	-2.110	-3.590		
	Probability	0.809	0.017	0.056	0.047	0.043	0.001		
$\pi = 8$	Coefficient	0.112	3.814	0.680	0.277	-8.742	-19.162	1233.51	0.508
	Std. Error	0.483	1.354	0.332	0.133	4.028	5.238		
	t statistics	0.230	2.820	2.050	2.090	-2.170	-3.660		
	Probability	0.819	0.008	0.049	0.045	0.038	0.001		
$\pi = 9$	Coefficient	0.085	4.362	0.674	0.254	-8.616	-18.457	1190.54	0.525
	Std. Error	0.475	1.423	0.326	0.130	3.959	5.133		
	t statistics	0.180	3.070	2.070	1.950	-2.180	-3.600		
	Probability	0.859	0.004	0.047	0.061	0.037	0.001		
$\pi = 10$	Coefficient	0.088	4.626	0.677	0.254	-8.640	-18.478	1192.37	0.525
	Std. Error	0.481	1.521	0.326	0.131	3.962	5.132		
	t statistics	0.180	3.040	2.080	1.940	-2.180	-3.600		
	Probability	0.857	0.005	0.046	0.061	0.037	0.001		
$\pi = 11$	Coefficient	0.343	3.986	0.783	0.247	-9.197	-19.189	1295.54	0.484
	Std. Error	0.480	1.673	0.337	0.136	4.117	5.367		
	t statistics	0.710	2.380	2.330	1.810	-2.230	-3.580		
	Probability	0.480	0.024	0.027	0.080	0.033	0.001		
$\pi = 12$	Coefficient	0.343	4.196	0.782	0.247	-9.207	-19.151	1295.74	0.484
	Std. Error	0.486	1.770	0.337	0.136	4.117	5.366		
	t statistics	0.710	2.370	2.320	1.810	-2.240	-3.570		
	Probability	0.485	0.024	0.027	0.080	0.033	0.001		
$\pi = 13$	Coefficient	0.500	3.593	0.799	0.249	-9.430	-18.877	1368.31	0.455
	Std. Error	0.490	1.973	0.346	0.140	4.227	5.515		
	t statistics	1.020	1.820	2.310	1.770	-2.230	-3.420		
	Probability	0.316	0.078	0.028	0.086	0.033	0.002		

*Significance levels of each variable can be read from the t statistics and probabilities in the table.

Annex 3. 2SLS-IV estimation of the threshold level of inflation for Ethiopia*

		Regression variables							
π	*growth*	γ_1	γ_2	*invest*	*Credit*	*ddrought*	*_cons*	RSS	R^2
$\pi = 5$	*Coefficient*	0.345	*2.385*	0.690	0.350	-9.337	-21.375	1302.99	0.393
	Std. Error	0.538	1.178	0.349	0.150	4.199	5.672		
	t statistics	0.640	2.020	1.980	2.340	-2.220	-3.770		
	Probability	0.526	0.052	0.057	0.026	0.034	0.001		
$\pi = 6$	*Coefficient*	0.297	2.920	0.642	0.361	-8.433	-20.988	1260.62	0.412
	Std. Error	0.517	1.247	0.346	0.147	4.159	5.539		
	t statistics	0.570	2.340	1.860	2.450	-2.030	-3.790		
	Probability	0.570	0.026	0.073	0.021	0.052	0.001		
$\pi = 7$	*Coefficient*	0.250	3.400	0.641	0.345	-8.373	-20.620	1222.52	0.430
	Std. Error	0.510	1.309	0.339	0.145	4.093	5.432		
	t statistics	0.490	2.600	1.890	2.380	-2.050	-3.800		
	Probability	0.628	0.014	0.068	0.024	0.050	0.001		
$\pi = 8$	*Coefficient*	0.238	3.892	0.645	0.341	-8.460	-20.500	1176.56	0.452
	Std. Error	0.491	1.345	0.331	0.142	4.006	5.317		
	t statistics	0.480	2.890	1.950	2.400	-2.110	-3.860		
	Probability	0.632	0.007	0.061	0.023	0.043	0.001		
$\pi = 9$	*Coefficient*	0.211	4.379	0.643	0.313	-8.375	-19.674	1142.680	0.467
	Std. Error	0.486	1.417	0.326	0.140	3.949	5.226		
	t statistics	0.430	3.090	1.980	2.230	-2.120	-3.760		
	Probability	0.668	0.004	0.057	0.033	0.042	0.001		
$\pi = 10$	*Coefficient*	0.213	4.639	0.646	0.312	-8.401	-19.673	1144.79	0.466
	Std. Error	0.492	1.515	0.326	0.140	3.952	5.222		
	t statistics	0.430	3.060	1.980	2.230	-2.130	-3.770		
	Probability	0.668	0.005	0.056	0.034	0.042	0.001		
$\pi = 11$	*Coefficient*	0.468	3.989	0.748	0.307	-8.946	-20.364	1246.11	0.419
	Std. Error	0.492	1.668	0.337	0.147	4.110	5.458		
	t statistics	0.950	2.390	2.220	2.090	-2.180	-3.730		
	Probability	0.349	0.023	0.034	0.045	0.038	0.001		
$\pi = 12$	*Coefficient*	0.468	4.196	0.747	0.307	-8.959	-20.306	1246.69	0.419
	Std. Error	0.498	1.765	0.337	0.147	4.111	5.455		
	t statistics	0.940	2.380	2.210	2.090	-2.180	-3.720		
	Probability	0.355	0.024	0.035	0.045	0.037	0.001		
$\pi = 13$	*Coefficient*	0.626	3.576	0.761	0.311	-9.177	-20.035	1317.56	0.386
	Std. Error	0.503	1.968	0.347	0.151	4.223	5.605		
	t statistics	1.240	1.820	2.190	2.050	-2.170	-3.570		
	Probability	0.223	0.079	0.036	0.049	0.038	0.001		

***Significance levels of each variable can be read from the t statistics and probabilities in the table.**