ESTIMATING THE THRESHOLD LEVEL OF INFLATION FOR ETHIOPIA

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ABSTRACT

This paper tries to investigate the existence of a threshold level of inflation in Ethiopia using intuitive analysis and an ad hoc threshold regression model. It mainly examines the presence of non-linear relationship between inflation and economic growth for the period 1982/83 through 2010/11. While the literature widely agrees on the of existence non-linear impacts of inflation on economic growth, our paper finds no evidence the existence of non-linear effect of inflation on economic growth in Ethiopia. This means that there is no evidence of the existence of a "threshold" level of inflation during the sample period. Instead, this paper finds the existence of a significant break when the inflation level equals to 10%. Our findings also portray that the negative impact of inflation on economic growth significantly reduces at elevated levels of inflation relative to very low levels.

Keywords: Economic Growth; Inflation; Ethiopian Economy; Threshold Inflation

JEL Classification: E31; E61; E63; C24

1. INTRODUCTION

Policy makers and central bankers are concerned about predicting the nature of inflationary process in an economy. This necessitates identification of the association between inflation and economic growth. Moreover, since price stability is a key factor in macroeconomic stability, growth objectives should account for the nature of inflation in a given country, and these objectives are mostly met through various policy options. However, unless critically addressed, the policy options used may prove to be inflationary and engulf the stimuli to economic growth.

Yet economic theories pose a variety of conclusions on the level of inflation that is detrimental to economic growth. Empirical studies provide various predictions regarding the association between inflation and economic growth. Hence, a logical inference from these theoretical and

empirical arguments is that the nature of the relationship of the two variables matters more than the existence of a systematic nexus between inflation and growth.

In recent years, Ethiopia has recorded a remarkable growth and has become one of the fastest growing countries in the World, but growth has been mostly inflationary. The inflationary pressure mainly comes from an increase in food prices. The global food price crisis in 2008 has left a notable mark in the Ethiopian inflation history. Annual food price inflation surpassed 90% in July 2008[1]. Nevertheless, there is no sound explanation on why this happened in a country that doesn't rely much on imported food. An increase in global food price increases must rather have had very minimal effects in Ethiopia because of the limited size of food imports, which amounts only to about 5% of agricultural GDP (Durevall et al., 2013). Oddly enough, this high inflation was also aligned with periods of better harvest, unlike past trends when there was a high association between high food prices and agricultural supply shocks mainly due to drought.

In a multitude of ways, it is easy to portray that macroeconomic policy in Ethiopia has often had loose ends on the side of price stability in recent years and the policy making has not given much focus on inflation as much as it should. Though the economy performed very well since 1997, inflationary growth has also been tremendous that consumers were not able to reap growth benefits in real terms. In most LDCs including Ethiopia where economic calculations are overwhelmed by political and ethnic debates, the answers to the policy questions mostly remains unanswered or are only pervasively answered.

Most economists would agree that inflation has distortional effects on long-term economic growth, if it is too high. Yet how high is too high? If high inflation is hostile for economic growth and low inflation is not, then it becomes natural to ask the point of twist. The central research questions for this study would be: Does there exist a threshold level of inflation for Ethiopia? If there exists, what is the threshold optimal level of inflation at which the relationship between economic growth and inflation becomes positive? If there exists more than one threshold inflation level, what would be the most optimal among them?

Studying the nature of this linkage, including the existence of a "threshold" for inflation will therefore enable us to find a way of making inflation more predictable and less inimical to economic growth. The "threshold" level is an optimal point where the effect of inflation on economic growth is expected to change sign. Even if quantifying such optimal rate of inflation has received tremendous importance among policy makers in many countries, standard macroeconomic models do not address this problem as much as they should. But many researchers including Sarel (1996), Kahn and Senhadji (2001), Mubarik (2005) and Espinoza et

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[1] IMF Country Report No. 09/296, September 2009 page 4

al (2010) have succeeded in modifying the standard economic models for estimating the "optimal" or "threshold" level of inflation. Generally, before taking any fiscal or monetary policy measures, predicting the existence and association between inflation and economic growth entails a great deal of importance and Ethiopia bears no exception to this.

The rationale for this research rests on the ongoing debate between the public, the media, and political contenders on one hand and the government on the other hand. The public generally agrees on the importance of the culmination of soaring inflations in the country. On the other hand, the government while admitting that the level of inflation has become so severe yet attributes it to be a natural outcome of the growth process. In effect, the government tends to take policy measures, which are mostly uninformed and ineffective. But what level of inflation is least detrimental to economic growth has not been yet made clear. Theoretically speaking, this level corresponds to the threshold level and this study tries to reveal this "threshold" level, if it exists, and tries to provide an empirical benchmark. With inflation being undesirably high in the country, policy makers need to be informed about the target level of inflation that is optimal for economic growth. This calls for proper measures, policies and interventions drawn from careful estimation of optimality conditions including optimal threshold level of inflation which this research tries to find out.

There are two reasons that necessitate this study. First, previous studies of inflation in Ethiopia focused mainly on the determinants, causes and consequences of inflation particularly in relation to budget deficit, money supply, prices and GDP rather than explicitly trying to find the optimal level of inflation. Thus, not much has been done on estimating the optimal threshold inflation level at a macroeconomic context. A noteworthy contribution done in the topic is by Duravell et al (2013) but it focuses mainly on the relationship between growth and inflation dynamics in food inflation. Other papers focus on the sources of inflation (Shiferaw, 2008), the determinants of inflation (Menji, 2008); and inflation volatility (Shiferaw, 2012). Moreover, Tadesse and Guttormsen (2011) using a rational expectations model and threshold regression, present evidence of speculative storage during periods of high prices over 1996–2006. However, given the data and the relationship between inflation and growth it appears much more important to determine an optimal level of inflation.

Secondly, panel studies might be less applicable in policy formulations of individual countries. Here the goal is not to get a ballpark image but rather to get a more specific and actionable policy information. Clustering countries together (as LDC, DC, IC), particularly in this case, would take away country specific details that can help shape a country specific policy. Moreover, since inflationary process is erratic by its nature and thus requiring unceasing follow up, panel studies might fail to indicate an optimal policy. The identification of country-specific inflation

thresholds in the inflation-growth nexus might provide information about the appropriate level of the target inflation. Hence, a thorough, country-specific study is vital, and in our case one that is tailored to Ethiopian settings is needed.

In general, there may be one, two or no threshold inflation levels for each country. Some studies found one threshold inflation level like: Bhusal and Tilpakar (2012) found 6% for Nepal, Ahmed and Mortaza (2005) found 6% for Bangladesh, Frimpong and Oteng-Abayie (2010) found 11% for Ghana. Iqbal and Nawaz (2009) found two threshold levels for Pakistan i.e. 6% and 11%. It is also possible that they find no threshold level of inflation at all. Kheir-El-Din and Abou-Ali (2008) didn't find any threshold level of inflation for Egypt. Since the institutional structure of an economy adapts to ongoing inflation, the real effects (and costs) of inflation can be expected to vary, not only among different economies, but also in the same economy at different periods (Fisher and Modigliani, 1978).

Therefore, this study tries to determine the optimal level of inflation for Ethiopia after taking in to account the methodological differences of the previous papers. One shortcoming of this study is the lack of diversified views on the estimation and most of the past empirical work depends highly on two previously mentioned IMF working papers. Lastly, the paper may be useful for inspiring further research on related topics in Ethiopia.

2. LITERATURE REVIEW

Economic theory reaches a variety of conclusions about, whether inflation is necessary or inimical to economic growth. Mundell (1965) and Tobin (1965) argue that some level of inflation is necessary for economic growth. They claim that an increase in the rate of inflation increases capital accumulation by shifting portfolio from money to capital.

According to Fisher and Modigliani (1978) the effects of inflation can vary enormously dependent on the institutional structure of the economy and the extent to which inflation is or is not fully anticipated. This also explains why there is growing concern among policy makers in predicting the nature of an inflationary process. This can only be done by identifying the association between inflation and economic growth and why sustained economic growth and low inflation rate are the two core objectives of any macroeconomic policy.

Fischer and Modigliani (1978) also mention that inflation might not reduce the level of investment but, it reduces the efficiency of investment and hence, hindering economic growth. Fischer (1993) later identifies the channel through which inflation affects economic growth: inflation reduces growth by reducing investment and productivity growth; budget deficits also reduce both capital accumulation and productivity growth. He also stresses that medium and high

inflations are stumbling blocks to economic growth through their adverse impact on efficient distribution of resources by changing the relative prices.

Recent empirical literature on the inflation growth nexus focuses mostly on the non-linear relationship. Even if quantifying such optimal rate of inflation has received importance for policy makers in many countries, standard macroeconomic models do not directly address this problem. But many researchers including Sarel (1996) Kahn and Senhadji (2001), Mubarik (2005), recently Espinoza et al.(2010) and others have succeeded in modifying the customary macroeconomic growth models is a way they could be fitted for estimating the optimal or threshold levels of inflation.

Most papers that attempt to predict the optimal inflation rate depend on the works of Khan and Senhadji (2001) and Sarel (1996). Other relatively different approaches include Espinoza et al. (2010) who applied a logistic regression to find an optimal threshold. Sarel (1996) uses OLS and tries to find the threshold level by plugging different optimal levels of inflation to the equation. The approach generally involves comparing together all of the estimated equations alongside each other and choosing the one with the highest R^2. Similarly, Khan and Senhadji (2001) use conditional least squares. Unlike Sarel (1996), Khan and Senhadji (2001) argue that inflation threshold is unknown, and thus it should rather be estimated along with other regression parameters. For this purpose, they use the conditional least squares method for estimation of the threshold inflation. This method estimates the model for any threshold by OLS, and selects the lowest Residual Sum of Squares (RSS) or Root Mean Squared Errors (RMSE). The slope parameters are then estimated for this value of the parameter by OLS.

Some researchers also attempt to determine the optimal inflation in individual countries (Bhusal and Tilpakar (2012) on Nepal, Ahmed and Mortaza (2005) on Bangladesh, Frimpong and Oteng-Abayie (2010) on Ghana and Iqbal and Nawaz (2009) on Pakistan, etc…). Others like Sarel (1995), Khan and Senhadji (2001) and Kremer et al. (2013) are more interested in a panel of countries. Kremer et al. (2013) estimate the threshold level of inflation for a panel of 124 countries. He finds that the inflation threshold level is fairly low (2.5%) for the industrialized countries and high (17.2%) for the non-industrialized countries. Their paper draws on Khan and Senhadji (2001) who found the threshold rate of inflation to be fairly low (1-3%) for developed countries and 7-11% for developing countries including Ethiopia. Sarel (1996) also found a threshold inflation of 8% using a joint panel database combining annual data from 87 countries.

Attempts to understand inflation have been greatly aided by the insight that anticipated inflation will have very different effects from unanticipated inflation (Parkin, 1976). But, such distinctions are only analytical since that has no immediate or direct correspondence with actual historical

inflation (Ibid, 1976). But as Billi and Khan (2008) assert that either type of inflations is costly unless managed effectively. There is wide spread unanimity among the public economists and policy makers that inflation is bad for the economy. In this regard, Billi and Khan (2008) demonstrate how Central Banks first choose to fight inflation before attempting it to keep it low and why policy maker have not typically targeted for zero inflation. In effect, they often tend to aim for low but positive inflation rates.

Several theories argue that inflation can either promote or harm economic growth depending on its level but the standard macroeconomic models do not accord well with the existence of such non-linear relationship between inflation and growth (Khan, 2008). However, recent studies modified the standard models and provided some interesting insight about this relationship (Khan, Ibid). According to Lucas (1973), inflation is quite important for economic growth if it is low enough to allow overcome rigidity of wages and prices, while Pyopko (2009) on the other hand, states that high inflation discourages long-term investments and distorts a tax system due to *shoe leather* and *menu costs*.

In general, there are theoretical arguments for a positive inflation-growth relationship for low level of inflation and a negative for high levels. Consequently, the inflation-growth associations tend to be non-linear and there exists some inflection point which changes impact of inflation from favorable to adverse which is the purpose of this research too.

3. DATA AND METHOD OF ANALYSIS

The study will be based on an annual time-series data set from the World Bank data base for the years 1982/83-2010/11 which uses 30 observations. Though we can obtain the same time series data from local sources like Ministry of Finance and Economic Development (MoFED) and National Bank of Ethiopia (NBE), some figures are not consistent with the data from IMF and WB. Thus for the sake of data consistency this study will entirely rely on World Bank, where data are currently better available for a reasonable number of observations. Our estimation will be aided by a visual plot of the residual sum of squares (RSS), the Root Mean Squared Error (RMSE) and the coefficient of determination (R^2) against time. This is mainly used to do the final identification of the optimal threshold level.

To estimate the threshold inflation for Ethiopia, the paper applies a time-series growth-inflation econometric model (threshold regression model) based on annual data by including various relevant variables. In order to locate the threshold level of inflation, we allow for one break at each step by varying optimal inflation rate starting from a low level to a high level. Causality issues will be dealt with standard statistical tests like Granger Causality during the analysis.

This research adopts the methodology proposed by Sarel (1996) and Khan and Senhadji (2001). Accordingly, the log-linear (log-log) form of the model following Sarel (1996) becomes:

$$Growth_t = \beta_0 + \beta_1 inf_t + \beta_2 D_t * (inf_t - \kappa) + \beta_3 inv_t + \beta_4 pop_t + \beta_5 fin + \varepsilon_t \ldots\ldots (1)$$

The dummy variables are expressed as:

$$D_t = \{1\}: \text{if } inf_t > \kappa \text{ and } = \{0\}: inf_t \leq \kappa$$

Table 3.2: Definition of Variables

Variables	Definition
κ	Optimal level of inflation
N	Population in millions
GCF	Gross Capital Formation
F	M2 as % of real GDP
Y	Real GDP
$Growth_t$	Growth rate of real GDP
inf_t	Inflation rate
inv_t	Growth rate of gross capital formation
pop_t	Population growth rate
fin_t	Growth rate of M2 as a % of real GDP
ε_t	Stochastic error term

The values of **κ** are given arbitrarily, aided by the graphical analysis, for estimation purpose such that κ =5%, 6%, 7%...17% and within this bound of κ equation (1) is estimated using STATA software package.

Iteration-Optimization Criterion

Following the extant literatures discussed in section two, we hypothesized that high inflation has an adverse effect on economic growth in Ethiopia after it exceeds a certain limit. Given the fact that our estimation is optimization in its nature, the optimal value of $\kappa(\kappa^*)$ can be obtained with the following two optimization conditions, if it exists.

1. Sufficient condition: optimizing the coefficient of determination: the point at which R^2 is the maximum

2. Necessary condition: optimizing the Root Mean Squared Error: the point at which the RMSE or the Residual sum of Squares (RSS), as of Khan & Senhadji (2001), is the minimum.

We set out these two iteration-optimization criteria in order not to rely on the first condition in which case R^2 can simply be too high due to spurious regression. Based on the two conditions we compare and contrast the values of RMSE or RSS of the respective regressions for each arbitrary value of **κ**.

In order to locate the threshold level of inflation one break is allowed by varying inflation rate from a low level to high level. Lastly standard statistical tools are used to identify the threshold of inflation and diagnostic tests to check the reliability of the regression estimates.

4. RESULTS AND ANALYSIS

A. The Trends in the Relationship between Inflation and Growth

The empirical and theoretical literatures discussed in section two suggest a two-fold relationship between inflation and economic growth. Figure 4.1 below illustrates the nature of relationship between inflation and real GDP growth rate in Ethiopia for the period 1982/83 to 2010/11.

**Figure 4.1: Real GDP growth rate and Inflation rates in Ethiopia**
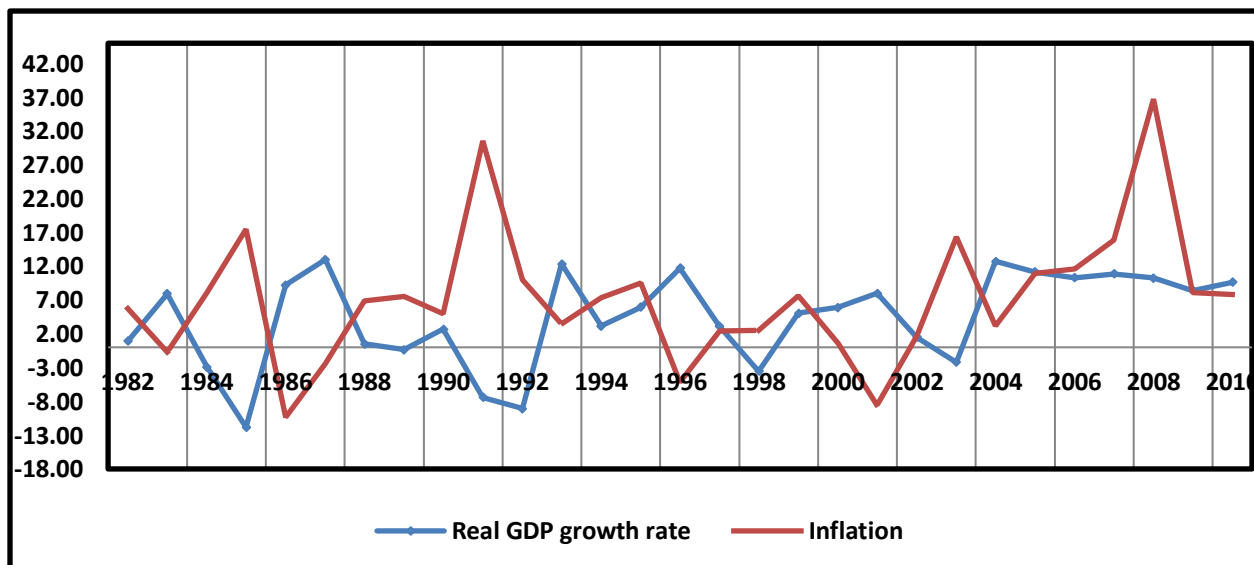
Source: Data from World Development Indicators

The first part of the above figure shows that high levels of growth during the period are matched with low inflation rates and low levels of growth with relative stable prices. The later part of the graph (mainly after the year 2004) doesn't indicate this association. Though real GDP growth rate varies across different inflation regimes, in this case the relationship between the two variables is found to be varying within the same regime of inflation too. Therefore, at this stage it is not clear whether low economic growth is associated with high or low levels of inflation or not.

For a better insight to the problem, we considered, figure 4.2 below which illustrates this scenario in a case in which the business cycle effects are somehow reduced in the relationship between the two variables.

**Figure 4.2: Five-year average real GDP and inflation**
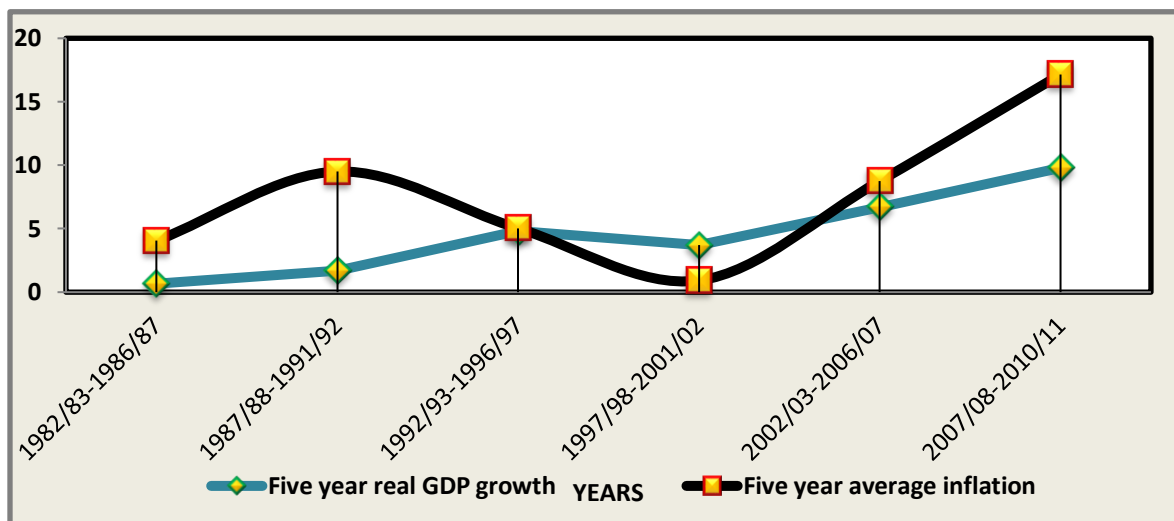
Just like figure 4.1, the illustrations based on figure 4.2 also somehow confirm the existence of a negative relationship between inflation and economic growth in Ethiopia, i.e. when inflation gets momentum, real GDP either decreases, or increases at a decreasing rate. Therefore, based on our observation period, it can be concluded that in Ethiopia, there was a room for rampant inflation to disrupt economic growth.

However, the above two analyses, does not clearly predict whether there exists a non-linear relationship between the two variables or not. For a better solution, thus, we resorted to understanding the historical nature of the relationship between inflation and economic growth. Figure 4.3 illustrates this kind of relationship between the two variables in which a range of inflation is selected on the basis of the maximum and the minimum levels of inflation from the

whole sample. We took 0% to be the minimum, and all the values above 17% are assigned to be high inflations.

Figure 4.3: Average real GDP growth rate and inflation
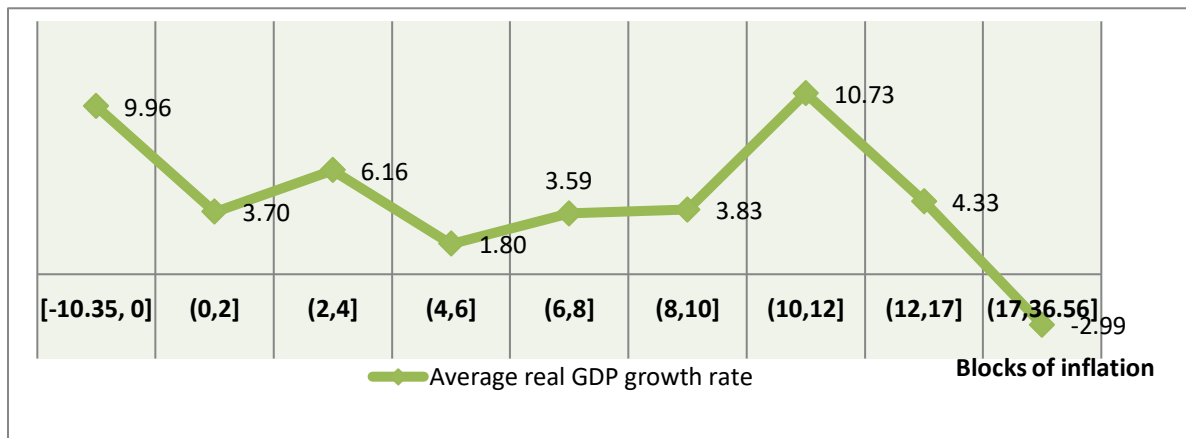
Source: Data from world development indicators

The analysis based on the above figure renders three important implications: first it illustrates that there exists a non-linear relationship, between inflation and economic growth in Ethiopia. The second and the most important implication is that, the figure illustrates that the threshold is roughly between 10 and 12% percent of inflation that may begin to affect economic growth in Ethiopia.

Lastly, the range of arbitrary values of threshold inflation (κ) are identified ex-ante from the above figure; ex post this helped us to ease the formal estimation procedure by reducing the number of arbitrary values of κ to be considered. However, the more formal procedure is to empirically test whether the change in sign is true or not as discussed in the next section. The above graphical analysis was only for an intuition of the threshold point.

B. Tests, Model Estimation and Interpretation of Results

1. Unit root and Co-integration Tests

In this study we used the DF/ADF unit root test in order to determine order of integration. The unit root tests revealed that all variables used in this study are I(1), that is they are stationary after the first difference, which is an indication that our analysis of co-integration analysis doesn't suffer from mixed order of integration. In table 4.5 results of the unit root tests on all variables have been reported, and the tests are conducted using STATA.

Table 4.3: Tests for non-stationarity of variables: DF/ADF unit root test results

Variables	DF		ADF		Order of integration
	With constant	**With trend**	**With constant**	**With trend**	
Lgdp	-0.686	-0.686	0.050	-0.519	I(1)
Lcpi	-1.628	-1.628	1.002	-1.035	I(1)
Linv	-1.735	-1.735	-0.197	-1.826	I(1)
Lpop	-0.904	-0.904	-1.891	-0.450	I(1)
Lfin	-1.060	-1.060	-1.556	1.713	I(1)
Dlgdp	-3.773	-3.773	-4.060	-4.756	I(0)*
Dlcpi	-2.822	-2.822	-4.248	-4.416	I(0)*
Dlinv	-2.992	-2.992	-6.425	-6.612	I(0)*
Dlpop	-3.201	-3.201	-4.626	-5.147	I(0)*
Dlfin	-1.871	-1.871	-3.085	-4.019	I(0)**
Critical values **1%**	-3.723		-3.730	-4.343	
5%	-2.989		-2.992	-3.584	

NB: 1. [*] and [**] means significant at 1 percent and 5 percent levels respectively.
2. Both tests have been performed on the basis of 5- percent level using STATA software package.

Since ADF tests are a bit preferable to DF, in case the error term is correlated, it can be concluded based on ADF that, all the variables are stationary at their first difference.

2. Co-integration Analysis

To ensure that inflation and real GDP growth rate are not co-integrated, Engle-Granger co-integration test is used. Subjecting logarithms of real GDP and CPI to unit root analysis we found that they are both I(1); that is they contain a unit root. In doing so, we generated random error term from the real GDP model by regressing logarithm of real GDP on logarithm of inflation (long run model) and a time variable.

Table 4.4: Engle-Granger unit-root test

Test	Test statistic	Critical values		
H$_0$: "e" has a Unit root	-1.573	1%	5%	10%
		-3.723	-2.989	-2.625

P-value = 0.4972

Accordingly, we accepted the null hypothesis of no co-integration, suggesting that the linear combination of these two variables, i.e. the error term, is not I(0). This indicates the relationship between logarithms of CPI and real GDP is not approaching equilibrium in the long run.

3. Estimation

In the final estimation, the growth rate for each variable was computed using their difference logarithmic transformation for a range of arbitrary values κ (from $\kappa =5\%$ to $\kappa=17\%$) using Sarel (1996) methodology. The range of arbitrary values is chosen based on the prediction in the graphical analysis. The following table summarizes the outputs of the iterated OLS regression for each arbitrary value of (κ) and depicts the sequences of R^2's and RMSE's as a function of the corresponding arbitrary threshold values for Ethiopia over the period- 1982/83 to 2010/11.

Table 4.5: Estimation of OLS coefficients of the non-linear regression model at κ=7 to κ=15 Percent [the dependent variable is real GDP growth] and H₀: β₂ =0

Variables	Parameter	κ=5%	κ=6%	κ=7%	κ=8%	κ=9%	κ=10%	κ=11%	κ=12%	κ=13%	κ=14%	κ=15%	κ=16%	κ=17%
	β_0	7.576	7.742	7.697	7.726	7.470	**7.606**	7.661	7.611	7.614	7.617	7.620	9.165	9.238
inf_t	β_1	-0.569 (0.060)	-0.518 (0.071)	-0.528 (0.053)	-0.438 (0.063)	-0.546 (0.013)	**-0.550 (0.008)***	-0.453 (0.025)	-0.391 (0.045)	-0.391 (0.044)	-0.392 (0.044)	-0.392 (0.044)	-0.385 (0.052)	-0.384 (0.038)
$D_t^*(inf_t - \kappa)$	β_2	0.407 (0.242)	0.339 (0.297)	**0.356 (0.247)**	0.244 (0.345)	0.397 (0.097)	**0.403 (0.065)****	0.275 (0.199)	0.198 (0.344)	0.199 (0.343)	0.199 (0.342)	0.200 (0.341)	0.186 (0.380)	0.196 (0.324)
inv_t	β_3	0.119 (0.053)	0.116 (0.061)	0.118 (0.056)	0.119 (0.056)	0.132 (0.031)	**0.123 (0.039)*****	0.121 (0.049)	0.124 (0.049)	0.124 (0.049)	0.124 (0.04)	0.124 (0.09)	0.123 (0.051)	0.121 (0.053)
pop_t	β_4	-0.681 (0.574)	-0.696 (0.568)	-0.670 (0.581)	-0.634 (0.606)	-0.499 (0.673)	**-0.461 (0.692)**	-0.516 (0.670)	-0.537 (0.664)	-0.538 (0.663)	-0.539 (0.663)	-0.539 (0.662)	-1.067 (0.413)	-1.074 (0.404)
M2 as % of GDP	β_5	-0.330 (0.002)	-0.327 (0.002)	-0.325 (0.002)	-0.326 (0.002)	-0.335 (0.001)	**-0.334 (0.001)***	-0.335 (0.001)	-0.333 (0.002)	-0.333 (0.002)	-0.333 (0.002)	-0.333 (0.002)	-0.330 (0.002)	-0.327 (0.002)
Root MSE		4.9306	4.9612	4.9337	4.9831	4.7815	**4.7116**	4.8998	4.9828	4.9823	4.9818	4.9813	4.9964	4.9739
R^2		0.5766	0.5714	0.5761	0.5676	0.6018	**0.6134**	0.5819	0.5676	0.5677	0.5678	0.5679	0.5653	0.5692
Durbin –Watson		2.0630	2.0763	2.0452	2.1079	2.0612	**2.0174**	2.0025	2.0052	2.0047	2.0042	2.0036	2.0217	1.9696
H₀: β₁ +β₂=0 (prob> F)		-0.162 (0.125)	-0.179 (0.151)	-0.172 (0.118)	-0.194 (0.152)	-0.149 (0.032)	**-0.147 (0.019)******	-0.178 (0.066)	-0.192 (0.122)	-0.192 (0.122)	-0.193 (0.121)	-0.192 (0.121)	-0.199 (0.114)	-0.188 (0.106)

Source: STATA output

*, ** and *** indicates significant at 1, 5 and 10 percent level respectively; the p- values are given in brackets.

$$Growth_t = 7.6059 - 0.5502 INF_t + 0.4032^* D_t(INF_t - 10) + 0.1232 INV_t - 0.4615 POP_t - 0.3343 M2_t$$

$$\kappa_{MIN} = 10 \qquad \widehat{\beta}_1 = -0.5502 \qquad \widehat{\beta}_1 + \widehat{\beta}_2 = -0.1470 \qquad R^2_{MAX} = 0.6134 \qquad RMSE_{MIN} = 4.7116$$

4. Optimization Criterion

Using Sarel's (1996) approach, the empirical counterpart of equation (1) reveals the threshold value of inflation in Ethiopia and also depicts the nature of that value. Accordingly, at $\kappa = 10$ both of the necessary and the sufficient conditions of the optimization model are met. At this point a maximum value of the coefficient of determination ($R^2 = 0.6134$) and a minimum value of the Root Mean Squared Error (RMSE = 4.7116) is obtained over the arbitrary values of inflation ranging from $\kappa \leq 5\%$ and $\kappa \geq 17\%$.

Figure 4.4a: Arbitrary values of k and the sequence of coefficients of determination
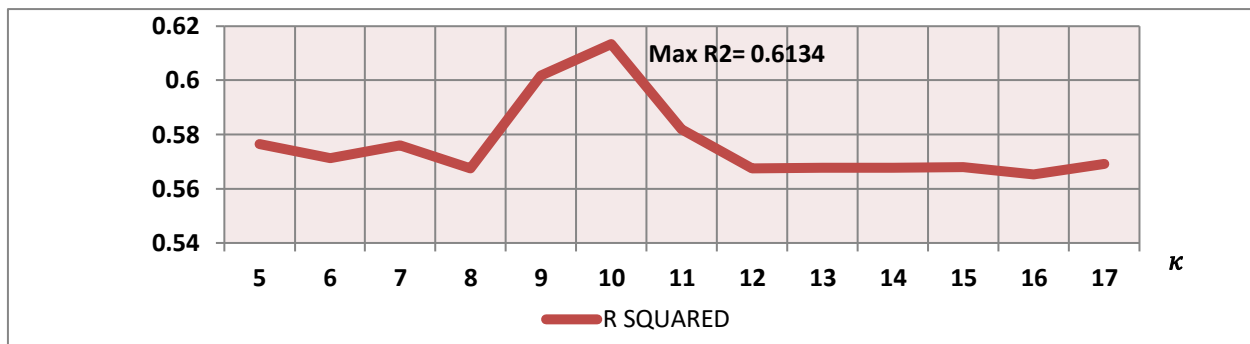
Figure 4.4b: Arbitrary values of k and the sequence of Root Mean Squared Errors
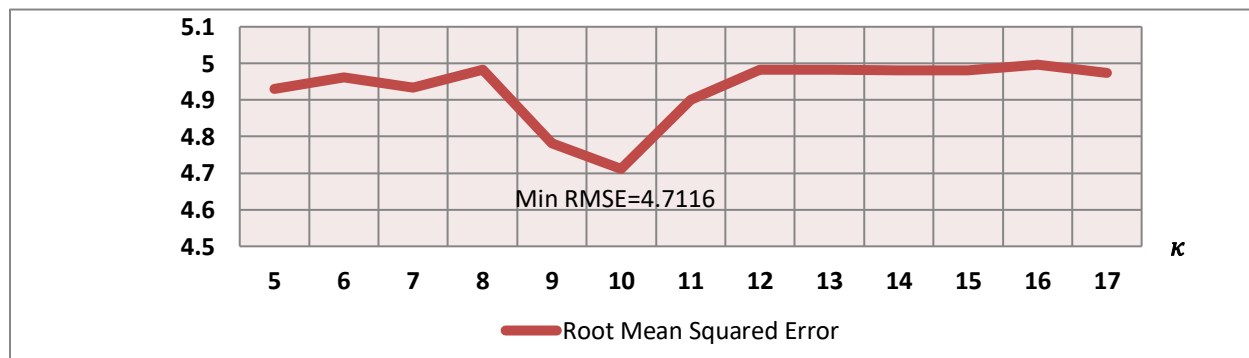
Figures "a" and "b" above, plot the sequence of Root Mean Squared Errors and the coefficients of determination as a function of arbitrary threshold levels of inflation. The two figures are *symmetric,* in a sense one is the mirror image of the other, suggesting the consistency in our selection of the arbitrary values. Compared to all other levels, at $\kappa = 10$, our regression line approximates the real data well as shown by the highest R^2. Among all regression the minimum

variance, i.e. minimum RMSE is observed at $\kappa = 10$ too. The sufficient condition of minimum RMSE is met at $\kappa = 10\%$.

5. Growth at High and Low Levels of Inflation

The above empirical results suggest that in Ethiopia at all levels economic growth is negatively related to inflation, but it appears better at high level of inflation! At $\kappa =10\%$ level of inflation, $\hat{\beta}_1$ is negative and statistically significant as shown by the p-value of (0.051). The threshold parameter $\hat{\beta}_2$ is statistically significant too, but with positive sign, implying the existence of significant break in the effects of inflation on economic growth. Furthermore, as depicted in table 4.7 we reject the null hypothesis that, the parameters $\hat{\beta}_1 \, and \, \hat{\beta}_2$ are jointly equal to zero at 5% level of significance.

Table 4.6: Tests of parameters for threshold effects at k=10

Equation	Coefficients	Tests	Test statistic	Prob>F	Decision
$\kappa =10\%$	$\hat{\beta}_1 = -0.55$ $\hat{\beta}_2 = 0.403$	H_0: $\hat{\beta}_1 = \hat{\beta}_2$=0 (Jointly equal to zero)	4.56	0.0215	**Reject** (the two betas are not equal)
		H_0: - $\hat{\beta}_1 + \hat{\beta}_2$=0 (The sum is equal to zero)	6.39	0.0188	**Reject** (the sum of the two betas is not equal)
		H_0: $\hat{\beta}_2 = 0$ (There is no structural break)	0.4032	0.065	**Reject** (There is a structural break)

When inflation is doubled $(\hat{\beta}_1 + \hat{\beta}_2 = -0.15)$ the sign appears negative and statistically significant, suggesting the effect of high inflation. At low levels, i.e. $(\hat{\beta}_1 = -0.55)$, a rise in inflation depresses economic growth by 0.55%, and approximately by 0.15% at high levels. The implication is that, in Ethiopia, inflation is harmful to economic growth both at very low and high level of inflation, but with different intensity.

This finding is in line with that of, Sarel (1996), Khan and Senhadji (2001) Mubarik (2005) and others regarding the magnitude of the threshold value ($\kappa =10\%$). Their empirical findings mostly suggested between 7 and 11% levels of inflation threshold for developing countries. The non-linearity assumption also holds for Ethiopia, but with a different context than the aforementioned works. In our case the relationship between the two variables does not change sign rather it changes slope, but this doesn't guarantee the existence of a true threshold of inflation.

Here 10% implies the lowest level of inflation that the current Ethiopian economic could accommodate without hurting the economic growth of the country. That means the economy does not benefit by keeping inflation much lower than 10% and much higher than 10%.

6. Non-Linearity

Even if the inference based on the above two optimization conditions, depict the existence of a break at 10 %, there is no evidence of non-linear relationship between inflation and economic growth in Ethiopia, since the break is that of magnitude rather than of sign. The only difference between the two effects (low and high level of inflation) is that, the severity of inflation decreases as it gets momentum! The break at κ =10% shows a significant difference in the negative impacts of inflation on growth between the two regimes of inflation (i.e. low and high). In accordance with theoretical predictions, if a break exists, then there should be some sort of non-linearity in the nexus between the two variables. Nevertheless, in our finding this non-linearity is weak in a sense it not change sign rather magnitude of the coefficients. In fact, priori, this was observed in the intuitive analysis too, typically by the fact that some of the double-digit levels of inflation were contemporaneous with double digit economic growth too.

The findings are also not offline with theoretical predictions. According to Keynesians theory, if economic growth is above the long run average sustainable growth rate, admittedly like the current trend in Ethiopia, then inflation is likely to occur. According to this theory if growth is driven by rising aggregate demand (AD), then the growth is likely to cause inflation.

This problem has been also stated in some other empirical findings. For instance, Iqbal and Nawaz (2008) have detected a threshold level of 10% for Pakistan below which the marginal impact of additional inflation on economic growth decreases, in which, their policy implication was to keep inflation below 10%. Desta (2011) also stressed that, using Keynesian full employment model, it is possible to assume that economic growth could precipitate inflationary situations if the nation achieves full employment. But theoretically, Ethiopia being a least developed country is not expected to have reached that level. Therefore, it can be asserted that the findings are perhaps a clear sign of unhealthy institutional frameworks within the economy.

The diagnostic tests performed for the optimal inflation equation suggests that our data have met the assumptions underlying the OLS regression, and therefore the results are dependable to some extent.

5. CONCLUSSIONS AND POLICY IMPLICALTIONS

A. Findings and Conclusions

This paper explores the relationship between inflation and economic growth for the period 1982/83-2010/11 both intuitively (graphically) and empirically and investigates the existence of threshold of inflation in Ethiopia. As of the graphical analysis and the intuition based on the historical relationship of inflation and growth illustrates a secular negative impact of inflation after 10%, while suggesting ambiguous nexus for blocks of inflation below 10%.

In the methodological front, the literature provides various methods of empirically identifying the thresholds of inflation for economies. In this paper, we applied the threshold model of Sarel (1996). Empirical results based on this method demonstrate that, in the sample period, there is statistically significant break in the impact of inflation on growth at 10 %. However, this break is found to be only within the negative effect of inflation, suggesting no positive relationship between the two variables. In other words, inflation is found to be harmful to economic growth at both high and low levels of inflation. Therefore, there is no evidence of non-linear relationship between inflation and economic growth in Ethiopia. As a result, based on the sample period and the methodology adopted; there is no "threshold" in Ethiopia in true sense of the term.

Another finding which actually rendered some digression to our finding is that, in Ethiopia as inflation gets high, its marginal effect on growth decreases, and this is perverse, which is perhaps a manifestation of the so called, high inflation-high growth paradox, being an attribute of unhealthy economy. Apparently, this seems not in line with the standard theory because at least low levels of inflation should have been contemporaneous with favorable economic condition.

So, does this mean that high inflation is good for Ethiopia? Resoundingly no; one of our justification stems from the Keynesians theoretical framework that if economic growth is above the long run average sustainable rate, then inflation is likely to occur. Therefore, our finding is not much beyond the theoretical prediction, and the study only suggests the structural break implied by the regression result at k=10% is a temporary (short run) phenomenon, and thus cannot be taken for granted as optimal.

B. Policy Implications

The findings of this paper have important policy implications for domestic policy makers and the public process in general. Above all the result of the study provides the central bank or the government with the evidence of inexistence of "threshold" inflation in Ethiopia in true sense of the term. So, what was the credibility of the inflation policies pursued so far when, in fact, there

exists no inflation level to be to be targeted at? Moreover, there seems no, as such, specific and low level of inflation with which the welfare of the society could be tremendously improved. Our findings portray that the negative impact of inflation on economic growth significantly reduces at elevated levels of inflation relative to very low levels. This indicates that growth is better simply as a result of policy options during inflationary periods. The policy options taken to calm down inflation proved rather ineffective and the cost of living has continued to spike.

Therefore, the focus of the government should be on identifying and mitigating the extraneous factors that obscure the negative association between low inflation and economic growth in Ethiopia. This also explains why monetary policies in Ethiopia fail to achieve desired objectives. This paper suggests that policy makers look in to the institutional underpinnings of the economy since unhealthy economy is the result of unhealthy institutions. Government should strive to fix the structural and institutional dysfunctions existing in the country, particularly in the financial, commodity, property and labor markets which might have hindered the proper functioning of the economy and policies.

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