Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.9, No.1, 2018

Do Prices Influence Economic Growth? Estimating the Inflation Threshold of the Ethiopian Economy

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Abstract
The study empirically examines the relationship between changes in the general price and economic growth in Ethiopia. The relevant macroeconomic variables are used in a quarterly dataset from 1992Q1 to 2015Q4 obtained from the National Bank of Ethiopia (NBE), Central Statistics Agency (CSA) , Ministry of Finance and Economic Corporation (MoFEC) and an international data sources including World penn Table and World Development Indictors (WDI). In assessing the relationship between prices and economic growth, an interesting policy issue arises. What is the threshold level of inflation for the Ethiopian economy? Real GDP growth used as a proxy for economic growth and general prices measured using the consumer price index (CPI), the study uses the Conditional Least Square (CLS) technique employed by Khan and Senhadji (2000). The estimation result suggests that 10% as the optimal level of inflation that facilitates economic growth. An inflation level higher than the estimated threshold level will affect the growth of the real GDP negatively. Likewise, if inflation rate is below the threshold level, it hurts the economy as real GDP could have grown more since inflation is positively related below the threshold point. Therefore, fiscal and monetary policy coordination is vital to keep inflation at its threshold level. This finding is useful for macroeconomic policy makers at the central bank as a guide for inflation targeting monetary policy.
Keywords: Economic Growth, consumer price index, Conditional Least Square

1. Introduction

The impact of inflation on economic growth is one of the most central points of macroeconomic issues that need to be resolved. Though there are numerous studies carried out, the relationship between inflation and economic growth is not well defined. This is mainly due to macro-economic and development conditions of the world, region or country under study. Regardless of this, recently, there exists a high level of consensus among researchers and economists that positive and lower level of inflation is positively related to economic growth while high and unstable level of inflation has negative impact on the growth of an economy. Due to this reason economists and policy makers largely aim for low and stable level of inflation that facilitate rapid rate of economic growth (Bruno and Easterly 1996: 141).

Smal (1998) points out the negative effects of inflation on the well being of individuals in the economy in the form of redistribution costs. The redistribution cost occurs through economic agents such as lenders, borrowers, fixed income earners and government by reducing the purchasing power of money. Economic agents cannot totally stop holding hard cash for transaction purposes and as a saving deposit. As inflation rises, a large amount of money buys fewer goods and services due to the falling purchasing power of money. This reduces the welfare of firms and individuals that hold money.

On the other hand, the well-being of lenders and borrowers is affected through a high inflation rate. Lenders are compensated for the lost purchasing power of their principal loan by the nominal interest rate, where it is determined by the level of the anticipated inflation. If the anticipated inflation is less than the actual inflation, then lenders real return declines causing redistribution of income from lenders to borrowers. If the anticipated inflation is higher than the actual inflation, then the well-being of borrowers declines. In most cases anticipated inflation is different from the actual one and hence nominal interest rate favors either the lender or the borrower (Smal 1998: 35 – 8).

The stable macro-economic history of Ethiopia, especially the single digit inflation (apart from the periods of drought) did not encourage policy makers and researchers to consider inflation as a problem. Due to this reason, the impact of inflation on the growth of the economy and the relationship between the two macro-economic variables is not studied well even though it is thoroughly discussed in the international literatures. This state of affair motivates this study using the quarterly disaggregated data of post socialist government in Ethiopia.

There exists a huge disagreement on the relationship between inflation and growth both on theoretical and empirical basis. The empirical divergence is mainly in the sign and significance of the linear relationship between inflation and growth. Regardless of this divergence, recent research findings agree on the non-linear relationship that positive, low and stable inflation is positively related to growth while high and unstable inflation has depressing effect on the growth of the economy. Still the level of inflation that turns to be discouraging to growth

is indecisive and depends on the development condition of the specific country.

Since inflation has not been considered as a problem in Ethiopia, there was no clear target level of inflation. Nonetheless, from the year 2010 onwards following the five year development plan of the Growth and transformation Plan (GTP), the monetary policy aims to keep inflation at 6%. This is because of the belief that a level of inflation higher than 6% is considered to be destructive to the economy (MoFED 2010: 15 – 16). However, this topic does not seem to be discussed intensively in this regard and hence such a gap inspires this study to provide policy implication regarding the target of inflation that the central bank should focus on.

Hence, the study tries to fill the knowledge gap in two aspects. First it eliminates the problem data mixing among different regimes. Other studies mix the data of the pure communist regime where there was no private investment in the economy with the current market oriented economy. An outcome with such mix of data may lead to wrong conclusion and hence wrong policy implication. This problem is eliminated in this study by just focusing on the period after the post socialist regime. Second, there seems to be conflicting views on the threshold level of inflation not only in global literature but also in Ethiopia. Such observation has also motivated this paper and contributes to the existing literatures.

2. Recent Literatures on Inflation and Growth

The New Classical View

Based on the rational expectations and continuous market clearing approach, the relationship between inflation and economic growth is explained by the inter-temporal substitution approach and the surprise model in the New Classical economics (Lucas 1996: 254 - 55).

According to the inter-temporal substitution approach rational workers supply more labour when real wage increases and they take more leisure when real wage falls. When workers supply more labour, productivity is expected to move up leading to higher economic growth. An increase in nominal wage however, will not have an impact on real economic variables such as employment and growth (Lucas and Rapping 1969: 726 – 33).

The surprise model explains more about the goods market in the economy than the labour market. A rational firm decides to increase its productivity only when price of its product increases. However, the price increase should be in relative terms. If the price increase is in absolute terms, then rational firms do not change their production and will have no real impact in the economy (Lucas 1973: 333 – 4).

For New Classicals, if there is any unexpected increase in wage or price, the increase surprises labour and goods suppliers. Such surprises will have a real impact on the economy in the short-run until economic agents adjust their expectations. Such surprises are usually related to an unannounced increase in money supply that causes the general price increase. If the money supply increase is announced and was expected by economic agents, then it will not have any real effect on the economy (Lucas 1973: 333).

Even if there is an unannounced increase in money supply, output might deviate from its natural rate only for the short-run and in the long-run it will be back to its natural rate when workers realize that the price increase is in absolute terms (Lucas 1996: 262).

Unlike Keynesians, wages and prices are assumed to be fully flexible and if future inflation is anticipated there will be zero sacrifice ratios for reducing inflation. This means if tight monetary policy is announced inflation can be reduced in the short-run with no trade-off. In such a case there will be no short-run effect since the level of inflation is anticipated. Unlike Monetarists, monetary policy is used not to increase aggregate demand but to control inflation. To achieve higher economic growth supply side policies play a more major role than the monetary policy (Lucas 1996: 260 – 2).

The New Keynesians View

Based on the major assumptions of Orthodox Keynesians, prices and wages are rigid for New Keynesians as well. These rigidities play an important role in exaggerating economic shocks that arise from either the demand or the supply side (Blanchard and Gali 2005: 15 – 7). If money supply is tightened then aggregate demand declines leading to lower economic growth and higher unemployment. But prices and wages are assumed to be rigid and thus the level of inflation remains unchanged (Vaona 2011: 95).

The fall in the aggregate demand is the reason for lower productivity by firms and unlike the New Classicals it is not the price that is discouraging production but it is the lack of demand. Firms produce only up to the point where they get demand for their production. If firms exceed this production then there will be no market for the additionally produced goods even at lower price since prices take a long time to adjust (Ball, Mankiw and Romer 1988: 8 – 9).

Furthermore, the New Keynesians claim that even if prices and wages are flexible output still varies due to the uncertainty that exists with prices. During a period of recession, risk avoiding firms prefer to reduce their output rather than dealing with the fluctuation of prices and the associated uncertainties. This implies that high and unstable prices affect productivity negatively (Krause and Lubik 2003: 25).

For New Keynesians high inflation has a negative impact on economic instability and hence growth. To

achieve rapid economic growth and to have fair distribution of income there must be low and stable inflation. For them reducing money supply to reduce inflation leads to recession due to price rigidities. Thus, in order to set monetary policy there has to be prior information about future values of inflation and output. In inflation targeting monetary policies, credibility of the policy is very important and hence the Central Bank's independence plays a crucial role in this case (Ambler 2008: 5 – 9).

Inflation creates costs in the economy. These costs can be seen as costs of anticipated inflation and costs of unanticipated inflation. Costs of anticipated inflation include shoe leather costs, menu costs and costs created by distortions in the non-indexed tax system. Costs of unanticipated inflation include distortions in the distribution of income, distortions in the price mechanism, and losses due to uncertainty. According to New Keynesians, inflation whether anticipated or unanticipated, has an overall negative impact on economic growth (Ambler 2008: 2 – 3).

Inflation and Growth in Ethiopia

Since the main aim of this study is to see the relationship between inflation and growth in Ethiopia, it will be important to see the relationship between these variables in the Ethiopian context. The relationship between the two variables is not studied well in the country as it is studied globally. The reason for this might be the low and stable history of the macro-economic condition of Ethiopia. Studies undertaken so far will be summarized in this section.

Ayalew (2000) studied the trade-off between inflation and unemployment in Ethiopia. The study aims to find out if there is: a trade-off between inflation and unemployment, long-run determinants of inflation in the country and whether the Ethiopian economy affords stabilization. He used quarterly data over the period of 1973(Q2) – 1999(Q4). To show the trade-off between inflation and unemployment, Ayalew has measured unemployment by estimating the potential output and taking the difference from the actual output. In other words, the output gap derived is used as a proxy for unemployment. To estimate the trade-off between unemployment and inflation, inflation is explained as a function of unemployment. The estimation result disclosed that there is no trade-off between the two variables under study. A 100% rise in the rate of unemployment increases inflation by 47%. Thus, the traditional Phillips Curve is not applicable to Ethiopia. To see the long-term determinants of inflation in the country, the explanatory variables that are used are inflation inertia, money supply, world price index, unemployment, drought and war. The estimation result has revealed that structural variables such as unemployment of resources explain inflationary pressures quite well in Ethiopia. Generally, the major finding of this study implies that as the unemployment level declines then inflation falls. This shows that in the Ethiopian context there is a positive relationship between economic growth and inflation assuming that the lower rate of unemployment is accompanied by higher economic growth.

Michael (2008) has examined the basic factors that determine the rate of inflation and has also assessed the long-run and short-run relationships between inflation and economic growth in Ethiopia. The study has tried to estimate the threshold level of inflation for Ethiopia. To execute the study Michael used annual data of relevant variables for the period 1971 – 2006. To see the long-run and short-run relationships between inflation and growth, he employed co-integration and error correction model. The threshold estimation is conducted using the technique developed by Khan and Senhadji (2001). The findings of the study show that money supply is the major factor for the rising inflation and that an increase in GDP has a price reducing effect. From the study it appears that there exist a negative relationship between inflation and economic growth.The co-integration test however confirms that a statistically significant long-run negative relationship exists between inflation and growth in Ethiopia. The estimated threshold level of inflation is 16%. It is therefore recommended that policy makers keep inflation below the 16% threshold level.

Asaminew (2010) has estimated the threshold level of inflation by using annual data from 1970 – 2010. He used the method developed by Khan and Senhadji (2001) and the model includes explanatory variables such as: inflation, investment, access to credit and drought. The finding of the study shows the threshold level of inflation in the case of Ethiopia as 8 – 10%. Assaminew recommends the need for smooth interaction between fiscal and monetary policies to maintain the inflation level close to the threshold. The difference in the threshold findings between the study of Michael (2008) and Asaminew is not methodological (since the methods used in both cases are similar) but it has more to do with model specification and estimation procedure error.

Teshome (2014) assessed the relationship between inflation and growth in Ethiopia. Descriptive analysis of the data from 2004 – 2010 is conducted. In the analysis Teshome has compared the Ethiopian situation with the other Sub-Saharan African (SSA) countries. The author points out that on the average Ethiopia's economic growth and inflation rate are higher than the SSA countries by 4.5% and 9% respectively. After analyzing the nature of the economic growth in the country he concluded that inflation does not affect the economic growth because of the broad based nature of the growth. He then concluded that from 2004 – 2010 average economic growth in Ethiopia is 11% and average rate of inflation during the same period is 16%. The period understudy has witnessed a positive relationship between inflation and economic growth. According to the author, no matter what happens to inflation, economic growth is not an affair of choice.

Geda and Tafere (2008) have also analyzed the forces behind the recent inflationary pressure in Ethiopia. Quarterly data for the period 1994/5 – 2007/8 is used. In the formulation of the VAR model explanatory variables for the Ethiopian inflationary process are: exchange rate, world price index, world non-food prices, real income, excess money supply, food imports, food aid, marketed surplus, unit wage costs and the exogenously administered prices. In order to avoid spurious regressions, unit root tests were conducted and all variables are found to be stationary at the first order I(1) that allows undertaking the VAR based co-integration test. After the cointegration vectors are identified for the models of food and non-food inflation, a single error correction model is estimated for both models. Among the explanatory variables of inflation income growth is the relevant variable in our case. In this study it is found out that one of the sources of food inflation is the rise of income. The reason given for this is the low level of income among households. Given the low level of income, an increase in income leads to higher food inflation because households spend their additional income on food items. These authors recommend that policy makers cool down economic growth through fiscal and monetary conservatism. Since the main source of the recent inflation in the country is food inflation, an increase in income is found to be the major determinant of food inflation. Hence, it can be concluded that there is a negative relationship between inflation and economic growth in Ethiopia.

Like the global empirical evidences, studies undertaken in Ethiopia have different findings on the relationship between inflation and economic growth. Studies conducted by Ayalew (2000), Geda and Tafere (2008) and Teshome (2011) suggest that there is positive relationship between economic growth and inflation. Ayalew and Teshome suggest that growth must take priority while Geda and Tafere suggest the importance of macro-economic stabilization. However, studies like Michael (2008) show a negative relationship between inflation and growth. In the threshold analysis of Assaminew (2011) there is a positive relationship between inflation and growth when inflation is below 11%, but the relationship becomes negative when inflation exceeds this point. The main differences in the results of these studies can be attributed to the model, methodology and the data. In general there are conflicting theories and empirical findings regarding the relationship between inflation and economic growth. The relationship between these two macro-economic variables is widely studied both in cross country panel data and single country time series data.

In Ethiopia however, because of stable macro-economic history of the country, the subject is not exhaustively studied with formal modeling and appropriate econometric procedure. Hence, this study contributes to the existing literatures on these topics.

3. Data and the Model

A growth model similar to the one developed by Khan and Senhadji (2001) is used to detect the threshold level of inflation in Ethiopia. This model permits us to estimate the threshold level of inflation through a technique known as conditional least square (CLS). The growth equation has six explanatory variables consisting of inflation, inflation threshold, population growth rate, investment growth rate, openness of the country and drought.

These explanatory variables are selected based on macro-economic theoretical framework and empirical growth literature. In many theoretical growth models such as Harrod (1938) and Domar (1946) population growth and capital accumulation are considered as essential determinants of economic growth. International trade theories, on the other hand, suggest that a country engages in trade because it benefits from the trade economically. Due to this reason, openness of the economy to the rest of the world is considered as one contributor to the economic growth of a country (Salvatore 2004: 62-71). Depending on the structure of the economy different empirical studies include different variables that can potentially affect the growth of the economy. In this growth model, drought is included as one of explanatory variables since the economy of the country under study is highly dependent on rain-fed agriculture (Dalle 2009: 77-79).

Arithmetically, the economic growth model of the country is thus specified as,

$$\mathbf{Growth_t = \beta_0 + \beta_1(inf_t) + \beta_2 * D_t(Inf_t - \Pi^*) + \beta_3(pop_t) + \beta_4(inv_t) + \beta_5(open_t) + \beta_6(Drought_t) + \varepsilon_t \ (1)}$$

where,

Growth = growth rate of real gross domestic product ,

Inf_t = inflation rate at time t measured by the consumer price index, pop_t = population growth rate at time t ,

inv_t = investment growth rate at time t,

Π^* = the threshold level of inflation

$open_t$ = openness of the economy to the rest of the world,

Drought = the index of years of drought

β's = slope coefficient of explanatory variables

In the process of estimating the threshold level of inflation, the variables in the equation are computed as:

$Growth_t = Dlog\ (RGDP_t)\%,$

$Inf_t = Dlog\ (CPI_t)\ \%,$

$Pop_t = Dlog\ (pop_t)\%,$

$Inv_t = Dlog(inv_t)\%,$

$Open_t = Dlog\ (open_t)\%$,

where, D = dummy variable that takes the value of one when inflation level becomes greater than the threshold and zero otherwise

$$\mathbf{D_t = 1: 100*D \log CPI > \Pi^*}$$
$$\mathbf{0: 100*D \log CPI \leq \Pi^*} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \mathbf{(2)}$$

By estimating equation **(1)** for different values of Π, which is assigned in an ascending order, the optimal value of Π will be the one that maximizes R^2 and minimizes the residual sum of square (RSS). All the data in this research are obtained from published and unpublished sources of the Central Statistics Agency (CSA), Ethiopian Investment Agency (EIA) and the National Bank of Ethiopia (NBE). Data for some relevant variables are not provided on a quarterly basis. However, it has to be noted that various techniques are used in order to convert the annual data to quarterly data for some variables.

The main objective of this study is to estimate the threshold level of inflation in the economy. In estimating a growth model given in equation **(1)**, ordinary least square (OLS) could have been used if the threshold level of inflation (*Π*) was known in advance. In such cases Non Linear Least Squares (NLLS) method seems the appropriate method of estimation. However, in this technique the threshold point (*Π*) enters into the model in a non-differentiable and non linear way that makes the method of NLLS inappropriate to use. The best way of identifying the threshold point is thus the technique of Conditional Least Square (CLS) that is originated by Hansen (1999) and developed by Khan and Senhadji (2001).

In the CLS technique, the basic idea is to find the level of inflation that minimizes the sum of squared residuals (RSS) or the one that maximizes the R^2 for different values of the threshold points assigned. As Hansen (1996) suggests, the growth equation (1) is estimated using the OLS method for different values of the threshold (*Π**) which is assigned in an ascending order as (1, 2, 3, … etc).

The value of the threshold (*Π*) is obtained by finding the maximum point among the assigned values of Πs in the estimation process that maximizes the R^2 or minimizes the residual sum of squares (RSS) from the respective regressions. As explained in the study of Khan and Senhadji (2001) the identification of the threshold point is given as:

$$\Pi^* = Arg_{\Pi} Max\, R^2 \left(\underline{\Pi}, \ldots, \overline{\Pi}\right)$$
$$\Pi^* = Arg_{\Pi} Min\, RSS \left(\underline{\Pi}, \ldots, \overline{\Pi}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \mathbf{(3)}$$

where, Π^* is the threshold level of inflation, $\underline{\Pi}$ and $\overline{\Pi}$ are the range at which the ascending numbers are given. Thus, according to equation **(3)**, among the values between the range, the one that maximizes the R^2 is the threshold level of inflation, i.e. Π^*.

In the method of Conditional Least Squares (CLS) before under taking the regression it is necessary to assign dummy values for the threshold level of inflation. For the threshold level of inflation say, 2%, dummy variable should be assigned 0 for all values that are less than or equal to 2% and 1 for all values that are higher than 2%. In the method of Conditional Least Squares (CLS) the researchers have undertaken a regression for each value assigned from $\underline{\Pi}$ to $\overline{\Pi}$. This way of estimating the threshold level of inflation is monotonous and tiresome. However, this is the only alternative so far to estimate the threshold point of inflation (Khan and Senhadji 2001: 6-7).

To estimate the long-run trend of the series, the Hodrick-Prescott filter of smoothing data is employed. This method of data smoothing is widely used among macro-economic researchers such as Hodge (2005), Mubarik (2005) and Hussain (2005). The HP filter computes the smoothed series of α of Y by minimizing the variance of Y around α (E-views 2007: 375). Technically the HP filter chooses α to minimize

$$\sum_{t=1}^{T}(Y_t - \alpha_t)^2 + \lambda \sum_{t=2}^{T-1}((\alpha_{t+1} - \alpha_t) - (\alpha_t - \alpha_{t-1}))^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \mathbf{(4)}$$

The larger the λ, the more smooth the series is, since the penalty parameter λ controls the smoothness of the series. For quarterly data such as ours, Hodrick and Prescott (1997) suggest the value of λ to be 1600.

In order to check for the reliability of the estimation, different diagnostic tests are implemented on the estimation where the R^2 is maximized and the RSS is minimized. The LM test is used to check for autocorrelation. The problem of Heteroscedasticity is detected using the Autoregressive Conditional Heteroscedasticity (ARCH) test. The normality test is carried out by the Jarque-Bera (JB) test. Finally to verify the stability of the model the Cumulative Sum of recursive residuals (CUSUM) test is employed.

Though most of the diagnostic tests are discussed in section 3.3.1, the CUSUM test for stability is missed. It is therefore important at this point to discuss the CUSUM test for stability. The CUSUM test for stability is carried

out based on

$$CUSUM_{\tau} = \sum_{t=K+1}^{\tau} \hat{v}_t^{(r)} / \hat{\sigma}_v \quad \text{..... (5)}$$

where, $\hat{\sigma}_v$ is the variance of the residual,

$\hat{v}_t^{(r)}$ represents the recursive residuals

and τ = K+1,…,T.

If the CUSUM value exceeds far from the zero line, it shows that the model is unstable. The 5% significance level of the test is obtained by rejecting stability when CUSUM crosses the lines ±0.948

[$\sqrt{T-K}$ + 2(τ-K)/$\sqrt{T-K}$ (Lutkepohl and Kratzig 2004: 53 – 55).

The research question of this study is addressed using methodologies described in this section. The next section analyzes the data and interprets the results inferential analysis using these methodologies. The Econometric Views (E-Views) 6 statistical software is employed to carry out the different estimations and diagnostic tests.

4. Results of Estimation and Interpretation

One of the problems faced in studying time series macroeconomic relationships is spurious regression. This problem can be solved by checking if the variables are the order of integration that is determined by unit root tests. In this paper two unit root tests (Augmented Dickey Fuller and Phillips-Perron) are applied and their results are discussed below.

The results of Augmented Dickey Fuller (ADF) and Phillips-Perron unit root test is summarized in Table 1 and 2 below at their first differences, respectively.

Table 1: ADF test Results at first difference

	Intercept	Critical Values at 5% level of significance	Intercept and trend	Critical Values at 5% level of significance	
dlog(CPI)	-7.548559	-2.901217	-7.813501	-3.471693	Reject the null hypothesis
dlog(RGDP)	-6.481044	-2.901779	-6.819320	-3.472558	Reject the null hypothesis
dlog(pop)	-9.223084	-2.905519	-8.665078	-3.478305	Reject the null hypothesis
dlog(inv)	-8.648269	-2.901217	-8.712702	-3.471693	Reject the null hypothesis
dlog(open)	-10.59321	-2.901779	-11.01292	-3.472558	Reject the null hypothesis

Table 2: The Phillips-Perron (PP) Unit Root test at first

Variable	Test Equation				Decision
	Intercept	Critical Values at 5% level of significance	Intercept and trend	Critical Values at 5% level of significance	
dlog(CPI)	-7.43234	-2.901217	-7.806577	-3.471693	Reject the null hypothesis
dlog(RGDP)	-11.54345	-2.901217	-26.60345	-3.471693	Reject the null hypothesis
dlog(pop)	-8.53434	-2.901217	-8.773452	-3.471693	Reject the null hypothesis
dlog(inv)	-8776455	-2.901217	-8.837453	-3.471693	Reject the null hypothesis
dlog(open)	-18.23343	-2.901217	-25.47342	-3.471693	Reject the null hypothesis

The tables 1 and 2 show the results of the unit root tests and reveal that all the variables used in this study are I(1) in both the ADF and PP unit root tests. In order to continue with the analysis, all variables in each model should be integrated in the same order. As shown in the tables above, all variables are integrated at their first order. Due to this reason the analysis will continue assessing the relationship between inflation and GDP growth.

Conditional Least Square (CLS) is the technique that is used to carry out the formal estimation of the threshold level of inflation. The intention of the CLS technique is to identify the level of inflation that maximizes R^2 or the

one that minimizes the residual sum of squares (RSS) among the different ascending values assigned as a threshold.

The variables employed in the threshold estimation are transformed in the form of growth rate such as GDP growth rate, investment growth rate, population growth rate and the rate of inflation as shown in the previous topic. In addition to this the Hodrick – Prescott method of data smoothening is used. The Hodrick – Prescott filter is a smoothening method widely used in macro-econometric analysis to obtain a smooth estimate of the long-run trend of a series.

Equation (1) that is re-written below is estimated and the maximum value of R^2 is assessed to identify the optimal level of inflation.

$$\mathbf{Growth_t = \beta_0 + \beta_1(inf_t) + \beta_2 * D_t(Inf_t - \Pi^*) + \beta_3(pop_t) + \beta_4(inv_t) + \beta_5(open_t) + \beta_6(Drought_t) + \varepsilon_t} \quad \mathbf{\ldots (1)}$$

The values of the threshold points (k) range from 2% - 15% and Table 3 below shows how the outcomes of R^2 vary as the inflation threshold assigned arbitrarily (k) increases. As clearly seen from Table 3 the value of R^2 is maximized at 10% level and hence this point is considered as the threshold level of inflation.

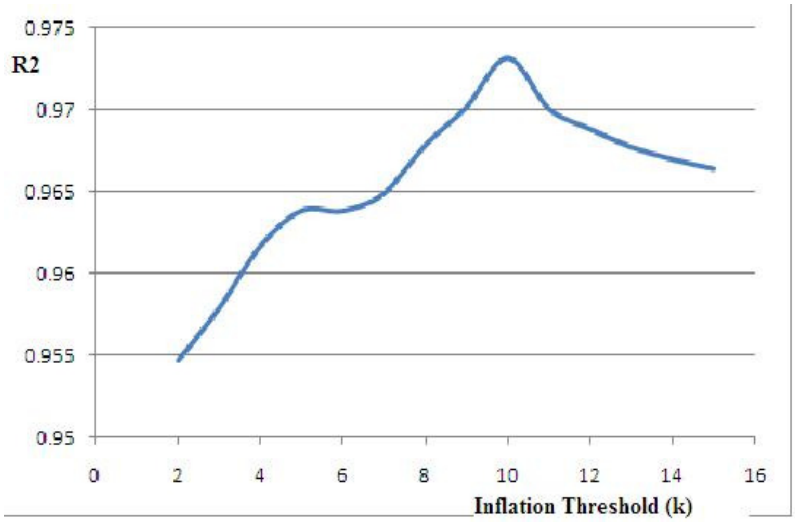
Table 3: CLS Estimation of the Inflation Threshold

k	Variable	Coefficient	Std. Error	t-stat	Prob.	R^2
	C	-0.010024	0.003291	-2.755953	0.0075	
	Inflation	0.523627	0.019744	25.71223	0.0000	
	D2(Inf-2)	-0.000634	0.000768	-1.235970	0.2208	
2	Investment Growth	-0.009152	0.003532	-3.449979	0.0010	0.954241
	Population Growth	2.479769	0.324661	7.025299	0.0000	
	Openness	0.439265	0.060308	6.563868	0.0000	
	Drought	-0.000321	0.000632	-0.469800	0.6400	
	C	-0.007563	0.006222	-2.973625	0.0041	
	Inflation	0.538057	0.020092	26.55284	0.0000	
	D3(Inf-3)	-0.001576	0.021345	-1.786491	0.0786	
3	Investment Growth	-0.015095	0.002910	-3.748740	0.0004	0.957634
	Population Growth	2.186573	0.341782	7.297561	0.0000	
	Openness	0.428278	0.026517	7.053349	0.0000	
	Drought	-0.000418	0.034662	-0.343881	0.7320	
	C	-0.002363	0.003502	-2.159950	0.0345	
	Inflation	0.438057	0.019462	27.64683	0.0000	
	D4(Inf-4)	-0.111576	0.000634	-2.484866	0.0155	
4	Investment Growth	-0.545095	0.003098	-4.872253	0.0000	0.961745
	Population Growth	2.182573	0.342553	6.383176	0.0000	
	Openness	0.428278	0.063446	6.750319	0.0000	
	Drought	-0.000418	0.000652	-0.640235	0.5243	
	C	-0.008818	0.003207	-2.679647	0.0094	
	Inflation	0.553977	0.020720	28.05854	0.0000	
	D5(Inf-5)	-0.001931	0.001153	-2.513755	0.0145	
5	Investment Growth	-0.020252	0.004670	-5.734561	0.0000	0.963374
	Population Growth	2.272742	0.315271	7.000350	0.0000	
	Openness	0.470404	0.060652	7.800075	0.0000	
	Drought	-9.12E-05	0.000659	-0.144325	0.8857	
	C	-0.007563	0.003288	-2.850884	0.0059	
	Inflation	0.538057	0.020202	27.58681	0.0000	
	D6(Inf-6)	-0.001576	0.000861	-1.506631	0.1369	
6	Investment Growth	-0.015095	0.003938	-5.789433	0.0000	0.963734
	Population Growth	2.186573	0.324320	7.157313	0.0000	
	Openness	0.428278	0.060759	7.899344	0.0000	
	Drought	-0.000418	0.000643	0.381885	0.7038	
	C	-0.009634	0.003477	-2.929470	0.0047	
	Inflation	0.559838	0.020092	26.46120	0.0000	
	D7(Inf-7)	-0.000198	0.000535	-0.188853	0.8508	
7	Investment Growth	-0.025760	0.002910	-5.926568	0.0000	0.964354
	Population Growth	2.346405	0.341782	7.251628	0.0000	
	Openness	0.481817	0.064317	7.769739	0.0000	
	Drought	0.000652	0.000662	0.997677	0.3223	

	C	-0.010338	0.003637	-2.801763	0.0068	
	Inflation	0.533490	0.020365	27.09012	0.0000	
	D8(Inf-8)	-0.000956	0.000513	0.882298	0.3811	0.967432
8	Investment Growth	-0.010909	0.002653	-6.409231	0.0000	
	Population Growth	2.494177	0.352977	7.270166	0.0000	
	Openness	0.453652	0.066922	7.687902	0.0000	
	Drought	-0.000228	0.000684	1.745746	0.0859	
	C	-0.008208	0.003166	-2.592824	0.0119	
	Inflation	0.556587	0.020800	26.75860	0.0000	
	D9(Inf-9)	0.002139	0.001150	1.866746	0.0678	
9	Investment Growth	-0.031624	0.004834	-6.542243	0.0023	0.970733
	Population Growth	2.234853	0.311856	7.185194	0.0039	
	Openness	0.444853	0.060345	7.365137	0.0023	
	Drought	0.001147	0.000638	1.798407	0.0771	
	C	-0.45652	0.023431	-5.386212	0.0328	
	Inflation	0.547326	0.026254	26.42392	0.0000	
	D10(Inf-10)	0.003511	0.432139	3.322291	0.0031	
10	Investment Growth	-0.031949	0.068675	-6.53585	0.0000	0.973512*
	Population Growth	2.125387	0.305459	6.925788	0.0000	
	Openness	0.407381	0.059762	6.816734	0.0000	
	Drought	0.552427	0.003211	1.844052	0.0702	
	C	-0.009082	0.003268	-2.778800	0.0073	
	Inflation	0.566596	0.020606	27.49681	0.0000	
	D11(Inf-11)	0.002157	0.001373	1.571482	0.1215	
11	Investment Growth	-0.035673	0.005288	-6.746294	0.0000	0.970843
	Population Growth	2.341907	0.326753	7.167201	0.0000	
	Openness	0.459280	0.060576	7.581920	0.0000	
	Drought	0.000984	0.000662	1.485250	0.1429	
	C	-0.011558	0.003340	-3.460700	0.3216	
	Inflation	0.579077	0.020114	28.78915	0.0000	
	D12(Inf-12)	-0.001593	0.054192	-0.841902	0.4021	
12	Investment Growth	-0.037343	0.005685	-6.357055	0.0000	0.968254
	Population Growth	2.594354	0.342301	7.579154	0.5632	
	Openness	0.504854	0.059074	8.546157	0.7342	
	Drought	0.072362	0.000717	1.061475	0.4236	
	C	-0.011627	0.216858	-3.238398	0.0426	
	Inflation	0.580539	0.025368	27.55576	0.0000	
	D13(Inf-13)	-0.235159	0.001534	-0.599618	0.4327	
13	Investment Growth	-0.037307	0.541757	-5.777711	0.0000	0.967766
	Population Growth	2.636507	0.390661	6.748841	0.0654	
	Openness	0.593752	0.071394	8.341053	0.0043	
	Drought	0.423772	0.075231	1.865456	0.2960	
	C	-0.01222	0.001145	-2.995401	0.0048	
	Inflation	0.585436	0.053736	26.67544	0.0000	
	D14(Inf-14)	-0.074368	0.023956	-0.341360	0.7342	
14	Investment Growth	-0.053250	0.053208	-5.421196	0.0420	0.967251
	Population growth	2.675472	0.438346	6.028866	0.0022	
	Openness	0.503423	0.053450	8.184634	0.0000	
	Drought	0.072191	0.006540	1.063474	0.3246	
	C	-0.012938	0.002316	-2.60004	0.0109	
	Inflation	0.543424	0.029443	25.70354	0.0000	
	D15(Inf-15)	-0.002351	0.094340	-0.509434	0.6557	
15	Investment Growth	-0.04532	0.000377	-4.999468	0.0000	0.961524
	Population Growth	2.55348	0.419658	5.248653	0.0000	
	Openness	0.493921	0.021192	8.166338	0.0000	
	Drought	0.004543	0.000044	1.203239	0.2763	

*Denotes the threshold level of inflation

From the results of Table 3, it is shown that all the explanatory variables in the growth model are significant at 10% level, i.e., when inflation is at its threshold. When inflation is at 10% the p-value of the coefficient for the rate of inflation is close to zero implying the significant relationship between inflation and economic growth at 1% level of significance. For the level of inflation that is more than 10% there is a significant negative relationship between inflation and growth. The results in Table 3 also show that 10% is the optimum level of inflation that the economy can absorb without affecting the economic growth. Among the given values of k, at 10% the value of R^2 is maximized at a point of 0.973512. The relation between the threshold k values assigned and the R-squared is given in Figure 1 below.



From Figure 1 one can see that the level of R-squared increases up to the point where the assigned inflation threshold (k) reaches 5%. However, R-squared does not show a change, neither decreasing nor increasing, as inflation threshold increases from 5% to 7%. The value of R-squared then increases again from 7% until it reaches 10%. From 10% onwards the increase in the inflation threshold reduces the value of R-squared showing that the value of R-squared peaks at 10%.

At the threshold level of inflation, i.e., 10%, the estimation result for all variables is statistically significant at 1% level except for drought which is also significant at 10%. Based on the results in Table 3 and Figure 1, the level of inflation at 10% is conducive to the economy while a level of inflation that is greater or less than the 10% has a negative effect on the economy.

The inflation threshold of 10% is not that high for a developing country such as Ethiopia. Most studies carried out in the estimation of the threshold level of inflation for developing countries have findings that are around 10%. Some of these studies include Khan and Senhadji (2001), Kremer, Nautz and Bick (2009), Jha and Dang (2011), Pollin and Zhu (2005), Bick (2010) and Mubarik (2005).

The results of these studies show that the threshold level of inflation for developing countries is mostly double digit, i.e., 10% or more. The findings from Khan and Senhadji (2001) shows that developing countries have a threshold level of inflation at about 11%. Kremer, Nautz and Bick (2009) found out that for developing countries an inflation rate up to 17% does not affect the growth rate of the economy. Similar to Khan and Senhadji (2001), Jha and Dang (2011) found out that 11% is a threshold level of inflation for developing countries. In a single country time series study for a developing country, Pakistan, Mubarik (2005) also reveals that 9% is the threshold level of inflation for the economy of the country. Therefore, the level of threshold 10% for Ethiopia should not be regarded as surprisingly high. Having the result of the threshold level of inflation from Table 3 the next issue will be dealing with the diagnostic test for the estimation where k = 10%.

For the model where the threshold level of inflation is 10%, a diagnostic test is carried out to check whether the model has Gaussian error terms. The diagnostic tests include normality test, serial correlation test, hetroscedasticity test and Cumulative sum (CUSUM) test of recursive residuals. The Jarque-Bera normality test is used to check if the error terms are normally distributed. The Breusch-Godfrey Lagrange Multiplier (LM) serial correlation test is used to check whether the error terms are serially independent. The autoregressive conditional heteroscedasticity (ARCH) LM test is used to check the problem of heteroscedasticity. The CUSUM test is employed to capture a non-zero mean of the residuals due to shifts in the parameters of the model. The results of these tests are summarized in Table 4.

Table 4: Diagnostic Tests for the optimal level of inflation

Test	Test Statistic	p-value	Conclusion
Normality Test (JB test)	1.237333	0.484534	Residuals Normally Distributed
Serial Correlation (LM test)	65.9764	0.1423	No serial Autocorrelation
Heteroscedasticity test (ARCH test)	1.162323	0.1762	No Heteroscedasticity
Stability (CUSUM)	Within the Bands		Stable

The Jarque-Bera normality test results shows that residuals are normally distributed based on the relative lower value of the test statistic and high probability value of the test statistic. The test statistic obtained in the Jarque-Bera test is 1.237333 and the p-value of the test statistic is 484534. According to the JB normality test, these values do not lead to the rejection of the null hypothesis that the residual series are normally distributed.

The Breusch-Godfrey serial correlation test result reveals that the error terms in the model are serially independent. However, at lower lags this case is not true and hence to remove the problem of autocorrelation taking higher lags is necessary. Hence, at higher lag the test statistic has a value of 65.9764 with its probability value of 0.1423 showing that the serial correlation problem is treated. The large p-value of the test statistic leads to the rejection of the null hypothesis that the error terms are serially correlated.

On the other hand, the result from the ARCH LM test shows that error terms have constant variance. This is due to the lower test statistic of the ARCH LM test that is 1.162323 and its relative higher p-value of 0.1762. From this result one can reject the null hypothesis that the error terms have non-constant variance.

Finally, the result from the cumulative sum (CUSUM) of recursive residuals shows that the structural stability of the model falls between the lines of $\pm 0.948[\sqrt{T-k} + 2(\tau - K)/T\text{-}K]$ at about 5% level of significance. Thus, CUSUM does not wander from the lines and stays within the bands at 5% level of significance implying the stability of the model.

As a conclusion, in estimating the threshold level of inflation, the findings from this chapter reveal that up to 10% level, inflation does not have a significant negative impact on the growth of the economy. However, if inflation rate exceeds the 10% level then the growth of the economy will be affected negatively. Based on the results of this section, then the conclusion and policy implications are given in the next section.

5. Conclusion

The objective of this study is to search for the optimum level of inflation that the economy can hold without the growth being affected negatively. In estimating the threshold level 10% level of inflation as a point of threshold is the main finding of this paper. Hence a level of inflation more than or less than 10% negatively affects the growth of the economy while the level of inflation at 10% keeps the growth of the economy at the optimal level. Even though this level of inflation is considered to be very high for developed countries, for a developing country such as Ethiopia 10% of inflation as a threshold point is tolerable. This result is similar to the popular study in this topic, i.e., Khan and Senhadji (2001) that estimated the threshold level of inflation as 10% for developing countries.

This study provides an important policy recommendation for Ethiopian macro-economic policy makers and the country's central bankers. Though inflation targeting is the current fashion among monetary policy makers, developing countries such as Ethiopia should not only aim to combating inflation but also should have to consider the economic position of the country. According to the finding of this study, a 10% level of inflation is the optimal level of inflation that helps the economy to grow optimally. Hence, the central bank which is responsible for the monetary policy of the country should aim to keep inflation at 10% so that the growth of the economy is not hampered. In order to achieve this target, coordination of the fiscal and monetary policies is necessary and thus the Ministry of Finance and Economic Development, the National Bank of Ethiopia, and the Revenue and Customs Authority must work together to achieve policy effectiveness. According to the recent five year development plan (GTP), government has a goal to keep inflation at 6%. Though this figure is a bit ambitious, it may also sacrifice economic growth at the expense of controlling inflation.

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