Inflation and Money Growth in Ethiopia: Is there a Threshold Effect?

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Abstract

This study analyses money growth - inflation nexus in Ethiopia using annual datasets covering the period 1970-2009. A significant aspect of the study is that it tries to identify the optimal level of money growth using Two Regime Threshold Model. The result from the two regime threshold model reveal that there is indeed a threshold effect in the relationship between money growth and inflation and the optimal level of money growth is estimated to be 17% which has an important policy implication- keep the money growth below 17%. Here, money supply creates inflationary pressures only when it exceeds 17%. A percentage increase in money supply above this threshold value is expected to cause 1.47 percent increase in annual inflation indicating that monetary factors are valid sources of inflation in Ethiopia.

Keywords: Inflation, money growth, two regime threshold model, Ethiopia

JEL Code: E3, E4, C4

1. Introduction

It is widely believed that moderate and stable rate of inflation promotes output growth, ensures return to savers, enhances investment, and accelerates economic growth. In general, price stability is an indicator of macroeconomic stability. People dislike price hikes because higher inflation rate reduces the purchasing power of their money making them unable to buy the same quantity and quality of goods and services as before, given their income. When inflation approached double-digit levels in USA, President Gerald Ford declared it “public enemy number one,” and President Ronald Reagan called it “the cruelest tax”. Thus, the public views inflation as detrimental to economic performance of a country. However, though majority of economists agree with the public, there are economists who argue that inflation is positive to economic performance.

Sharing the public’s view, the obvious question that comes in mind is what determines inflation? Alternatively, what are the sources of inflationary pressures? However, the answer is different according to different schools of thought. For example, the Structuralist school emphasizes supply side factors as determinants of inflation. Inflation is determined by developments and bottlenecks on the real side of the economy. In this approach, monetary factors are given less emphasis as sources of inflation because the proponents assumed that price changes largely took place on the real side of the economy, not on the monetary sector. Thus, monetary authorities have to accommodate wage and price increases (Bernanke, 2005). In contrast, the monetarist approach emphasizes, “*Inflation is always and everywhere a monetary phenomenon*” in the sense that an increase in money stock eventually leads to a rise in prices in the same proportion. That is, there is a positive one-to-one relationship between monetary and price growth (see for example, Roffia and Zaghini, 2008).

Price stability is recognized as primary objective of central banks. Yet the role of money in the conduct of monetary policy to achieve the said stability is debatable. Many economists believe that inflation is monetary phenomenon in the sense that money growth in excess of the growth rate of the economy is inflationary. When the monetary authority increases the money supply at a rate that exceeds the demand for cash balances at the existing price level, the higher demand for goods and services triggers a rise in the price level as the public tries to convert its excess cash holdings in to real items. There are studies that confirm this hypothesis (Gerlach, Browne, and Honohan 2004; Nelson, 2008; Dawyer, Jr, and Hafer 1999, Kulakisizoglu and Kulakisizoglu, 2009).

There are also economists who argue that money growth does not help in predicting the dynamics of inflation because either their relationship is weak or inflation and money growth are unrelated. Turnovsky and Wohar (1984) found that the causality between money supply and aggregate prices in the United States is neutral and concluded that money and inflation are unrelated. De Gregorio (2004), for several low inflation countries with very rapid growth of money, finds that money growth does not necessarily cause inflation. Roffia and Zaghini (2008), for 15 industrialized economies found that it is only in approximately half of the cases they investigate that positive relation between inflation and money growth exists.

The above mixed empirical evidence may be attributed to the inherent nonlinearities between the two variables. For example, Milas (2007), using a Markov switching regression model for the United Kingdom, finds that money growth is inflationary if it exceeds 10% threshold level. Similarly, Bachmeier, Leelahanon, & Li (2007) using a fully nonparametric model and a threshold regression model find that nonlinear models are more successful at forecasting inflation than linear models.

In Ethiopia, empirical studies are very scant on this issue. Tafere (2008), using a monetarist and structuralist model found that the sources of inflation in Ethiopia are different for food and non-food inflation and in the short run and log run as well. However, he only considered the period 1994/95 to 2007/08. A similar study conducted by Loening, Durevall, and Birru (2009) using error correction models found that money stock does not explain inflation in the short run its but growth does. However, their analysis focuses only on the period January 1999 to November 2008.

Thus, we contribute to this debate empirically quantifying and testing the nature of the relationship between money growth and inflation using a Two-Regime Threshold Model over extended period (1970-2009). Particularly, we estimate the threshold level of money growth above which additional money is inflationary which has an important policy implication.

2. Conceptual Framework

The building block for this study is the quantity theory of money, which links money supply, velocity, prices, and real income, and can be written as an identity

$$MV = PY \tag{1}$$

where M stands for money supply, V velocity, P price level and Y represents real income. Money supply is assumed exogenous and income velocity of money is independent of the other variables in identity 1. Under these assumptions, identity 1 can be written as the theory of price determination as follows.

$$P = \frac{MV}{Y} \tag{2}$$

taking log of equation (2), yields

$$\log P = \log M + \log V - \log Y \tag{3}$$

differentiation (3) with respect to time yields the equation for inflation

$$\frac{1}{P}\frac{dP}{dt} = \frac{1}{M}\frac{dM}{dt} + \frac{1}{V}\frac{dV}{dt} - \frac{1}{Y}\frac{dY}{dt} \tag{4}$$

or in terms of growth rates

$$\Delta_P = \Delta_M + \Delta_V - \Delta_Y \tag{5}$$

Equation (5) shows that the rate of inflation (Δ_P) is determined by the growth in money supply (Δ_M), growth in velocity (Δ_V), and growth in real income (Δ_Y). As envisioned in the early versions of the quantity theory of money (Fischer 1911), we assume that velocity is constant and its growth rate is zero. As could be obvious velocity changes when the institutions in the economy change. In Ethiopia, the financial system is underdeveloped and the use of different payment modalities such as credit cards is yet to flourish. Hence, our assumption is valid. Therefore, with constant velocity assumption equation (5) reduces:

$$\Delta_P = \Delta_M - \Delta_Y \tag{6}$$

Note that equation (6) suggests that the growth rate in price is proportionate to the growth rate in money supply in excess of output growth.

Besides the aforementioned variables, short run cost shocks such as an oil price shock or a change in the exchange rate (Gerlach, Browne, and Honohan 2004) affect inflation even though not in the long run. Therefore, considering budget deficit, oil price shock and incorporating annual rainfall as a proxy for supply side constraints, the basic model becomes:

$$Inf_t = \beta_0 + \beta_1 gm_t + \beta_2 gdpg_t + \beta_3 loilpr_t + \beta_4 lrain_t + \beta_5 bd_t, \qquad (7)$$

where *gm* is the growth rate of money supply, gdpg is the growth rate of real gdp, loilpr is the logarithm of oil price in US dollars, lrain is the logarithm of annual rainfall, bd for budget deficit and subscript t stands for time.

3. Econometric Models and Estimation Methods

Adding error term (μ_t) to capture effect of other variables, we specify the econometric model to analyze inflation in Ethiopia as:

$$Inf_t = \beta_0 + \beta_1 gm_t + \beta_2 gdpg_t + \beta_3 loilpr_t + \beta_4 lrain_t + \beta_5 bd_t + \mu_t \qquad (8)$$

Since there is a particular econometric issue related to the estimation and inference in empirical models with threshold effects, we follow the methodology developed by Hansen (2000) and Caner and Hansen (2004). In particular, these authors develop tests for threshold effects, estimate the threshold parameter, and construct asymptotic confidence intervals for the threshold parameter. Their basic idea is that threshold estimation is that an exogenously given variable, called “threshold variable”, is used to split the sample in two groups or regime, which can or cannot be a regressor. This theory derives the asymptotic distribution of OLS or 2SLS estimates of the threshold parameter.

A two regime threshold autoregression can be formulated as:

$$y_t = \theta_1^{'} x_t + e_{1t} \qquad\qquad if \quad q_t \leq \gamma \tag{9a}$$

$$y_t = \theta_2^{'} x_t + e_{2t} \qquad\qquad if \quad q_t \succ \gamma \quad , \tag{9b}$$

where q_t denotes the threshold variable (in our case money growth), splitting all the observed values into two classes or regimes. The terms y_t and x_t are *m* vector dependent and explanatory variables, respectively. The e_{it}, for i=1,2, is the white-noise or error term of property of *iid* (independently identically distributed) and γ denotes the threshold value or parameter. If we knew γ the model could be easily estimated by OLS. Since the threshold is unknown a priori so it should be estimated in addition to other parameters. Note that when the threshold variable is smaller than the threshold parameter, the model estimates equation (9a) and when the threshold variable is larger than the threshold parameter, the model estimates the equation (9b).

Defining a binary variable $d_t(\gamma) = \{q_t \leq \gamma\}$ where $\{.\}$ is the indicator function, with d=1 if $q_t \geq \gamma$ or d=0 otherwise, and setting $x_t(\gamma) = x_t d_t(\gamma)$, then equation (9a) and (9b) can be written as a single equation as:

$$y_t = \theta^{'} x_t + \delta^{'} x_t(\gamma) + e_t \tag{10}$$

where, $\theta = \theta_2$, $\delta = \theta_1 - \theta_2$, and θ, δ , and γ are the regression parameters to be estimated. The residual sum of squares as a result of estimating the regression parameters can be written as follows:

$$s_1(\gamma) = \hat{e}_{1t}(\gamma)^{'} \hat{e}_{2t}(\gamma) \tag{11}$$

Caner and Hansen (2004) recommend estimating equation (10) using 2SLS (two stages least squares) technique. The easiest way to implement this procedure is through minimization of the sum of squared residuals as a function of expected threshold value. Hence, we can rewrite the optimum threshold value as:

$$\hat{\gamma} = \arg\min \; s_1(\gamma) \tag{12}$$

Conditional on $\hat{\gamma}$, the regression equation is linear in θ and δ', yielding the conditional 2SLS estimates of $\hat{\theta}(\gamma)$ and $\hat{\delta}(\gamma)$ by regression of dependent variable on explanatory variables.

Following the foregoing procedure, the linear equation in equation (7) can be specified as a nonlinear equation under a two-regime threshold autoregression (TAR) model as:

$$Inf_t = (\beta_{10} + \beta_{11} gm_t + \beta_{12} gdpg_t + \beta_{13} loilpr_t + \beta_{14} lrain_t + \beta_{15} bd_t) d[q_t \leq \gamma] + (\beta_{20} + \beta_{21} gm_t + \beta_{22} gdpg_t + \beta_{23} loilpr_t + \beta_{24} lrain_t + \beta_{25} bd_t) d[q_t > \gamma] + \mu_t \quad (13)$$

From equation (13), the optimal threshold value can be determined by obtaining the threshold value that minimizes the residual sum of squares (RSS). Since the main objective of this paper is to investigate the inflationary threshold effects in the relationship between inflation rate and money growth in Ethiopia, the annual growth rate of inflation is employed as the threshold variable in the analysis.

The main question in equation (13) is, therefore, whether or not there is a threshold effect. This requires a careful scrutiny between the linear model, i.e., equation (7), vis-à-vis the two-regime model, equation (13). The null hypothesis of no threshold effect (H_0: $\beta_{1i=}$ β_{2i}) is tested against an alternative hypothesis where threshold effect is present (H_0: $\beta_{1i} \neq \beta_{2i}$). However, traditional procedures of hypothesis testing cannot be applied, because under the null hypothesis of no threshold effect exits, the threshold parameter γ will be unidentified. Hansen (1996) suggests a standard heteroscedasticity-consistent Lagrange Multiplier (LM) bootstrap method to calculate the asymptotic critical value and the p-value. To do this, a test with near-optimal power against alternatives distant from H_0 is the LR statistics.[1]

4. Data and Context

We use annual data for the period 1970-2009 collected from National Bank of Ethiopia (NBE), Ministry of Finance and Economic Development, Central Statistics Agency and International

[1] See also Hansen (1999; 2000) and Hansen and Soe (2002) for details of the test.

Monetary Fund. In the endeavors directed towards achieving sustainable economic growth, the role of the monetary authority in Ethiopia is to maintain price and exchange rate stability. Hence, macroeconomic stability as proxied by price stability plays an important role in all economic decisions and fosters employment and economic growth. Moreover, exchange rate stability is meant to ensure the countries international competitiveness and to use exchange rate intervention as a monetary policy tool to influence both foreign reserve position and domestic money supply (NBE, 2009).

We use data on general price, money stock/supply, GDP (gross domestic product), budget deficit, oil price, and rainfall. There are different measures of money stock. However, since National Bank of Ethiopia uses broad money (M2) as a policy variable (see NBE, 2009), we considered this variable in our estimation. Summary statistics of the variables considered is provided in the appendices (see Appendix A). The mean of inflation is about 7.7% while the mean of money growth is about 12.9%. While the standard deviation of inflation is 7.7, the standard deviation of money growth is 115.7 which is about 12 times that of the former. Further, their distribution is non normal as Jarque-Bera test rejects the null hypothesis of normality for both series.

A closer look at the behavior of the two variables- inflation and money growth during the period 1970-2009 reveals that both variables closely move together in the same direction (see Figure 1).

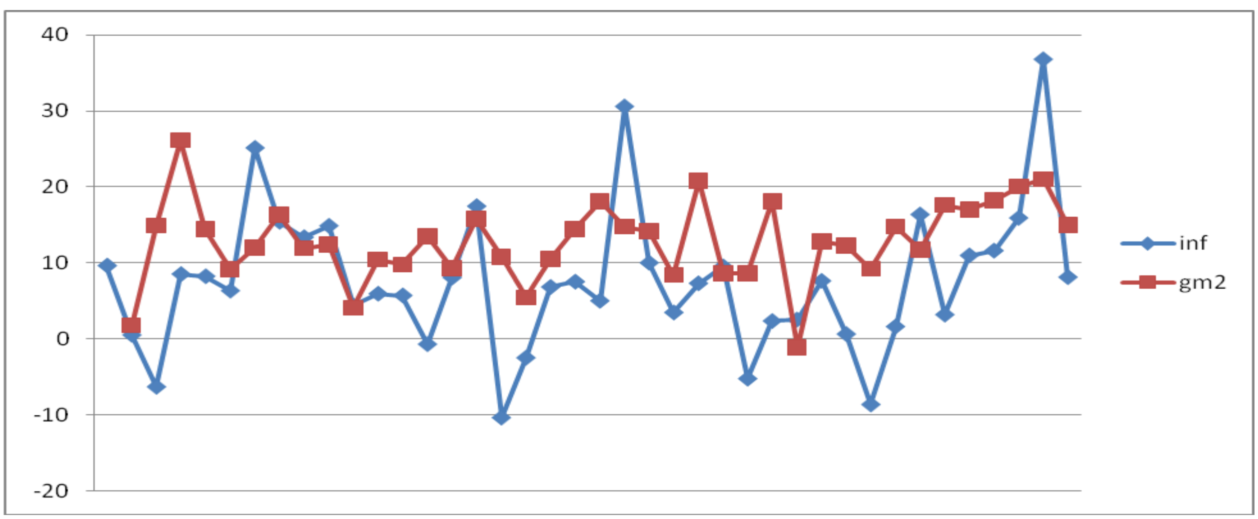

Figure 1: Inflation and money growth (1970-2009)

The time series property of the data we use was also examined using ADF test due to Dickey and Fuller (1979, 1981), and PP due to Phillips (1987) and Phillips and Perron (1988). These tests are applied at level and at first difference of the variables. Test results are presented in the appendices (see Appendix B). The results show that the null hypothesis of unit root is rejected, at least at 5% level of significance, in both tests except for real GDP in the first difference. In ADF test, it turns out that real GDP is not significant even at 10% both at level and first difference. However, when PP test is applied real GDP become significant at 1% level at the first difference. Overall, these results suggest that the underlying variables are difference stationary.

Further, the test for cointegration was conducted using the maximum-likelihood test procedure established by Johansen and Juselius (1990) and Johansen (1991). Details of the test results are presented in the appendices (see Appendix C). The test shows that in the long-run, the variables are cointegrated; thus the existence of a meaningful long run relation. In the table below, the LR test indicates one cointegrating equation(s) at 5% significance level as the trace statistic 22.1195 is above the 5% critical value (29.68).

5. Empirical Results

As outlined in section 3, the initial step to see the existence of threshold effect is to estimate equation (13) using 2SLS as suggested by Caner and Hansen (2004) and computing RSS for different values of the threshold parameter. The optimal threshold level is the one that minimizes RSS. The test results are summarized in the following table.

Table 1: Test Results of Threshold Effects

Test Hypothesis	Optimal Threshold	LR test statistic	1% Critical Value	5% Critical Value	P-Value
H_0 : no threshold	17%	36.7 (LR_0)	7.35	10.59	0.000
H_0: one threshold		0.125 (LR_1)	7.35	10.59	0.813

Applying Hansen's (2000) testing procedure, we found evidence of one threshold in the relationship between money growth[2] and inflation. More specifically, the LR_0 test statistic is 36.7, which is significant at 1% level with a bootstrap p-value of 0.000 indicating that the threshold exits. However, in an attempt to test for two thresholds, the LR_1 test statistic is 0.125 which is well below the 5% critical value indicating that the null hypothesis of one threshold cannot be rejected significantly. Therefore, the test procedure implies one threshold and, thus, two regimes in the relationship between inflation and money growth in the country. The optimal threshold at which the residual sum of square is minimized is 17%. The results are similar to the findings of Milas (2007) except the magnitude of the threshold is higher in our case.

After estimating the threshold level using 2SLS and testing its significance, Caner and Hansen (2004) proposed the model parameters to be estimated by GMM. For comparison purposes, the first column in table 2 presents estimates for a linear regression equation that ignore the threshold effect. Column two and three provide estimates of the two-regime threshold autoregressive model.

Table 2: Regression Results of Inflation rate and Money Growth in Ethiopia (1970-2009)[a]
Dependent variable: Inflation

Variables	Linear Model	Threshold Model	
		Regime 1: ≤17%	Regime 2: > 17%
constant	35.61391 (129.3935)	1.785103 (37.96798)	-85.69495 (118.2563)
Money Growth	2.194453 (4.345978)	-0.4484866 (0.6849215)	1.472167* (.7087817)
GDP Growth	0.0930879 (0.0799819)	0.4765417 (0.7707039)	0.0436404** (.0115594)
Budget Deficit	0.0038652 (.0033405)	0.0018692 (0.0015056)	0.0019319 (0.0011776)
Oil Price	1.141137 (16.47499)	5.63862 (4.437037)	11.91485* (3.973082)
Rainfall	-12.94897 (26.65294)	-8.535948 (10.14296)	4.785771 (21.7275)
N R^2	38	29	9 0.91

[a] ** and * represent significant at 1%, and 5%, levels respectively while numbers in parentheses are standard errors.

[2] All growth rates were calculated as the first difference of their logs. The interest rate is proxied by real lending rate, exchange rate by real effective exchange rate and credit by the total credit to the private sector.

As the above table reveals, in contrast to the results obtained in the low money growth regime and in the linear specification, in the high regime model, money growth has a significant impact on inflation. More specifically, the impact of money growth on inflation is positive and significant at 5% level with a coefficient of 1.47. That is, an increase in money stock by 1% leads to increase in inflation by 1.47%. On the other hand, under low-inflation regime and linear specification, money growth does not have significant effect on inflation. The estimated non-linear relationship between inflation and money growth is consistent with the empirical conclusion derived in previous studies such as Bachmeier, Leelahanon, & Li (2007) and Milas (2007). That is, under high inflation regime, money growth has a positive effect on inflation.

In the high regime, a percentage change in oil prices is expected to change inflation by 11.9% indicating that oil shocks are important sources of inflation in the country (see Gerlach, Browne and Honohan 2004). Similarly, the coefficient on real GDP growth is positive and significant at 1% significance level. On average, this model predicts that a 1% increase in real GDP leads to a rise in inflation approximately by 0.04%. Finally, rainfall is insignificant in all specifications. Thus, according to our empirical result it appears that the monetarist view is valid in the context of Ethiopia.

6. Conclusions and Implications

The findings can be summarized as follows. First, the probe on the link between money growth and inflation revealed that their relationship is nonlinear. Particularly, the study found the existence of threshold effect in the relationship between inflation and money growth. Money growth is inflationary only when it is greater than 17%. Hence, an important policy implication is- ‘keep the money growth below 17%’. Second, as indicated by the significance of the coefficient of money growth, the monetarist view on the causes of inflation is valid in Ethiopia. Last but not least, our study analyzed the nonlinear effects of money on inflation using single equation model applying 2SLS. However, an interesting issue of further research could be employing Multivariate Threshold Vector-Autoregressive (MTVAR).

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Appendices

Apendix A: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis	Jarque-Bera	Prob
Inflation	40	7.7	9.4	-10.3	36.7	0.83	4.45	7.93	0.02
Money Growth	39	12.9	5.4	-1.1	26.1	-0.22	3.55	0.80	0.67
GDP Growth	39	25.2	115.7	-10.2	711.7	5.61	33.57	1723.17	0.00
Budget Deficit	40	-680.9	2388.1	-8580.9	4815.0	-0.80	5.00	10.71	0.00
Oil Price	40	3.6	0.5	2.8	4.6	0.19	2.03	1.79	0.41
Rain Fall	40	4.6	0.2	4.1	4.9	-0.12	3.54	0.58	0.75

Appendix B: Results of Unit Root tests with ADF and PP [a,b]

Variables	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)	
	At Level	First Difference	At Level	First Difference
lcpi	-0.093	-3.710**	0.170	-4.915**
lgdp	8.854	14.522	2.056	-6.233**
lm2	0.727	-4.049**	1.307	-5.983**
loilpr	-2.208	-4.349**	-2.030	-5.115**
lrain	-2.785	-7.906**	-3.949**	-11.792**

[a] The ADF and PP tests are based on the null hypothesis of unit roots.

[b] **, and * indicate significant at 1%, and 5% levels respectively, based on the critical t-statistics as computed by MacKinnon (1996).

Appendix C: Johansen tests for cointegration

Trend: constant   Number of obs = 38
Sample: 1972 - 2009   Lags = 2

Max rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	20	50.935417	.	128.9275	47.21
1	27	104.3394	0.93984	22.1195*	29.68
2	32	111.73297	0.32236	7.3324	15.41
3	35	115.33736	0.17280	0.1236	3.76
4	36	115.39915	0.00325		