A note on excess money growth and inflation dynamics: evidence from threshold regression

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Abstract

We test the effect of excess money growth on inflation using Threshold Regression technique developed by Hansen (2000). The empirical test is conducted using annual data from India for the period from 1953-54 to 2007-08. The results clearly exhibits that the relationship is not linear and without a strong credit growth, excess money growth has lesser inflationary effects.

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1. Introduction

A positive "one-to-one" relationship between money supply growth and inflation theorized by the quantity theory of money captivated many empirical studies. Although there is theoretical consensus on money neutrality supported by empirical evidences both in time-series and cross-countries analyses, the exact nature of this relationship is still an open issue[1]. A recent strand of the empirical literature have recognized that the development in asset prices and credit dynamics might influence the nature of this positive "one-to-one" relationship between monetary and price growth. Specifically many studies have found that significant money stock expansions that are not coupled with sustained credit increases and strong dynamics in other asset prices are less likely to have inflationary consequences (Roffia and Zaghini 2008, Bordo and Jeanne, 2002; Borio and Lowe, 2002; Machado and Sousa, 2006 Borio and Lowe, 2004, Detken and Smets, 2004, Van den Noord, 2006). We test this proposition using a Threshold Regression technique proposed by Hansen (2000) for the data from a developing country, India.

This paper is organized as follows. Section 2 presents the methodology. Section 3 describes the data used in this study. Section 4 reports the empirical results and finally Section 5 concludes the paper with policy implications.

2. Methodology

The primary objective of the paper is to test the relationship between money supply growth and inflation dynamics with a focus to investigate two potential possibilities. First are there any external variable plays a significant role in these theoretically one-to-one related variables. Second is there any non-linearity exists between these two variables? We shall apply the recent threshold regression method developed by Hansen (2000), in order to capture a non-linear effect of money supply growth on the inflation dynamics.

[1] See Lucas (1980), Lothian (1985), McCandless and Weber (1995), Jaeger (2003), Gerlach and Svensson (2003) and Benati (2006) among many others.

The threshold model allows to split the sample into different regimes and tests the relationship for each of these regimes respectively.
An empirical threshold regression model is given by:

$$y_t = \theta_1^{'} x_t + u_t \qquad q_t \leq \gamma \qquad (1)$$
$$y_t = \theta_2^{'} x_t + u_t \qquad q_t > \gamma \qquad (2)$$

Where $\boldsymbol{y_t}$ and $\boldsymbol{q_t}$ are the observation of the dependent variable and the threshold variable respectively, and $\boldsymbol{x_t}$ are the independent variables. The threshold variable $\boldsymbol{q_t}$ may be an element of $\boldsymbol{x_t}$ and it is used to split up the sample into two groups which are called "regimes". The random variable $\boldsymbol{u_t}$ is a regression error.

The model (1)-(2) can be written in a single equation form with the introduction of the dummy variable $\boldsymbol{d_t = I\ (q_t \leq \gamma)}$ where I (•) denotes the indicator function. If we set the variable $\boldsymbol{x_t\ (\gamma) = x_t\ d_t\ (\gamma)}$, then equations (1)-(2) are equal to

$$y_t = \theta^{'} x_t + \delta_n^{'} x_t(\gamma) + u_t \qquad (3)$$

Where $\theta = \theta_1$ and $\delta = \theta_1 - \theta_2$ Equation (3) allows all regression parameters to differ between the two regimes. Hansen (2000) develops an algorithm based on a sequential OLS estimation which searches over all values $\gamma = q_t$; t =1... T. The procedure also provides estimates of δ andθ. The null hypothesis of linearity against a threshold specification can be expressed as $\theta_1 = \theta_2$.

Hansen (2000) proposes a heteroskedasticity-consistent F-test bootstrap procedure to test the null of linearity. Since the threshold value is not identified under the null, the p-values are computed by a fixed bootstrap method. The independent variables $\boldsymbol{x_t}$ are supposed to be fixed, and the dependent variable is generated by a bootstrap from the distribution N (0, u_t)) where u_t is the OLS residual from the estimated threshold model. Hansen (2000) shows this procedure yields asymptotically correct p-values. If the null hypothesis of linearity is rejected, one can split up the original sample according to the estimated threshold value.

3. Data

This paper uses annual data for the period from 1953-54 to 2007-08. The variables considered for this study are M3 money stock for money supply, Wholesale Price Index (WPI) for inflation rate, Gross Domestic Product at factor cost, Bank Credit and World Oil Prices. All the variables on India are from Handbook of Statistics on Indian Economy published by Reserve Bank of India. West Texas Intermediate is considered as World Oil Price and collected from Energy Information Administration of US Government.

Following Borio and Lowe (2004), we construct the ‘M3Gap’ that is defined as the deviation of the ratio of money to GDP from its trend. Similarly deviation of the ratio of bank credit to GDP from its trend is calculated as ‘CreditGDPGap’. The trend is derived from a Hodrick-Prescott filter (with a smoothing parameter of 100) over the whole sample period. In all these measures a positive value denotes an excess amount from the trend. Inflation rate (Inf) is calculated as logarithmic difference of the Wholesale Price Index. The growth rate of GDP and Oil Prices denoted by ‘GDPGR’ and ‘DoilPrice’ is calculated as logarithmic difference of the Real Gross Domestic Product at factor cost and the World Oil Prices.

To account for the lag effect of money on inflation we constructed a measure excess inflation (exinf) as follows[2]:

$$ex\inf_t = Average(Inf_{t+1}, Inf_{t+2}, Inf_{t+3}) - Average(Inf_t, Inf_{t-1}, Inf_{t-2})$$

Standard ADF Test shows that all variables considered in this study are I (0).

4. Empirical Results

Following Hansen (2000), we estimated the equation with CreditGDPGap as the threshold variable

[2] Following Roffia and Zaghini (2007) a 3-year lead-lag average inflation is considered to construct exinf. We also constructed a 2-year lead-lag average inflation to check the robustness of the results.

$$ex\inf_t = \beta_{10} + \beta_{11}M3Gap_t + \beta_{12}GDPGR_t + \beta_{13}Doil\Pr ice_t + u_t \qquad CreditGDPGap_t \le \gamma \tag{4}$$
$$ex\inf_t = \beta_{20} + \beta_{21}M3Gap_t + \beta_{22}GDPGR_t + \beta_{23}Doil\Pr ice_t + u_t \qquad CreditGDPGap_t > \gamma \tag{5}$$

Table 1 provides the standard OLS estimation results of the equation before the threshold variable is introduced. Table 2 presents the results from the estimation of equations 4 and 5 with CreditGDPGap as the threshold variable. Figure 1 denotes the confidence interval construction for threshold in the sample split.

Table 1: Estimation Results from standard OLS without threshold

Coefficients	**Values**
Intercept	0.00089 (0.0104)
M3Gap	1.4154** (0.4482)
GDPGR	0.0782 (0.1868)
DoilPrice	-0.0011 (0.0008)
R^2	0.2196

In the parentheses are standard errors. ** and * denotes significance at 1% and 5% levels

Figure 1: Sample split: Confidence interval construction for threshold.

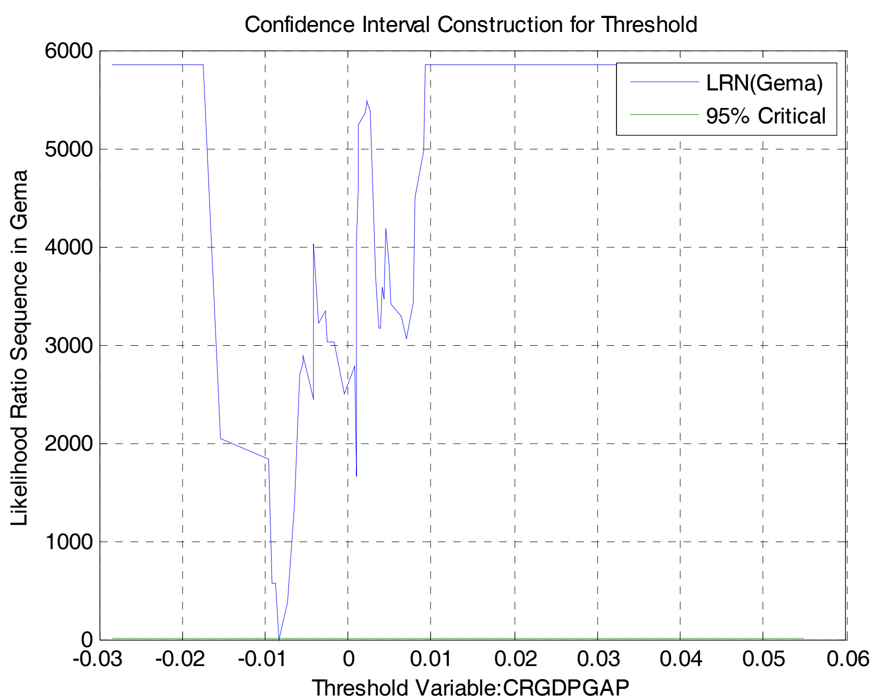

Table 2: Estimation Results from Equation 4 & 5

Coefficients	Regime 1 Values	Regime 2 Values
Intercept	-0.0933** (0.0203)	0.0065 (0.0088)
M3Gap	0.9527** (0.2300)	1.6971** (0.5078)
GDPGR	1.3800** (0.3512)	0.0527 (0.1739)
DoilPrice	-0.0010 (0.001)	-0.0006 (0.0011)
R^2	0.7887	0.2184
γ	≤-0.008242	>-0.008242

In the parentheses are standard errors. ** and * denotes significance at 1% and 5% levels

The results clearly exhibits the effect of excess money denoted as M3Gap on the inflation denoted as Exinf is significantly higher in the higher CreditGDPGap regime. The sample split happening at γ = -0.008242 for the threshold variable. With this we further examined the variables as robustness check. Out of 53 observations in the sample period, 11 observations fall in the lower CreditGDPGap regime (Regime 1) and the remaining 42 observation constitutes the higher CreditGDPGap regime (Regime 2). As mentioned a positive value in M3Gap and Exinf represents an excess quantity from its trend we gave an indicator value of 1 for these positive values and 0 for the rest. The following tables narrate a clear picture on the significant influence bestowed by the CreditGDPGap in understanding the effect of excess money on inflation dynamics.

Table 3: Average Exinf in Regime 1 and 2

	M3Gap	
	0	**1**
Regime 1 (Lower CreditGDPGap)	-0.04 (6)	0.002 (5)
Regime 2 (Higher CreditGDPGap)	-0.01 (19)	**0.028 (23)**

In the parentheses are number of observations in that category

In simple terms we can interpret the results from Table 3 as higher money growth coupled with higher credit in the economy results in higher inflation. Further we examined the average M3Gap in the two regimes to substantiate the claim. Table 4 presents the results.

Table 4: Average M3Gap in Regime 1 and 2

	M3Gap	
	0	**1**
Regime 1 (Lower CreditGDPGap)	-0.02 (6)	**0.017 (5)**
Regime 2 (Higher CreditGDPGap)	-0.01 (19)	0.010 (23)

In the parentheses are number of observations in that category

Table 4 clearly exhibits that the average M3Gap is higher at lower CreditGDPGap still it has not induced average inflation, while the lower average M3Gap in higher CreditGDPGap induces higher inflation.

Further we conducted some more robustness check in the estimated threshold regression model. We used another measure of inflation with 2-year lead-lag average and obtained almost similar results as above. Additionally we tested the model with two more threshold variables namely Bank Rate and OutputGap. We constructed 'OutputGap' as deviation of Real Gross Domestic Product at factor cost from its trend along the lines of other gap variables. The results are not very significant. We also estimated the equation 4 & 5 including the standardized OutputGap variable as an independent variable instead of GDPGR and found almost similar results with the sample split for the threshold variable CreditGDPGap.

5. Conclusion

This paper aims at understanding the one-to-one relationship between excess money growth and inflation theorized by the Quantity Theory of Money using a threshold regression method developed by Hansen (2000). The empirical analysis is done on the annual data from India for the sample period from 1953-54 to 2007-08. The results clearly show that the relationship between excess money growth and inflation is not linear. The excess money growth is not the only determinant of inflation in the short run. In conclusion it clearly shows that excess money growth that is not coupled with strong credit growth has lesser inflationary consequences.

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