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Searching Threshold Inflation for India

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Abstract

The present study is an effort to examine econometrically the presence of threshold level of inflation for India, in an environment where expected inflation is in double digit. This upward pressure on inflation is mainly due to rise in food prices; and high investment due to surge in domestic and international demand backed by industrial. High inflation not only costs central bank of the country but, it also affects the output negatively, if it is beyond the tolerable limit. Study uses specification of Sarel (1996) and Khan and Senhadji (2001) to estimate the point of threshold. The estimation result of the study confirms the presence of threshold level of inflation for India at 6 percent inflation rate and thus advocates the view of maintaining inflation rate below 6 percent for the healthy output growth rate in Indian economy. But study fails to confirm the same in Sarel (1996) sense.

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1. Introduction

This paper investigates the possible existence of threshold inflation in inflation–growth relationship for India. For more than last thirty months or so, inflation in India has kept policy makers off guard.[1] In the situation when economy is recovering from worst hit financial crisis, where global and domestic demands are bound to register strong growth high and persistent inflation, is not only worry for Reserve Bank of India (RBI) but for the fiscal policy also. As India's main growth driver—corporate investment—is yet to catch the trends of 2003–08 periods, when investment growth was around 16 percent. This means that during 2008–09, no industrial capacity has been created. Now, once the global and domestic demand will shoot-up, investment has to increase, this will further add pressure to the existing high inflation in upward direction. In this backdrop, it is essential to revisit the old question –what is the tolerable level of inflation for policy makers in India?

Relationship between inflation and growth has been much asserted both theoretically and empirically in macroeconomics. For most of the time before 70's debate on inflation-growth relation dwindled between the arguments that either there is no relation or the relation is positive. The period 1970s, which is marked by high inflation and low growth brought a profound change in the existing debate of 'no' or 'positive' link between inflation and growth. But again, the experience of the 1970s could not contribute much to the existing debate other than adding third dimension of 'inflation hurts growth'. Thereafter, a large number of theoretical and empirical studies fueled the support to position that however, high or low inflation adversely affects growth. Study by Sarel (1996) made a distinction in this debate. Sarel (1996) attempts to study the inflation—growth link in light of a threshold inflation beyond which inflation hurts growth and concludes that an threshold inflation of about 8 per cent for a pooled sample of a large number of countries, including India. Later, Khan and Senhadji (2001) estimate the threshold level of inflation for both developing and developed countries separately using non–linear models.

There is handful of studies in the Indian context which earlier examined the threshold level of inflation for India. The Chakarvarty committee (1985) which was set up for monetary reforms had put-up 4 percent of inflation as threshold inflation. Later in the mid–1990s, the then RBI governor, C. Rangarajan (1998), brought Central Bank focus on inflation rate at 6–7 per cent known as "acceptable level" of inflation. Study by Vasudevan and Dhal (1998) and Kannan and Joshi (1998) found the threshold level to be around 6 percent. Results of Samantaraya and Prasad (2001) are also on the similar line as they found the threshold level to be around 6.5 percent. In a comparatively recent study, Singh and Kalirajan (2003) provide argument against any threshold level for India, contrary to the studies mentioned earlier.

Given the present condition of persistent high level of inflation in the Indian economy and its implications for monetary and fiscal policy both, it will be of interest to estimate the threshold level of inflation, if any, in Indian context to understand the significance of

[1] For a very short period (March 2009–October 2009) inflation was low and for some time during this period even negative but again it to its running trend of near to double digit around March 2010.

tightening of monetary policy to curb inflation. Estimation results based on the Spline regression though provide primary evidence in favor of threshold inflation but further examination of it in Sarel (1996) sense rejects presence of any threshold level for India. This result find congruence with study Singh and Kalirajan (2003) as even the estimation results using Hansen (1997) method of threshold estimation shows very high level of threshold inflation. Rest of the paper has been schemed as follows: Methodological issue, model formation and data description has been dealt in section 2. Empirical result and discussion on result has been put in section 3 and finally, section 4 presents conclusion of the study.

2. Model Specification, Methodology and Data Description

Spline regression is a restricted form of regression which is used to estimate the model when the model behaves differently after certain level of some variable value, called threshold point for that variable. In order to estimate the threshold level of inflation in inflation–growth relationship in India, present study develops the empirical model based on the framework developed by Khan and Senhadji (2001). Further, empirical growth literature has been followed to identify the control variables to be used. Empirical works of growth literature identifies investments (public and private both), education, population growth rate, terms of trade and government expenditure as major determinants of growth (see Barro 1991; Sala–i–Martin 1997; and Romer 1993). We follow this conventional variable to estimate the growth and inflation relation even at country level study. Following the seminal work of Friedman's (1977) and Levi and Makin (1980) inflation volatility has also been introduced in the growth model.

$$\Delta Y_t = \alpha_0 + \beta_1 INF_t + \beta_2 INFVOL_t + \sum_{i=1}^{n} \beta_i X_t + U_t \qquad \textbf{(1)}$$

Equation (1) estimates the simple inflation growth relationship based on the variables identified. Equation (1) is modified with introduction of $D(INF_t - \Pi^*)$ to estimate the inflation growth relation in light of threshold inflation (see equation 2).

$$\Delta Y_t = \alpha_0 + \beta_1 INF_t + \beta_2 INFVOL_t + \beta_3 D(INF_t - \Pi^*) + \sum_{i=1}^{n} \beta_i X_t + U_t \qquad \textbf{(2)}$$

where,

ΔY_t = Growth rate of real output and growth rate of real per capita output, calculated as $\Delta Y_t = ((Y_t - Y_{t-1}) / Y_{t-1}) * 100$. For estimation with quarterly data, ΔY_t is growth rate of real output only;

INF_t = Inflation, calculated as $INF_t = ((WPI_t - WPI_{t-1}) / WPI_{t-1}) * 100$;

$INFVOL_t$ = Volatility of inflation calculated as five point moving average of inflation;

Π^* = Threshold level of inflation;

D = Dummy variable; $D = 1$ if $INF_t > \Pi^*$ and $D = 0$ if $INF_t < \Pi^*$;

X_t = Set of control variables identified from growth literature, which includes—government expenditure as percentage of GDP (GFCE), private and public investment as percentage of GDP (INVPRI and INVPUB respectively) interest rate (RBR) and population growth rate POPGR. Set of control variables for estimation with quarterly data includes government expenditure as percentage of GDP (GFCE), investment as percentage of GDP only;

U_t = Error term follows N (0, σ^2).

Now equation (2) will have set of series of extra inflation $(INF_t - \Pi^*)$ depending upon the value of Π^*; 4 to 8.75 percent is the range of Π^* in the present study. In case when $(INF_t - \Pi^*) < 0$ (inflation is low) then β_1 will be the estimate of inflation and it will be ($\beta_1 + \beta_2$), i.e. sum of the coefficient of lagged inflation and extra inflation. The structural break or threshold occurs at the value of (Π^*), for which the R–square is maximum. It is generally argued that the coefficient of $D(INF_t - \Pi^*)$ indicates the difference in the inflation effect on growth between the two sides of the structural break and its *t*–statistic value tests whether or not the structural break is significant. As mentioned in Singh and Kalirajan (2003), at some value of Π^*, the log likelihood of the regression is maximized (and the sum of the squared residuals is minimized) but the value of Π^* at which the sum of the coefficients of $(INF_t - \Pi^*)$ and INF_t significantly change sign may be less than at Π^*. Therefore, analysis of the entire set of coefficients is equally important in deciding about the target inflation level, which is attempted in this paper.

Study uses annual data covering the period of 1971 to 2009 and quarterly data for the period 1996:1 to 2009:3 to comprehend the threshold level of inflation on growth for India. The data has been culled from Handbook of Statistics on Indian economy (2010) published by RBI. The growth rate of GDP is based on constant prices at 1999–2000 as base year; inflation is estimated by using wholesale price index (*WPI*), which is also based on 1993–94 prices.

3. Empirical Results

Test of stationarity result based on ADF unit root test reveal mixed results, where some variable are stationary and some are integrated of order one i.e. some variable are I(0) and some are I(1). For sake of brevity we are not providing here the results of unit root test. For analysis, threshold level of inflation, variables are used in difference form which ever variable is I(1) to avoid problem of spurious regression.

To have general understanding of the kind of relationship inflation and output growth have in Indian case, first a linear regression is run involving GDP growth rate, inflation, inflation volatility and other control variables. This regression is started with lag of two for all variables; result of most contemporaneous estimation is put in Table 1. The coefficient of inflation and inflation volatility come out to be negative and significant. This negative coefficient of inflation clearly suggest existence of long run negative relation between inflation and output growth and negative coefficient of inflation volatility indicates that

volatility in inflation affects output growth negatively through its effect on returns on investment and unexpected policy. It is important to mention that initially the estimation includes variable of interest rate (RBR) also, but the coefficient of the variable was found to insignificant and the Wald test of variable deletion favored dropping of the interest rate variable and hence, dropped.

A same exercise is repeated with GDP per capita growth rate as the dependent variable for consistency. Even then, the result is quite similar (see Table 1). Thus, it can be said that in long run, inflation and inflation volatility is not good for output growth in India. But this linear relationship result does not provide any clue about the level of inflation, which is harmful to the output growth.

(Table 1 about here)

Now, following Khan and Senhadji (2001), extra inflation $(INF_t - \Pi^*)$ is introduced in the growth equation, so as to check for possible presence of threshold level of inflation. Result with variable of extra inflation (presented in Table 2a and 2b) shows that there exist a threshold level at 6 percent of inflation.[2] Positive coefficient of inflation, once, extra inflation is introduced in the growth equation indicates that below the threshold level of inflation, inflation does not hurt output growth.

(Table 2a about here)

However, as Singh and Kalirajan (2003) points out that at some value of Π^*, R–square of the regression is maximized but the value of Π^* at which the sum of the coefficients of extra inflation and Π^* significantly change sign may be less than at Π^*.

Plot of sum of the coefficient of inflation and extra inflation and R–square against Π^* for all twenty estimated equation is used to see whether the estimated threshold level does qualify the Sarel (1996) sense of threshold (see figure 1 and 2). Looking at the figure 1 and 2, where the R–square are plotted against different values of Π^*, it can be said that the threshold level of inflation is 6 percent. Now if we take a look at the Table 2 it is observed that for GDPGR and GDPPCGR, sum of INF_t and $(INF_t - \Pi^*)$ both the coefficient is negative and significant. Whereas, looking at the plot of figure 3 and 4 for the sum of coefficients of INF_t and $(INF_t - \Pi^*)$, it is clear that the sum of coefficients is negative. These findings indicate that there is no threshold level of inflation—in Sarel (1996) sense—for India.

Both the equations (equation 1 and 2) are also estimated for quarterly data with slight change in variable, but the results were not very convincing as the coefficient of threshold variable was coming out to be insignificant, so the idea of further analysis using quarterly data was dropped. Results of quarterly data can not be directly compared with annual data

[2] Table 2 only presents the regression result for threshold inflation i.e. at 6 percent of inflation to conserve space. Result is available on demand from author for entire spectrum of threshold inflation.

results as number of variables were dropped from the main equation due to unavailability of the data. Thus study relies mainly on the results of estimated equation with annual series.

Considering the contrary nature of results with regard to Bhanumurthy and Alex (2008), Kannan and Joshi (1998), we further perform Hansen (1997) test to check the consistency of the estimated model. Estimation result using Hansen (1997) procedure though revealed presence of threshold but at a very higher level of inflation (see figure 5). Thus, on the basis of combined results of spline regression and that of Hansen test, it could be said that there is no threshold inflation for India.

4. Conclusion

Using annual data, present study examines the presence of threshold level for India. Result of the study shows the presence of the threshold for India at 6 percent level of inflation. Despite the fact that the estimated threshold inflation is out of the comfort zone of the RBI, but still it is below the present level of inflation. Existence of threshold around 6 percent inflation rates confirms the existing nervousness in both monetary policy and fiscal policy. In addition to this, negative link between inflation volatility and output growth recalls for use of policy instrument so that inflation can be put on a stable path.

Though the estimation results primarily favors presence of threshold level of inflation for India but in Sarel (1996) sense it lacked to provide evidence on threshold inflation. In this light, the results, certainly advocates that lowering down the inflation in Indian context will results in higher output growth. High and persistent inflation not only puts central bank of the country in trouble, as maintaining low and stable price level is one of the central aim of the central banks; but it also have welfare cost of foregone economic output. The reasons, that could be adhered to why inflation inhibit growth in particular to Indian context is probably the effect of inflation on rate of investment. Higher rate of investment is required to meet the growing demand of a developing economy; inflation will hurt output growth through its effect on lowering the rate of investment. Second, a huge population in India works in unorganized sector and their wage is not indexed to inflation, which means that the real disposable income effect will reduce the total consumption and further will have its effect on growth as Indian economy is largely driven by domestic demand. With increasingly openness of the economy and ever increasing requirements of it in the sense of investment and with high capital inflows it has become very much important for the RBI to use policy for inflation. During the time of high capital inflow RBI need to sterilize, actively, the domestic monetary base to maintain low and stable inflation.

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Tables and Figures

Table 1: Regression Result for Inflation and Growth

Dependent Variable→	**GDPGR**	**GDPPCGR**
ΔGFCE(-1)	–1.503 (0.898)	–1.489 (0.888)
ΔINVPR(-1)	0.417*** (0.231)	0.379*** (0.229)
ΔINVPU(-2)	1.633** (0.461)	1.652** (0.456)
INF(-1)	–0.318*** (0.080)	–0.314*** (0.080)
INFVOL(-1)	–0.451*** (0.130)	–0.456*** (0.129)
POPGR(-1)	–4.724*** (0.497)	-
R–squared	0.494	0.533
Adjusted R–squared	0.407	0.452
Durbin–Watson stat	1.742	1.742
JB	1.442 [0.486]	1.480 [0.486]
Breusch–Godfrey Serial Correlation LM Test (F–statistic & p–values)	0.366 [0.697]	0.463 [0.634]
Heteroskedasticity Test: ARCH (F–statistic & p–values)	1.023 [0.319]	0.803 [0.377]

Note: ** and *** indicates significance at 5 and 1 per cent level of significance.
Standard error in ( ) bracket and p–value in [] parenthesis.

Table 2a: Regression Result for Inflation, Threshold Inflation and GDP Growth Rate

Dependant Variable	**GDPGR**						
Equation no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Threshold Inflation	5.25	5.50	5.75	6.00	6.25	6.50	6.75
R- square	0.4443	0.4468	0.4514	0.4540	0.4536	0.4518	0.4487
Explanatory variable	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**
ΔGFCE(–1)	–1.17 (0.94)	–1.19 (0.94)	–1.24 (0.94)	–1.27 (0.94)	–1.31 (0.94)	–1.34 (0.95)	–1.37 (0.95)
ΔINVPR(–1)	0.51** (0.24)	0.52** (0.24	0.53** (0.24)	0.55** (0.24)	0.55** (0.24)	0.55** (0.24)	0.56** (0.24)
ΔINVPU(–2)	1.71*** (0.51)	1.73*** (0.51)	1.74*** (0.51)	1.74*** (0.51)	1.72*** (0.51)	1.70*** (0.51)	1.70*** (0.51)
INF(–1)	0.72** (0.31)	0.69** (0.30)	0.67** (0.29)	0.64** (0.28)	0.61** (0.27)	0.57** (0.26)	0.55** (0.25)
INFVOL(–1)	–0.19 (0.16)	–0.18 (0.16)	–0.17 (0.16)	–0.17 (0.16)	–0.17 (0.16)	–0.17 (0.16)	–0.16 (0.16)
POPGR(–1)	–1.77* (0.88)	–1.75* (0.88)	–1.73* (0.87)	–1.73* (0.87)	–1.76* (0.86)	–1.80* (0.85)	–1.83* (0.85)
THRES	–1.03*** (0.36)	–1.01*** (0.35)	–1.01*** (0.34)	–0.99*** (0.33)	–0.97*** (0.32)	–0.95*** (0.32)	–0.93*** (0.32)
Test	**(Test Statistics and p-value)**						
Wald Test	8.90 [0.006]	9.288 [0.005]	9.784 [0.004]	10.175 [0.004]	10.40 [0.003]	10.506 [0.003]	10.542 [0.003]
Jarque-Bera Test of Normality	0.858 [0.650]	0.810 [0.666]	0.736 [0.691]	0.737 [0.692]	0.810 [0.666]	0.920 [0.631]	1.083 [0.581]
Breusch-Godfrey Serial Correlation LM Test	0.404 [0.671]	0.337 [0.716]	0.266 [0.767]	0.240 [0.789]	0.224 [0.800]	0.217 [0.806]	0.211 [0.810]
ARCH Test of Conditional Heteroskedasticity	1.030 [0.320]	1.045 [0.314]	0.976 [0.330]	0.889 [0.353]	0.775 [0.385]	0.661 [0.442]	0550 [0.463]

Note: : *, ** and *** indicate significant at 10, 5 and 1 percent level of significance.
Out of the 20 equation estimated with threshold inflation ranging from 4.00 to 8.50 this table contains the result of threshold inflation ranging from 5.25 to 6.75.
Standard error given in ( ) bracket and p-value given in [ ] parenthesis.

Table 2b: Regression Result for Inflation, Threshold Inflation and GDPPC Growth Rate

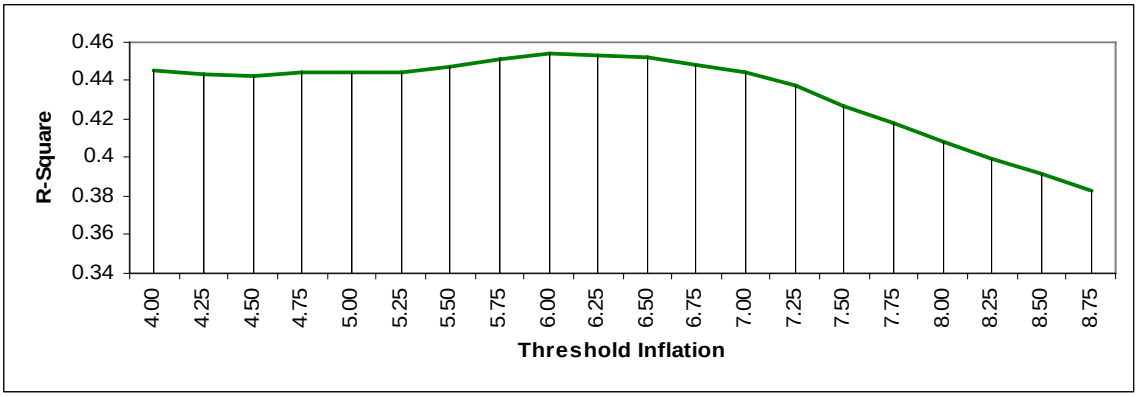
Dependant Variable	**GDPPCGR**						
Equation no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Threshold Inflation	5.25	5.50	5.75	6.00	6.25	6.50	6.75
R- square	0.4985	0.5008	0.5044	0.5060	0.5050	0.5026	0.4991
Explanatory variable	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**	**Coef. (std. error)**
ΔGFCE(-1)	–1.181 (0.918)	–1.203 (0.917)	–1.246 (0.917)	–1.280 (0.917)	–1.315 (0.921)	–1.343 (0.926)	–1.379 (0.933)
ΔINVPR(–1)	0.467* (0.238)	0.478* (0.237)	0.492** (0.236)	0.505** (0.235)	0.510** (0.235)	0.515** (0.236)	0.519** (0.237)
ΔINVPU(–2)	1.737*** (0.501)	1.749*** (0.501)	1.761*** (0.500)	1.760*** (0.499)	1.742*** (0.498)	1.724*** (0.498)	1.722*** (0.500)
INF(–1)	0.731** (0.305)	0.702** (0.294)	0.680** (0.283)	0.651** (0.272)	0.616** (0.262)	0.578** (0.253)	0.547** (0.247)
INFVOL(–1)	–0.189 (0.152)	–0.183 (0.152)	–0.177 (0.152)	–0.173 (0.152)	–0.171 (0.153)	–0.171 (0.154)	–0.169 (0.155)
THRES	–1.045*** (0.347)	–1.028*** (0.339)	–1.020*** (0.331)	– 1.004*** (0.324)	– 0.982*** (0.318)	– 0.954*** (0.312)	– 0.935*** (0.310)
Test	**(Test Statistics and p-value)**						
Wald Test	9.550 [0.005]	9.958 [0.003]	10.45 [0.001]	10.82 [0003]	11.02 [0.003]	11.09 [0.002]	11.09 [0.002]
Jarque-Bera Test of Normality	0.829 [0.66]	0.779 [0.677]	0.718 [0.798]	0.735 [0.692]	0827 [0.661]	0.956 [0.619]	1.141 [0.561]
Breusch-Godfrey Serial Correlation LM Test	0.325 [0.725]	0.261 [0.772]	0.197 [0.822]	0.176 [0.840]	0.167 [0.847]	0.165 [0.48]	0.167 [0.847]
ARCH Test of Conditional Heteroskedasticity	1.096 [0.302]	1.104 0.301]	1.025 [0.319]	0.931 [0.342]	0.811 [0.374]	0.693 [0.411]	0.580 [0.480]

Note: *, ** and *** indicate significant at 10, 5 and 1 percent level of significance.

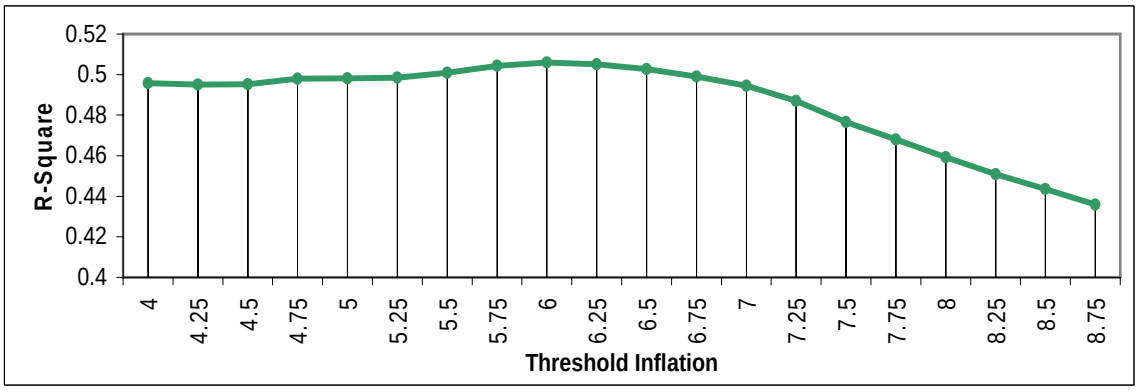
Out of the 20 equation estimated with threshold inflation ranging from 4.00 to 8.50 this table contains the result of threshold inflation ranging from 5.25 to 6.75.

Standard error given in ( ) bracket and p-value given in [ ] parenthesis.

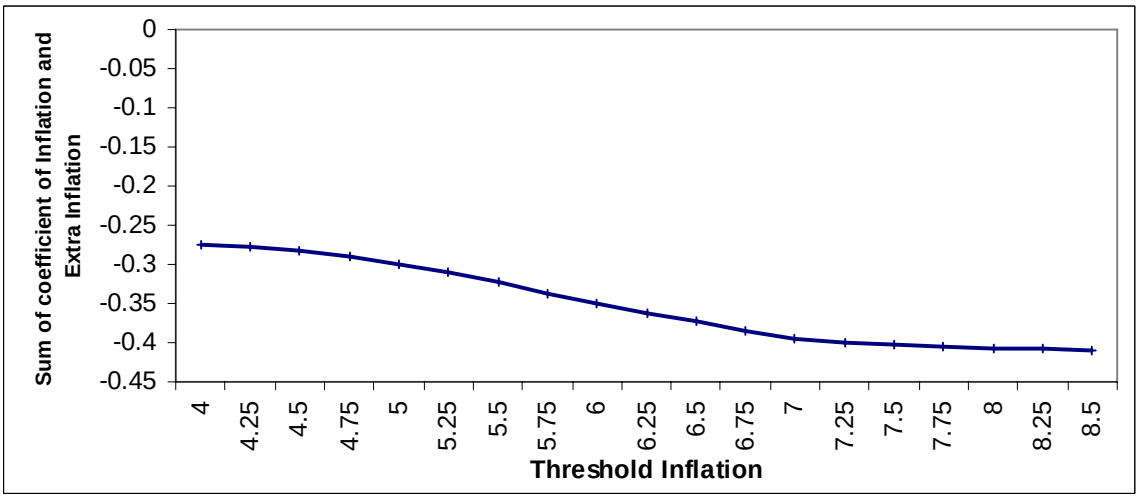
Figure–1: R^2 of the estimated equation against different values of extra inflation (when GDPGR is dependent variable)



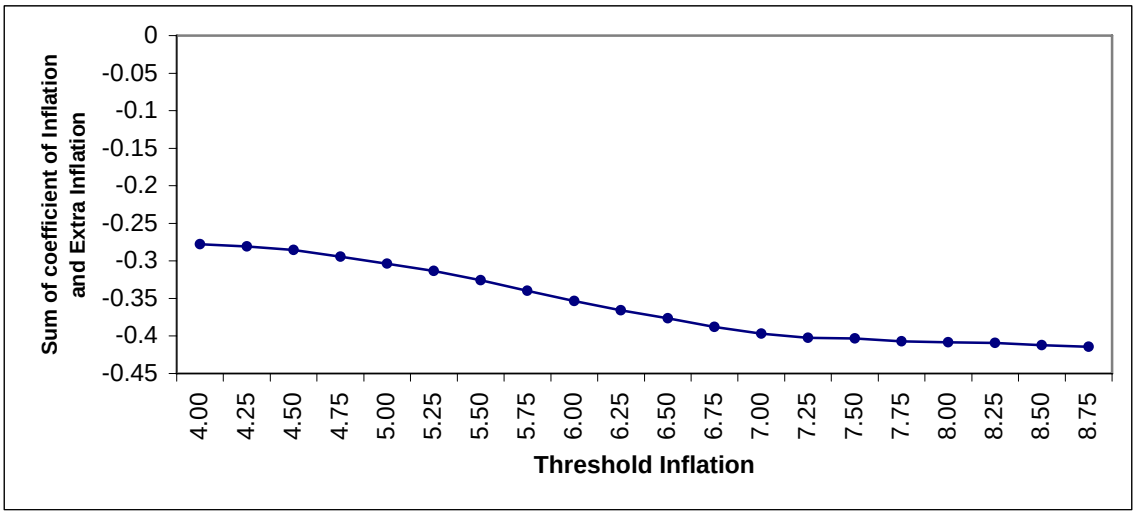
Figure–2: R^2 of the estimated equation against different values of extra inflation (when GDPPCGR is dependent variable)



Figure–3: Inflation and Extra Inflation Coefficient against different values of extra inflation (when GDPGR is dependent variable)



Figure–4: Inflation and Extra Inflation Coefficient against different values of extra inflation (when GDPPCGR is dependent variable)



Figure–5: Hansen (1997) threshold test results