Threshold Level of Inflation – Concept and Measurement

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Abstract

Threshold inflation that maximizes long-term growth in an economy is dependent on fiscal deficit (FD) and current account deficit (CAD). Since the existing empirical literature on threshold inflation lacks a robust theoretical framework, the present study considers the theory developed by Dholakia et al. (2020) to estimate threshold inflation that maximizes steady state growth (SSG). Based on an appropriate degree of polynomial for investment rate and capital productivity with a cross-country data set of 58 countries for the period 1995 to 2018, the study broadly confirms higher threshold inflation with higher growth in emerging market economies as compared to the advanced economies. By introducing country-specific intercept and selected slope dummies, the study finds that the threshold inflation for India is around 6 per cent. An important finding of the study is that the long run trade-off between inflation and SSG is asymmetric such that a reduction in inflation rate leads to a much smaller gain in the long-term growth when inflation is higher than threshold compared to when inflation is lower and rises towards the threshold level. Also, the threshold inflation and corresponding growth are not unique for a country but depend on the other two parameters – FD/GDP and CAD/GDP. Policymakers may choose to set the inflation target below the threshold level only after considering the costs of sacrificing growth and implied poverty alleviation rate with likely benefits in terms of the distributional and financial stability implications which are not examined in this study.

Keywords – Inflation Targeting, macroeconomic policy, Inflation Growth, Threshold Inflation, Cross-Country Panel.

JEL Codes – C30, E31, E58, E60, O11, O42.

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Threshold Level of Inflation – Concept and Measurement

Macroeconomic management in a country requires fixing long-term targets for real growth, inflation rate, fiscal deficit (FD) and current account deficit on balance of payments (CAD) as a proportion of GDP. Since it is imperative that all these four macro parameters are set in an internally consistent manner, this paper builds on the framework proposed by Dholakia (2020) to study the relationship between inflation and growth, taking into account the interdependence between all the target variables. Specifically, the paper focuses on the issue of threshold inflation – the optimal inflation rate that maximizes the long-term growth, which has received renewed attention recently as inflation has surged globally in the aftermath of the COVID crisis and the Russia-Ukraine war. The empirical findings of the paper are based on cross-country data with a focus on the Indian economy.

The debate on the relationship between inflation and output/employment growth has been subject to rigorous theoretical and empirical work which was only bolstered with the empirical observation of a negative relationship between nominal wage growth and unemployment rate (Phillips, 1958). While the Phillips-curve was originally based on the UK macroeconomic data, Samuelson and Solow (1960) using USA data observed an implied zero-inflation rate of unemployment to be around 3 per cent in the pre-World War-II years and about 5-6 per cent during the post-war years. This laid the ground for the analysis of exploitable trade-off that supposedly exists between inflation and unemployment.

Such trade-offs, however, exist only during the short to medium term, because in the long run, as argued by Friedman (1968) and Phelps (1967), the Phillips curve is vertical and no trade-off between inflation and unemployment or output would exist. If we accept this argument, there would be nothing like threshold inflation. Alternatively, in this framework, threshold inflation could exist only if the long run Phillips curve is non-linear, yielding a backward-bending aggregate supply curve. The possibility of a backward bending Phillips curve has been suggested by some studies due to incomplete incorporation of inflation expectations in wage contracts (Akerlof *et al.*, 2000; Palley 2003, 2011).

Another strand of literature that developed in parallel to the Phillips curve literature sought to explain the impact of inflation on steady state growth through its impact on investment. Since an increase in inflation makes present consumption costlier, it can promote higher savings, thereby leading to higher investment and growth. On the other hand, higher inflation also erodes the real wealth of households, which could lead to lower savings, investment and growth (Mundell, 1963; Tobin, 1965; Sidrauski,1967a & b; Stockman, 1981; Haslag, 1995, 1997).

An alternative perspective on 'optimal inflation' was propounded by Bailey (1956) and Friedman (1969) based on the intuition that while the private opportunity cost of holding money is positive (equals the nominal interest rate), the social marginal cost of printing money can be considered as negligible. A wedge between the two costs would, therefore, generate inefficiency to the extent that nominal interest rate is greater than zero. The optimal nominal interest rate should thus be equal to zero. In a steady state economy, this would require the inflation rate to be negative and numerically equal to real return on capital. Phelps (1973), however, argued that since inflation effectively acts as a tax generating revenue for the government, all the distortions associated with taxation can be minimised by taxing everything at the same rate. Therefore, Friedman's rule of zero nominal interest rate is not consistent with economic efficiency and there would be a need to tax liquidity by having a positive nominal interest rate and inflation. It has, however, been shown that Friedman's rule of zero nominal interest rate for optimal inflation remains valid under certain conditions when inflation tax turns out to be more distortionary than other taxes such as taxes on consumption or labour income (Chari, Christiano and Kehoe, 1996). Other channels that influence the inflation-growth relationship such as uncertainty or credit rationing have also been explored in several studies (Friedman, 1977; Ball, 1992; Pindyck, 1991; Bernanke, 1993; Bertola & Caballero, 1994; Choi *et al*.; 1996). Thus, the theoretical literature on optimal level of inflation seems divided.

In this paper, we argue that the concept of threshold inflation is based on the long-term equilibrium inflation rate that maximizes the steady state rate of growth for the economy. Thus, the concept of "long run" involved in the threshold inflation is not the same as the one used in the trade cycle theory. The difference between the two lies in the analytical treatment of investment. The latter considers investment only as a component of aggregate demand in the system and abstracts out its capacity and production augmenting role, whereas the former explicitly treats investment as capacity and production augmenting factor of production. As a result, in the trade cycle theory, the potential output or "the full employment output" remains constant in the "long run" around which the short to medium term fluctuations are sought to be explained. On the contrary, in the steady state growth theory, the potential output is taken to grow at a constant rate. Therefore, the Phillips curve framework that pertains to the trade cycle theory is not appropriate for defining and measuring the threshold inflation. We must consider the growth theory framework for the purpose.

The first formal growth model (Harrod, 1948) provided the steady state growth (SSG) solution as the natural growth rate, which is given by addition of the rates of growth of labour supply (n) and technical progress *i.e.* total factor productivity growth (TFPG), being equal to the warranted growth rate, which in turn is given as multiplication of the desired investment rate (sd) and capital productivity (IOCR). Since Harrod (1948) treated all these four parameters as given constants for an economy, his steady state growth solution was unstable. The neo-classical growth theory provided a stable steady state growth solution in terms of exogenous factors such as technical progress (TFPG) and growth rate of labour supply (n). In an open economy, as argued by Dholakia (2020), however, both these factors are likely to be endogenous and not exogenous as argued by Harrod (1948) due to his assumption of a closed economy. In an open economy, the rate of inflation can become an important determinant of the steady state rate of growth. It can influence TFPG through its effect on investment and effectiveness of research and development expenditure (Briault, 1995). Similarly, by determining the cost of living and standard of life in a country, it can also impact the rate of in or out migration and hence the rate of growth of labour (n). Role of inflation in determining the growth path over a long time horizon is particularly relevant for a developing economy. In this framework, the concept of threshold inflation could be effective only if the warranted growth rate is non-linearly related to inflation rate such that the second derivative is negative.

In this context, there are good reasons and arguments in the literature to expect such a relationship between the warranted growth and inflation in any economy. The theory of growth and threshold inflation proposed by Dholakia (2020) shows that, in the absence of any intervention from the government and other exogenous factors, the warranted growth would always have a tendency to be at the maximum level corresponding to the threshold level of inflation and that the natural growth would adjust to the warranted growth in the steady state growth. Thus, the steady state growth would occur at the threshold inflation in an economy left to market forces. Since this is a base case, the government can avoid unnecessary adjustment costs in practice by targeting long-term inflation and growth respectively at the threshold inflation and steady state growth. At this stage, the FD/GDP and CAD/GDP targets can be treated as exogenously given.

Using this theoretical framework, we estimate the threshold inflation and corresponding growth rate at different levels of FD/GDP and CAD/GDP for a sample of

58 advanced and emerging market economies for the period 1995 to 2018. We also specifically examine the threshold inflation in the case of India by incorporating a slope dummy into the panel regression equation. The paper is divided into 5 sections. In the next section, we briefly survey the related literature, followed by discussion on data and methodology in section 3. The fourth section presents empirical results based on cross-country panel data. The last section concludes the study with discussion on the implications of our findings for macroeconomic target setting.

2. Literature Review

It is evident from the above discussion that there is substantial amount of theoretical literature suggesting non-linear association between inflation and growth. Consequently, a growing body of empirical literature has corroborated the existence of a non-monotonic relationship between inflation and economic growth. Major focus on empirical analysis of the threshold level of inflation began with Sarel (1996), which uses data for about 90 countries for the period 1970-90 and examines the possibility of nonlinear effects of inflation on economic growth. The study finds significant structural break in the inflation and growth relationship when the inflation rate is 8 per cent beyond which inflation adversely affects economic growth in a statistically significant manner. Ghosh and Phillips (1998) deploy a nonlinear model and find evidence of a 2.5 per cent inflation as threshold level. The widely cited Khan and Senhadji (2001) study re-examined the issue of the existence of threshold level of inflation, using new econometric techniques on CPI data. They estimate threshold inflation at 1-3 per cent for industrial countries and 11-12 per cent for developing countries. Burdekin *et al.* (2004) and David *et al.* (2005) find a much higher level of threshold inflation and also conclude that the non-linearity in the inflation-growth relationship must always be accounted for and that a sample of industrial and developing countries should not be mixed. Vaona and Schiavo (2007) employ non-parametric and semi-parametric estimation techniques to find the existence of a non-linear relationship between inflation and growth using a sample of 85 countries (out of which 19 were developed countries) for the period 1960-1999. They estimate the threshold level of inflation at about 12 per cent for developed countries but find no clear relationship in the case of developing countries.

Some recent cross-country studies on the subject include Bick (2010), Espinoza *et al.* (2011), Jha and Dang (2012) and Kremer *et al.* (2013) which mostly rely on threshold panel regressions estimated over a sample period from 1950 to 2010. They find a threshold level of inflation in the range of 10-12 per cent for developed countries and 12-

20 per cent for developing countries. In contrast, Omay and Kan (2010) find a statistically significant negative relationship between inflation and growth above an endogenously determined threshold level of inflation at 2.52 per cent for six industrialised countries. Das and Loxley (2015) investigate the inflation-growth relationship for 54 developing countries from Asia, Latin America and Sub-Saharan Africa and obtain threshold level in the range of 15-24 per cent.

A wide range of threshold inflation estimates suggested by the literature points towards an important aspect that the estimate of threshold inflation is sensitive to the data frequency, sample size and time span of the study. In addition, regime and structural changes also make substantial difference to the estimates. Country-specific macroeconomic features, such as the level of financial development, capital accumulation, trade openness and fiscal expenditures also influence the non-linear inflation-growth relationship (Eggoh and Khan, 2014). On the other hand, the studies focusing on individual countries, especially those among developing economies, find much lower levels for threshold inflation. Chowdhury and Ham (2009) use a threshold VAR model and find 8.5-11.0 per cent range for threshold level of inflation for Indonesia. Based on the data from 1970 to 2005, Munir and Mansur (2009) find threshold inflation level of 4 per cent for the Malaysian economy. In the case of Mexico, Risso *et al.* (2009) find that GDP growth and overall macro-economy was at risk of being jeopardized if inflation rate exceeded 9 per cent. Mubarik (2005) finds similar results for Pakistan's economy. Vinayagathasan (2013) analyses several Asian economies over a period 1980-2009 and finds that inflation hurts growth when it exceeds 5.43 per cent but inflation lower than this level has no effect on growth. Thanh (2015) finds that inflation above the threshold level of 7.84 per cent starts to impede growth in ASEAN-5[5] countries. A threshold inflation of 7.97 per cent is observed for Turkish Republics[6] by Aydin *et al.* (2016).

Another striking feature of the existing empirical literature on the relationship between inflation and economic growth is the lack of a theoretical framework supporting the estimation strategy. As a result, it is natural that the estimates are likely to be subject to the specification error both in terms of omitted or unnecessarily included variables and functional form. Further, these studies on relationship between growth and inflation do not use the simultaneous equation framework and therefore their results suffer from the simultaneity bias (Chaturvedi *et al.*, 2009). When the relationship in a simultaneous

[5] Original five member-countries, namely, Indonesia, Malaysia, Philippines, Singapore, and Thailand

[6] Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, and Turkmenistan

equation model is considered and the tests for causality direction between growth and inflation are conducted by Chaturvedi *et al.* (2009), they find the causality running only from inflation to growth and, that too, negatively for their sample of South-East and South Asian countries. Using only Indian data, however, Dholakia (2014) finds bi-directional causality between growth and inflation. It is important to test the direction of causality and exogeneity to avoid errors and biases in the estimation of the threshold inflation.

The early discussions on inflation-unemployment trade-off in the Indian context could be attributed to Rangarajan (1983) and Dholakia (1990). Rangarajan analyses the relationship for the industrial sector and concludes that there was no trade-off between inflation and unemployment. Dholakia (1990) uses the extended Phillips curve framework for the whole economy and finds a horizontal aggregate supply curve thus denying that there exists a trade-off between inflation and growth in India. These studies were, however, based on the pre-liberalisation period when prices of many commodities were administered. More recent studies by Paul (2009) and Dholakia and Sapre (2012) find an upward sloping aggregate supply curve. Dholakia and Sapre (2012) incorporate the speed of adjustment in the extended Phillips curve framework and find a positive relationship between output and inflation.

For the Indian economy, a number of studies also find evidence of a threshold level of inflation rate beyond which inflation has adverse impact on growth rate, implying a backward-bending dynamic aggregate supply curve. Mostly, these studies use spline regression techniques and provide estimates of threshold inflation in the range of 4-7 per cent (Table 1).

Table 1: Threshold Inflation Estimates for Indian Economy

Study	**Period**	**Inflation Threshold (%)**	**Methodology**	**Measure**	**Data Frequency**
Kannan and Joshi (1998)	1981-1996	6-7	Spline regression	WPI	Annual
Vasudevan, Bhoi and Dhal (1998)	1961-1998	5-7	Spline regression/ Non-linear approach	WPI	Annual/ Monthly
Report on Currency and Finance (2002)	1971-2000	5	Spline regression	WPI	
Singh and Kalirajan (2003)	1971-1998	No Threshold (negative relation between growth and inflation)	Spline regression	WPI	Annual

Bhanumurthy and Alex (2010)	1976-2004/ 1997 Q1-2005 Q4/ Jan 2000-April 2007	4-4.5	Non-linear least squares	WPI	Annual/ Quarterly/ Monthly
Singh, Prakash (2010)	1971-2009	6	Spline regression/ Non-linear least squares	WPI	Annual
RBI Annual Report 2010-11		4 - 6	Spline regression/ Non-linear least squares/ Logistic Smooth Transition Regression		
Pattanaik and Nadhanael (2013)	1972-2011	6	Spline regression, Non-linear approach, VAR	WPI	Annual
IMF (2012)	1996-2012	5-6			Quarterly
Mohanty *et al* (2011)	1996-2011	4-5.5	Spline regression/ Non-linear least squares/ Logistic Smooth Transition Regression	WPI	Quarterly
RBI (2014)	1997-2013	6.2-6.7 (CPI-C)/ 4.6-5.8 (WPI)	Logistic Smooth Transition Regression/ Threshold VAR	WPI/CPI-C	Quarterly
Mohaddes and Raissi (2014)	1989-2013	5.5	Cross-section augmented distributed lag approach, Panel ARDL	CPI-IW	Annual
Behera and Mishra (2017)	1990-2013	4	Spline regression	WPI	Monthly
Rangarajan (2020)	1982-2009	6-7	Non-linear approach/Non-linear Least Squares/ Threshold autoregressive model	WPI	Annual
Dholakia (2020)	1996-2019	5.4-6	Macro-theoretic model	CPI	Annual

Source: Compiled by authors from various sources.

Table 1 shows that the studies in the Indian context have mostly used WPI as a measure of inflation. Moreover, some of the studies have surprisingly used quarterly and monthly data to analyse steady state growth and long run equilibrium inflation rates with a view to estimating the threshold inflation. Since the steady state growth and equilibrium inflation rates are essentially long run concepts, employing monthly or quarterly data for such analysis may not be appropriate as these data typically tend to give more weights to transitory developments. Ideally, the threshold level of inflation as discussed in the previous section should be treated as a long-run concept which can be estimated more meaningfully by using annual data. Moreover, the empirical studies on estimation of threshold level of inflation in the Indian context are largely based on pure statistical exercises without any strong theoretical basis as was the case with most of the cross-country studies mentioned above. This limitation was effectively addressed by Dholakia (2020) by providing a theory of growth and threshold inflation. The Harrod growth model with open economy instead of a closed economy is used as a starting point which makes the natural or potential growth of the economy a variable unlike a constant in the original model. That in itself would ensure balance between the warranted growth and natural growth resulting in a stable steady state growth solution. Introduction of inflation rate as a determinant of the warranted growth through both its components – investment rate and incremental output capital ratio (IOCR) – ensures that the warranted growth rate remains at the maximum level that corresponds to the threshold inflation rate. Based on this theoretical framework, Dholakia (2020) argued that threshold inflation for any economy is not unique but depends on policy parameters like FD/GDP ratio and CAD/GDP ratio. Accordingly, they provided a whole range of estimates of threshold inflation rate in India consistent with alternative values of FD/GDP ratio and CAD/GDP ratio. In the present paper, we apply the framework of Dholakia (2020) by operationalizing their theory with a cross-country estimation of the model.

3. Methodology and Data

The theoretical and methodological framework for estimating threshold inflation is developed in Dholakia (2020) which argues that in an inflation targeting framework of monetary policy, long run inflation becomes a policy parameter and may be treated only as an explanatory variable and the long-term growth as a dependent variable. The lead-lag correlation based on the cross-country panel data also supports such a direction of causality (Table A1). The table reveals that growth leads to inflation with a lag of 2 years and the effect remains over the next five-six years with weak correlations, but inflation leads to growth over a much longer period of eight-nine years and with much stronger correlations. Apart from pointing towards direction of causality, this also suggests that it may be a better idea to work with moving averages of inflation and growth, rather than annual numbers, to address the issue of direction of causality more effectively.[7]

The foundation of the theoretical framework is based on the stable steady state growth solution in an open economy as below:

$$Gn = Gw = G = \frac{s}{ICOR} = s \times IOCR \quad (1)$$

where *Gn*, *Gw* and *G* are respectively the natural, warranted and actual growth rates; *s* is the investment rate defined as a ratio of investment to GDP; *IOCR* is the incremental output capital ratio. This result assumes that the economy is at full employment long run equilibrium in the trade cycle context and hence saving equals investment. In order to get an operational model of threshold inflation, it is essential to relate both the components on the right-hand side of equation (1) to the rate of inflation in the economy. The literature suggests that inflation is one of the determinants of both the investment rate (s) (Ferderer, 1993; Serven and Solimano, 1993; Pindyck and Solimano, 1993; Kalckreuth, 2000; Byrne and Davis, 2004; and Fisher, 2009) and the capital productivity (IOCR) (Rondan and Chavez, 2004). Furthermore, total investment in an economy could come from the government, foreign sources and domestic private investors or firms. As argued in Dholakia (2020), the public investment rate depends on the fiscal policy of the government which is essentially captured by the fiscal deficit to GDP ratio net of effective revenue deficit. Public investment also affects private investment through ‘crowding in’ or ‘crowding out’ (Mitra 2006; Bahal and Raissi, 2015). Private investment also depends upon real interest rate (*r*) through the financing cost channel and opportunity cost channel. Several studies find a negative relationship between real interest rate and corporate investment (Tokuoka, 2012; IMF, 2013). A strand of literature also suggests a positive relationship between inflation and inflation uncertainty and its adverse influence on investment decisions of enterprises (Ferderer, 1993; Serven and Solimano, 1993; Pindyck and Solimano, 1993; Kalckreuth, 2000; Byrne and Davis, 2004; and Fisher, 2009). For India, Tokuoka (2012) finds that volatility of inflation has a negative and significant impact on corporate investment. Regarding the foreign investment, its major determinants could be the real interest rate and Macroeconomic Vulnerability Index (MVI) suggested by GoI (2015), which is defined as

[7]We have examined the direction of causality only between inflation and growth because these are the only endogenous variables in the proposed theoretical framework. FD/GDP and CAD/GDP are treated as exogenous variables in the framework. Moreover, like inflation, they are also policy parameters. Further, we have considered five-year moving average in this paper to address problems of the direction of causality in a steady state framework.

the sum of the three policy parameters, namely inflation rate, fiscal deficit (FD) as a percentage of GDP and the current account deficit on balance of payments (CAD) as a percentage of GDP.

Thus, considering all the three components of the investment rate and the ultimate factors determining each of them, we get the following equation

$$s = \Phi(\pi, FD/GDP, CAD/GDP, r) \tag{2}$$

The next component of our model is the equation for capital productivity or incremental output capital ratio (IOCR). It is important to note that IOCR used in the equation (1) above to define the real growth rate is the capital productivity over time when everything may change. Thus, it is a concept measured through the total differential of the aggregate production function rather than the partial derivative with respect to capital. As a result, total factor productivity growth (TFPG) can be shown to be an integral part of the IOCR[8]. The role of inflation on productivity stems from more efficient allocation of resources due to increased cost of investment (Danquah *et al.,* 2011). Since capacity utilisation measures the extent to which an economy uses its installed production capacity, increase in capacity utilisation would mean more efficient use of resources and hence higher TFPG. The output gap is used as a proxy to measure the capacity utilization (Michaelides and Milios, 2009). Higher fiscal deficit may affect productivity through increased aggregate demand, and current account deficit (CAD) through foreign investment and technology transfer. Thus, considering the ultimate determinants of IOCR as discussed above, we get the following equation for IOCR –

$$IOCR = \Phi(\pi, FD/GDP, CAD/GDP) \tag{3}$$

Considering equations (1) to (3) together, we can express growth in general as –

$$G = \Phi(\pi, FD/GDP, CAD/GDP, r) \tag{4}$$

Since growth (G) is a product of s and IOCR, its precise functional form depends on the functional forms of the two components, particularly with respect to inflation (π). If both the components are linear in π, the equation for growth would be a polynomial of degree two, which is the case considered by Dholakia (2020). However, if any one of the components has a polynomial of degree two or more in π, the equation for G would be a

[8] Let $Y = F(K,L,t)$ be the aggregate production function. Therefore, $dY/dK = (F'_L)*(dL/dK) + (F'_K) + (F'_t)*(dt/dK)$ by taking total differential of Y with respect to K. Dividing the numerator and denominator of the last term on the right-hand side of this equation by Y, we get – $dY/dK = (F'_L)*(dL/dK) + (F'_K) + TFPG/s$.

polynomial of the sum of the two degrees in π. Similarly, the interaction terms would also be accordingly more. Keeping in view the large dataset for estimating the above equation, it would be appropriate to consider cross-country panel data for relatively recent period so that a suitable degree of freedom is obtained without going too far back in time.

After estimating the above equation, the threshold level of inflation may be calculated using the first partial derivative of this equation and first and second order conditions for maximisation. It is evident that there would not be a unique value of threshold inflation since it would depend on the values of other explanatory variables, particularly the policy targets for FD and CAD. This is one of the main contributions of this approach – it allows estimation of the threshold level of inflation which is consistent with other macroeconomic policy parameters.

In view of the above, our country-wise panel dataset, compiled from the *World Economic Outlook* database of the International Monetary Fund (IMF), consists of, *inter alia*, annual time-series data on gross domestic product (GDP), total investment (as per cent of GDP), current account balance (as per cent of GDP), fiscal balance (as per cent of GDP) and consumer price index-based inflation for 194 countries from 1980 to 2018. Data on crude oil prices (WTI Brent Crude) and terms of trade were extracted from *Bloomberg* and IMF's commodity terms of trade database. We rank all the countries on the basis of their share in annual World GDP in 2017[9] and select the top 65 countries that together represent 95 per cent of the total World GDP. Out of these, we further select the countries having continuous data on all four variables for our entire sample period from 1995 to 2018. This leaves us with a panel dataset of 58 countries in total which includes 26 advanced economies (AEs) and 32 emerging market economies (EMEs). In order to smooth out plausible short- and medium-term business cycle fluctuations, we treat all variables by computing a five year-moving average for each of them. Additionally, since some of the countries in our sample (such as Brazil, Russia, Poland and Turkey) experienced bouts of very high inflation, especially during the early 1990s, the data is winsorized in order to limit the effect of outliers on our econometric exercise described next.

The final data set used for estimation showed an average growth rate of 3.5 per cent for the full sample with a standard deviation of 3.6 per cent. The inflation rate, on the other hand, showed larger variation with standard deviation of 15.1 per cent and an

[9] Country-wise share in World GDP as of 2018 was not used since it was not available for many countries and/or was based on provisional estimates at the time data was obtained.

average of 8.3 per cent. The variations in growth and inflation rates were larger in the case of emerging market economies compared with advanced economies. Advanced economies in the sample, on an average, showed surplus in the current account while the current account of emerging market economies was in deficit. It may be noted that the overall current account is negative and not in balance. This is because the average has been computed for each country on the basis of ratios of respective country's GDP which need not be zero. Another reason is because many smaller countries are not part of the sample. Gross fiscal deficit showed a more or less similar pattern across advanced and emerging market economies, partly reflecting the impact of winsorization (Table 2).

Table 2: Summary Statistics for the Final Panel Data Sample used in the Study

Country Sample/ Statistics	GDP Growth (%)	Inflation Rate (%)	CAD (% of GDP)	Fiscal Deficit (% of GDP)
Full Sample				
Mean	3.5	8.3	-0.7	2.1
Median	3.4	3.5	0.3	2.4
Min	-7.3	-1.2	-23.8	-11.6
Max	12.7	80.9	24.3	13.5
Std. Dev	3.6	15.1	6.1	4.2
Advanced Economies				
Mean	2.6	2.4	-1.9	2.0
Median	2.5	2.0	-1.3	2.3
Min	-7.3	-1.2	-23.8	-11.6
Max	12.7	20.3	14.5	13.5
Std. Dev	2.8	2.5	5.8	4.2
Emerging Market Economies				
Mean	4.3	13.1	0.3	2.2
Median	4.7	6.8	1.2	2.5
Min	-7.3	-1.2	-23.8	-11.6
Max	12.7	80.9	24.3	13.5
Std. Dev	4.0	19.0	6.1	4.2

4. Empirical Estimates

As discussed above, the benefit of using cross-country panel data is a considerably large number of observations that would allow estimating higher-order polynomials of the reduced-form equation for long-run growth with adequate degrees of freedom. Similarly, this also makes it possible to study the non-linear relationship between inflation and long-run growth simultaneously for developed and developing countries. With a view to obtain the appropriate order of polynomial, we begin by separately estimating the equation for investment rate as a function of its own lagged value, inflation, current account deficit and fiscal deficit (equation 2). Since inflation is our primary variable of interest, we consider both linear and quadratic forms of relationship between investment rate and inflation. Using measures for goodness of fit (adj-R^2) and Bayesian information criterion (BIC) for model selection, we find that a quadratic form of relationship between investment and rate of inflation provides the best fit (Table A2). We repeat the same exercise for IOCR – the other main determinant of long-run growth in our model apart from rate of investment – and find that a linear form of relationship between IOCR and inflation provides the best fit (Table A3). Combining these results would give a cubic form of relationship in the reduced form equation of growth on inflation. Speaking mathematically, this implies that there is a possibility of finding a growth-maximizing rate of inflation (the local maxima) and a growth-minimizing inflation rate (the local minima). Although our interest lies in finding the growth-maximizing rate of inflation, it would be interesting to get an idea about the growth-minimizing rate of inflation and the corresponding growth rate. Fiscal deficit and current account deficit are other determinants of long-run growth. Therefore, the final model can be depicted as shown below:

$$G_{it} = \alpha + \Sigma\delta_i + \Sigma\lambda_t + \beta_1\pi_{i,t-1}^3 + \beta_2\pi_{i,t-1}^2 + \beta_3\pi_{i,t-1} + \beta_4 CAD_{i,t-1}^2 + \beta_5 FD_{i,t-1}^2 + \beta_5 CAD_{i,t-1} + \beta_6 FD_{i,t-1} + \gamma_1 CAD_{i,t-1}\pi_{i,t-1}^2 + \gamma_2 CAD_{i,t-1}\pi_{i,t-1} + \gamma_3 FD_{i,t-1}\pi_{i,t-1}^2 + \gamma_4 FD_{i,t-1}\pi_{i,t-1} + \varepsilon_{i,t}\ (i = 1..N; t = 1..T) \quad (5)$$

where, G_{it}, $\pi_{i,t-1}$, $CAD_{i,t-1}$, $FD_{i,t-1}$ represent the GDP growth rate, inflation, current account deficit and fiscal deficit as proportions of GDP of country *i* at time *t or t-1,* respectively; β_i represent the slope coefficients, γ_i are the interaction coefficients and $\varepsilon_{i,t}$ is the error term. Considering the empirical form of the growth model as described above, we estimate a panel regression model with country-fixed effects (δ_i) to control country-level heterogeneity in our panel dataset. Standard statistical tests suggest the presence of serial correlation, heteroscedasticity and cross-sectional dependence in our model, which may arise due to unobserved shocks or policies, prompting us to estimate the model with robust standard errors (Driscoll and Kraay, 1998; Hoechle, 2007). Further, we also include time-fixed effects (λ_t) in the model to control the effect of any large-scale macroeconomic fluctuations or technological changes that may have uniformly impacted all countries across time.

The full and sub-sample regression estimates have been provided in Table 3. Panel (A) represents our baseline model estimated for the full sample where long-run growth is assumed to depend non-linearly on inflation, fiscal deficit and current account deficit. In panel (B) and (C) of Table 3, the same model has been estimated for Advanced Economies (AEs) and Emerging Market Economies (EMEs) separately. The estimations suggest a satisfactory goodness of fit considering that there are a large number of independent variables, heterogeneities in the dataset and that all variables are proportions (measured as percentages). Redundant variable and Wald tests confirmed that the higher polynomials of order 2 and 3 of inflation rate were significant at 10 per cent level of significance (Table A4).

Table 3: Growth Regressions - Results

Explanatory variable	Full Sample (A) GDPg	AEs (B) GDPg	EMEs (C) GDPg
Inf^3(-1)	0.0000257 (0.0000208)	0.000219 (0.00301)	0.0000123 (0.0000240)
Inf^2(-1)	-0.00336* (0.00192)	-0.0401 (0.0402)	-0.00214 (0.00223)
Inf(-1)	0.116** (0.0473)	0.372 (0.228)	0.117** (0.0457)
CAD^2(-1)	0.00436** (0.00181)	-0.000367 (0.00324)	0.0129*** (0.00260)
FD^2(-1)	-0.00234 (0.00525)	-0.0114* (0.00619)	0.00185 (0.0133)
FD(-1)*Inf^2(-1)	-0.000158 (0.000169)	0.00422 (0.00463)	-0.000239 (0.000152)
FD(-1)*Inf(-1)	-0.00431 (0.00742)	-0.0140 (0.0418)	0.00800 (0.00805)
CAD(-1)*Inf^2(-1)	0.0000809 (0.0000787)	-0.0183** (0.00695)	0.000149* (0.0000748)
CAD(-1)*Inf(-1)	-0.00400 (0.00600)	0.0642* (0.0365)	-0.0122** (0.00514)
FD(-1)*CAD(-1)	-0.0182*** (0.00483)	-0.00867 (0.00781)	-0.0347*** (0.00753)
FD(-1)	-0.163** (0.0765)	-0.0253 (0.0671)	-0.421*** (0.0699)
CAD(-1)	-0.0297 (0.0441)	-0.177*** (0.0583)	0.183*** (0.0364)
Constant	3.474*** (0.309)	2.144*** (0.475)	4.357*** (0.218)
adj. R^2	0.3205	0.5504	0.4419
N	1218	586	632

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Country FE = Yes; Time FE = Yes.
Source: Authors' estimates.

Based on these regression estimates, the optimum values of steady state growth rate and threshold inflation rate, for alternative values of the fiscal deficit and current account deficit, are provided in Table 4. If we consider a fixed value for fiscal deficit (FD/GDP) at 6.0 per cent and for current account deficit (CAD/GDP) at 2.0 per cent of GDP, our model predicts a threshold inflation rate of 11.0 per cent for the full sample, 4.2

per cent for advanced economies but a much higher threshold rate of inflation at 24.9 per cent for emerging economies. It may be noted that in our empirical strategy, we have used lagged values to address the issue of endogeneity inherent in a regression involving growth, inflation, FD, and CAD. As a further robustness check, we employ dynamic panel generalized method of moments (GMM) for estimation of the above equation. The GMM results are broadly in line with the OLS estimates. For the full sample, threshold inflation varies from 6.3 per cent to 13.8 per cent, and the optimal growth rate lies in a range of 4.8 per cent to 6.0 per cent for different values of FD and CAD (Table A5 and A6).

Table 4: Threshold inflation and Optimal Growth Estimates

(per cent)

FD (as % of GDP)	**CAD** (as % of GDP)	**Full Sample**		**Advanced Economies**		**EMEs**	
		Threshold inflation	Growth rate	Threshold inflation	Growth rate	Threshold inflation	Growth rate
3.00	2.00	15.40	3.64	3.65	2.24	28.55	5.23
3.00	2.50	15.25	3.59	3.40	2.14	27.90	5.19
6.00	**2.00**	**11.00**	**2.73**	**4.16**	**1.84**	**24.86**	**3.94**
6.00	2.50	10.83	2.66	3.78	1.70	24.33	3.86
6.50	2.00	10.43	2.59	4.28	1.75	24.47	3.74
6.50	2.50	10.26	2.51	3.86	1.61	23.96	3.64
7.00	2.00	9.89	2.44	4.40	1.66	24.11	3.53
7.00	2.50	9.72	2.36	3.95	1.52	23.62	3.43

Source: Authors' estimates.

Our model can be flexibly extended to generate country-specific estimates through appropriate adjustments. To show this, we include a binary independent variable for India in our baseline regression model for growth. We also introduce a slope dummy variable by interacting a binary variable with inflation to obtain India-specific estimates. This model specification essentially adjusts the average mean growth rate and slope of equation with respect to inflation for the sample to derive India-specific estimates[10], presented below in Table 5. For macroeconomic policy targets consistent with maintaining fiscal deficit at 6.0 per cent and current account deficit at 2.0 per cent of GDP, our estimates suggest a threshold inflation level of 6.1 per cent and optimal growth rate of 7.5 per cent for India.

[10] It may be noted that estimates for a specific country derived from the international panel data by introducing a binary variable for the country may be very different from the estimates based exclusively on the country's time series data. This happens because, while the degrees of freedom are higher with more appropriate functional form in the case of the former compared to the latter, the estimates of the error variance – co-variance matrix also differ considerably in the two cases. In the former, they depend on all countries included in the sample that are not strictly comparable to the specific country in question. As a result, the estimates based on the international panel data for a country may be considered as a broad benchmark and the precise estimates for further use in policy making should be derived from exclusive data on the country.

Chart 1 provides the estimated growth - inflation scenarios in India given the alternative combinations of the other policy targets – fiscal deficit and current account deficit as proportion of GDP.[11] The chart shows that the local maximum and minimum values of growth rate with respect to inflation rate in India are very close. The growth is maximized at around 6 per cent of long-term inflation rate and is minimized around 9.5 per cent of inflation. If we consider the inflation target at 4 per cent instead of the threshold level of 6 per cent, the long-term growth rate would decline by about 80 basis points (bps). On the other hand, if we consider the inflation target of 8 per cent instead of the threshold level of 6 per cent, the long-term growth rate would decline by only about 30 bps. Thus, the trade-off between long-term inflation and growth is not symmetric on both sides of the threshold inflation. When the inflation target is less than the threshold level, the sacrifice is 0.4 per cent point growth per one per cent point reduction in long-term inflation. However, if the inflation target exceeds the threshold level, the sacrifice of growth is only 0.15 per cent point per one per cent point increase in the long-term inflation.

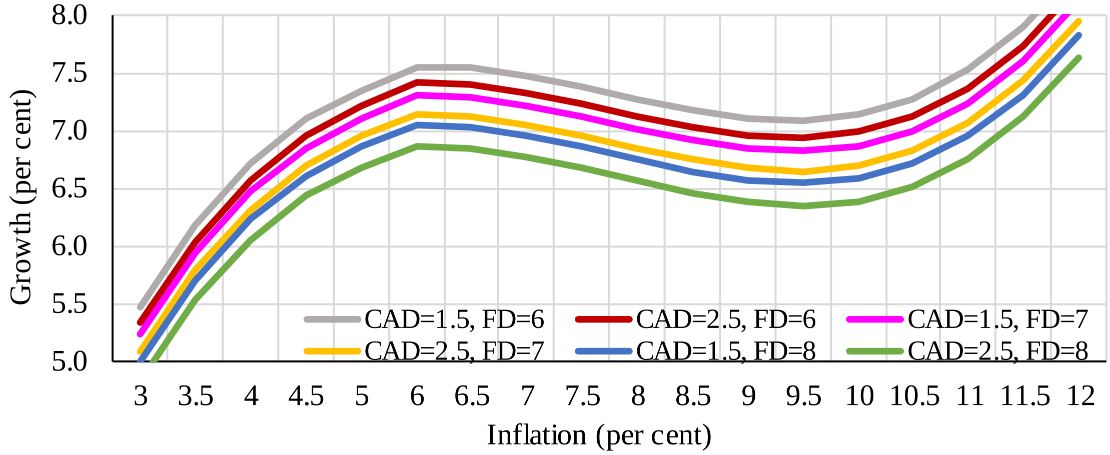
Table 5: India-specific Threshold inflation and Optimal Growth Estimates

FD (as % of GDP)	**CAD** (as % of GDP)	**Threshold Inflation** (per cent)	**Growth Rate** (per cent)
5.0	2.0	6.15	7.74
5.0	2.5	6.15	7.68
6.0	2.0	6.13	7.48
6.0	2.5	6.12	7.41
7.0	2.0	6.10	7.22
7.0	2.5	6.10	7.14
8.0	2.0	6.08	6.96
8.0	2.5	6.08	6.87

Source: Authors' estimates.

[11] It is seen from Table 5 and Chart 1 that both threshold inflation and corresponding growth rates are lower when CAD/GDP or FD/GDP are rising other things remaining the same. Compared to the average FD/GDP and CAD/GDP for the whole sample, the Indian numbers are quite large. If the relationship between growth and these two variables is non-monotonic like with inflation, the reported results could be explained. Since the focus of the current study is on threshold inflation, we have not probed into those relationships, which in any case would require a separate study.

Chart 1: Long Run Trade-Off between Inflation and Growth in India



Source: Authors' estimates.

Since the estimates generated from any model could be sensitive to model specification and sampling, we subject our model to sensitivity checks based on inclusion of other exogenous variables and sampling (Table A7). Table 6 shows the threshold inflation and growth estimates after adding terms of trade (ToT) as an additional independent variable in our growth regression model[12]. Similarly, Table 7 shows the estimates based on model estimated for panel of countries that are net importers of crude oil[13]. Note that derived estimates for threshold inflation and optimal growth are very similar to those presented earlier.

Table 6: Threshold Inflation and Optimal Growth Estimates with Terms of Trade

(per cent)

FD (as % of GDP)	**CAD** (as % of GDP)	**Full Sample**		**EMEs**	
		Threshold inflation	Growth rate	Threshold inflation	Growth rate
3.0	2.0	18.35	3.55	31.60	5.10
3.0	2.5	17.99	3.49	30.50	5.00
6.0	**2.0**	**11.66**	**2.44**	**26.64**	**3.50**
6.0	2.5	11.36	2.36	25.62	3.38
6.5	2.0	10.65	2.26	25.94	3.24
6.5	2.5	10.35	2.18	24.94	3.11
7.0	2.0	9.65	2.09	25.28	2.97
7.0	2.5	9.36	2.00	24.29	2.84

Source: Authors' estimates.

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[12] Terms of trade data has been sourced from International Monetary Fund.

[13] Information on country-wise net exports of crude oil has been taken from the Energy Information Administration website - https://www.eia.gov/.

Table 7: Threshold Inflation and Optimal Growth Estimate for Oil Importing Nations

FD (as % of GDP)	CAD (as % of GDP)	Oil importing countries	
		Threshold inflation (%)	Growth rate (%)
3.0	2.0	15.91	5.20
3.0	2.5	16.63	5.24
6.0	**2.0**	**13.49**	**4.17**
6.0	2.5	14.25	4.18
6.5	2.0	13.06	3.99
6.5	2.5	13.83	3.99
7.0	2.0	12.61	3.81
7.0	2.5	13.39	3.81

Source: Authors' estimates.

5. Concluding Remarks

The study draws upon literature on economic growth which suggests that growth depends on investment rate and productivity of capital. Inflation rate influences investment rate through the uncertainty channel. Apart from the inflation rate, fiscal and current account deficit are other major determinants of investment. Similarly, capital productivity is also influenced by inflation that allows flexibility in relative prices for the necessary structural changes in the economy. Thus, the proposed framework entails a non-linear relationship between long-term steady state economic growth and long run equilibrium inflation.

The major aim of this study was to consider a proper functional form for estimating a threshold level of inflation consistent with theoretical foundations. Cross country panel data provide enough degrees of freedom to experiment with alternative functional forms. The empirical evidence suggests that the appropriate functional form for long-term growth is a polynomial of third degree in π, and second degree in FD/GDP and CAD/GDP ratios. The long-term growth-maximizing level of equilibrium inflation rate is the threshold inflation for an economy. A cubic function also provides the opposite of threshold inflation, *i.e.,* the growth-minimizing inflation rate. Empirical exercise carried out in the present paper suggests that the growth-maximizing inflation rate is lower than the growth-minimizing inflation rate given the values of FD/GDP and CAD/GDP ratios. It is not theoretically correct to say, therefore, that any higher rate of inflation than the threshold level is always inimical to growth[14]. On the other hand, it is correct to say that an inflation rate lower than the threshold rate is always harmful to growth. Therefore, it is extremely important for the policy makers to identify the threshold level of inflation in the economy. It is also clear from the discussion of the concept and the empirical exercise carried out in the present paper that the threshold inflation is not unique in an economy, but always varies with the values of FD/GDP and CAD/GDP ratios. Thus, setting internally consistent targets for FD/GDP ratio, CAD/GDP ratio, inflation rate and real growth rate is crucial for efficient macroeconomic management. If targets for this quartet are fixed independently of each other, they can result in substantial avoidable cost to the system, not only because the system would not be able to achieve all the targets, but also because the system would remain in disequilibrium requiring unnecessary policy interventions or adjustment costs.

This, however, does not imply that the policy makers have to set the inflation target at the threshold level given the targets for the CAD/GDP and FD/GDP ratios. If the threshold inflation rate is somehow considered to be too high, the policy makers can choose a lower inflation target only by consciously sacrificing long-term real growth of GDP. The present paper has provided clear theoretical and empirical evidence that inflation - growth trade-off exists even in the long run. Those who firmly believe in the lack of any trade-off between inflation and growth (employment) in the long run and frame policies and targets accordingly are prone to ignore huge social costs of such policies. This point can be illustrated with the Indian case. Dholakia and Kadiyala (2017) estimate that a cumulative sacrifice of 3 to 4 per cent of GDP is involved to bring down the equilibrium inflation rate by one percentage point. Exercise undertaken in the present study suggests that the long-term growth would fall by 40 basis points (or 0.4 percentage point) per one percent point reduction in inflation if the initial inflation rate was less than the threshold rate. However, if the initial inflation rate was higher than the threshold rate, it would result in an increase of long-term growth by 15 basis points. Even in the latter case, it would take more than two decades to recover the cost of sacrificing GDP to bring down the equilibrium rate of inflation. In the former case, the cost only compounds. Thus, the costs and benefits of fixing a long-term inflation target will have to be weighed carefully while making the choice.

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[14] This is because the cubic function (polynomial of degree three) has local maxima and minima that would be different from the global maxima and minima, which are associated with infinite values in both directions. If, however, the local growth minimizing inflation rate was lower than the local growth-maximizing inflation rate, it would be correct to say that higher inflation rate than the threshold level will always be inimical to growth.

References

Akerlof, G. A., Dickens, W. T., Perry, G. L., Bewley, T. F., & Blinder, A. S. (2000). Near-rational wage and price setting and the long-run Phillips curve. *Brookings papers on economic activity*, *2000*(1), 1-60.

Aydın, C., Esen, Ö., & Bayrak, M. (2016). Inflation and economic growth: a dynamic panel threshold analysis for Turkish Republics in transition process. *Procedia-Social and Behavioral Sciences*, *229*, 196-205.

Bahal, R., & Raissi, M. T. (2015). Crowding-Out or Crowding-In? Public and Private Investment in India. Working Paper WP/15/264, International Monetary Fund, Washington D.C., USA.

Bailey, M. J. (1956). The welfare cost of inflationary finance. *Journal of political Economy*, *64*(2), 93-110.

Ball, L. (1992). Why does high inflation raise inflation uncertainty? *Journal of Monetary Economics*, *29*(3), 371-388.

Behera, J., & Mishra, A. K. (2017). The recent inflation crisis and long-run economic growth in India: An empirical survey of threshold level of inflation. *South Asian Journal of Macroeconomics and Public Finance*, *6*(1), 105-132.

Bernanke, B. S. (1993). Credit in the Macroeconomy. *Quarterly Review-Federal Reserve Bank of New York*, *18*, 50-50.

Bertola, G., & Caballero, R. J. (1994). Irreversibility and aggregate investment. *The Review of Economic Studies*, *61*(2), 223-246.

Bhanumurthy, N. R., & Alex, D. (2010). Threshold Level of inflation for India (No. Institute of Economic Growth Discussion Paper Series No. 124/2008). *New Delhi: University Enclave*.

Bick, A. (2010). Threshold effects of inflation on economic growth in developing countries. *Economics Letters*, *108*(2), 126-129.

Briault, C. (1995). The costs of inflation. *Bank of England Quarterly Bulletin*, *35*(1), 33-45.

Burdekin, R. C., Denzau, A. T., Keil, M. W., Sitthiyot, T., & Willett, T. D. (2004). When does inflation hurt economic growth? Different nonlinearities for different economies. *Journal of Macroeconomics*, *26*(3), 519-532.

Byrne J. P., Davis E. P., 2004. Permanent and Temporary Inflation Uncertainty and Investment in the United States. *Economics Letters* 85(2): 271-277.

Chari, V. V., Christiano, L. J., & Kehoe, P. J. (1996). Optimality of the Friedman rule in economies with distorting taxes. *Journal of Monetary Economics*, *37*(2), 203-223.

Chaturvedi, V., Kumar, B., & Dholakia, R. H. (2009). Inter-Relationship between Economic Growth, Savings and Inflation in Asia. *Journal of International Economic Studies*, *23*, 1-22.

Choi, S., Smith, B. D., & Boyd, J. H. (1996). Inflation, Financial Markets, and Capital Formation. Federal Reserve Bank of St. Louis Review, 78, 9-35.

Chowdhury, A., & Ham, R. (2009). Inflation targeting in Indonesia: Searching for a threshold. The Singapore Economic Review, 54(04), 645-655.

Danquah, M., Moral-Benito, E., & Ouattara, B. (2011). TFP growth and its determinants: nonparametrics and model averaging. *Banco de Espana Working Paper* No. 1104.

Das, A., & Loxley, J. (2015). Non-linear relationship between inflation and growth in developing countries. *Economic & Political Weekly*, *50*(37), 59-64.

David, D., Pedro, G. P., & Paula, H. E. (2005). *Threshold effects in the relationship between inflation and growth: a new panel-data approach* (No. 38225). University Library of Munich, Germany.

Dholakia, R H (1990). Extended Phillips Curve for the Indian Economy. *Indian Economic Journal*, 38 (1), pp 69-78.

Dholakia, R. H. (2014 a). Sacrifice Ratio and Cost of Inflation for the Indian Economy. *Indian Institute of Management Ahmedabad, Working Paper No.* WP2014-02-04.

Dholakia, R. H. (2014 b). Cost and Benefit of Disinflation Policy in India. *Economic and Political Weekly,* 49(28), July 12; pp.165-169.

Dholakia, R. H., & Sapre, A. A. (2012). Speed of Adjustment and Inflation–Unemployment Trade-off in Developing Countries–Case of India. *Journal of Quantitative Economics*, 10(1), pp. 1-16.

Dholakia, R.H. and Kadiyala, V.S. (2017). How Costly is the Deliberate Disinflation in India? – Estimating the Sacrifice Ratio. *Journal of Quantitative Economics*, 15(1), pp. 27-44.

Dholakia, R. H. (2020). “A Theory of Growth and Threshold Inflation with Estimates”, (Presidential Address by Ravindra H. Dholakia to the annual conference of The Indian Econometric Society, Madurai on Jan.8, 2020), *Journal of Quantitative Economics*, 18(3), Sept. 2020, pp.471-493.

Driscoll, J. C., & Kraay, A. C. (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of economics and statistics*, 80(4), 549-560.

Eggoh, J. C., & Khan, M. (2014). On the nonlinear relationship between inflation and economic growth. *Research in Economics*, *68*(2), 133-143.

Espinoza, R., Leon, H., & Prasad, A. (2011). When should we worry about inflation?. *The world bank economic review*, *26*(1), 100-127.

Ferderer J. P., 1993. The Impact of Uncertainty on Aggregate Investment Spending: An Empirical Analysis. *Journal of Money, Credit and Banking* 25(1): 30-48.

Fisher G., 2009. Investment Choice and Inflation Uncertainty, London School of Economics, mimeo.

Friedman, M. (1969). *The optimum quantity of money, and other essays* (No. HG538 F866).

Friedman, M. (1977). Nobel lecture: inflation and unemployment. *Journal of political economy*, *85*(3), 451-472.

Ghosh, A., & Phillips, S. (1998). Warning: Inflation may be harmful to your growth. *Staff Papers*, *45*(4), 672-710.

GoI (2015). *Economic Survey 2014-15*, Ministry of Finance, New Delhi, July.

GoI (2019): *Economic Survey 2018-19,* Ministry of Finance, New Delhi, July.

Harrod, R. F. (1948). *Towards a Dynamic Economics: Some recent developments of economic theory and their application to policy*. MacMillan and Company, London.

Haslag, J. (1995). *Inflation and intermediation in a model with endogenous growth* (No. 9502). Federal Reserve Bank of Dallas.

Haslag, J. H. (1997). Output, growth, welfare, and inflation: a survey. *Economic Review-Federal Reserve Bank of Dallas*, 11-21.

Hoechle, D. (2007). Robust standard errors for panel regressions with cross-sectional dependence. *The stata journal*, *7*(3), 281-312.

IMF. (2013). IMF Country Report No. 13/37: India Article IV Consultation. International Monetary Fund, Washington D.C., USA.

Jha, R., & Dang, T. N. (2012). Inflation variability and the relationship between inflation and growth. *Macroeconomics and Finance in Emerging Market Economies*, *5*(1), 3-17.

Kalckreuth von U., 2000. Exploring the Role of Uncertainty for Corporate Investment Decisions in Germany, *Deutsche Bundesbank Research Centre Discussion Paper Series. Economic Studies* 05.

Kannan, R., & Joshi, H. (1998). Growth-inflation trade-off: Empirical estimation of threshold rate of inflation for India. *Economic and Political Weekly*, 2724-2728.

Khan, M. S., & Senhadji, A. S. (2001). Threshold effects in the relationship between inflation and growth. *IMF Staff papers*, *48*(1), 1-21.

Kremer, S., Bick, A., & Nautz, D. (2013). Inflation and growth: new evidence from a dynamic panel threshold analysis. *Empirical Economics*, *44*(2), 861-878.

Michaelides, P., & Milios, J. (2009). TFP change, output gap and inflation in the Russian Federation (1994–2006). *Journal of economics and business*, *61*(4), 339-352.

Mitra, P. (2006). Has government investment crowded out private investment in India?. *American Economic Review*, 96(2), 337-341.

Mohaddes, M. K., & Raissi, M. M. (2014). Does Inflation Slow Long-Run Growth in India? (No. 14-222). *International Monetary Fund.*

Mohanty, D., Chakraborty, A. B., Das, A., & John, J. (2011). Inflation Threshold in India: An Empirical Investigation. *Reserve Bank of India Working Paper Series*, (*18/2011).*

Mubarik, Yasir A., (2005). Inflation and Growth: An Estimate of the Threshold Level of Inflation in Pakistan. *SBP-Research Bulletin*, *1*(1), 35- 44.

Mundell, R. (1963). Inflation and real interest. *Journal of Political Economy*, *71*(3), 280-283.

Munir, Q., & Mansur, K. (2009). Non-linearity between inflation rate and GDP growth in Malaysia. *Economics bulletin*, *29*(3), 1555-1569.

Omay, T., & Kan, E. Ö. (2010). Re-examining the threshold effects in the inflation–growth nexus with cross-sectionally dependent non-linear panel: Evidence from six industrialized economies. *Economic Modelling*, *27*(5), 996-1005.

Palley, T. I. (2003). The backward–bending Phillips Curve and the minimum unemployment rate of inflation: Wage adjustment with opportunistic firms. *The Manchester School*, *71*(1), 35-50.

Palley, T. I. (2011). *Monetary Union Stability: The Economics of the Phillips Curve: Formation of Inflation Expectations versus Incorporation of Inflation Expectations* (No. 4-2011). IMK at the Hans Boeckler Foundation, Macroeconomic Policy Institute.

Pattanaik, S., & Nadhanael, G. V. (2013). Why persistent high inflation impedes growth? An empirical assessment of threshold level of inflation for India. *Macroeconomics and Finance in Emerging Market Economies*, *6*(2), 204-220.

Paul, B P (2009). In Search of the Phillips Curve for India. *Journal of Asian Economics*, 20, pp 479-88.

Phelps, E. S. (1967). Phillips curves, expectations of inflation and optimal unemployment over time. *Economica*, 254-281.

Phelps, E. S. (1968). Money-wage dynamics and labor-market equilibrium. *Journal of political economy*, *76*(4, Part 2), 678-711.

Phelps, E. S. (1973). Inflation in the theory of public finance. *The Swedish Journal of Economics*, 67-82.

Phillips, A. W. (1958). The relation between unemployment and the Rate of change of money wage rates in the United Kingdom, 1861–1957 1. *Economica*, *25*(100), 283-299.

Pindyck R. S., Solimano A., 1993. Economic Instability and Aggregate Investment. *NBER Working Papers* 4380.

Pindyck, Robert S. (1991). Irreversibility, Uncertainty, and Investment. *Journal of Economic Literature*, 29 (3), 1110-1148.

Rangarajan, C (1983): "Conflict between Employment and Inflation" in A Robinson *et al* (ed.), *Employment Policy in a Developing Country: A Case Study of India* (London: Macmillan).

Rangarajan, C. (2020). The New Monetary Policy Framework-What it Means*.* *Journal of Quantitative Economics*, Vol. 18, No.2, May 2020, pp. 457-470.

RBI (2002): *Report on Currency and Finance, 2001-02*, Reserve Bank of India, Mumbai.

RBI (2011): Annual Report, 2010-11, Reserve Bank of India, Mumbai.

RBI. (1985). Report of the Committee to Review the Working of the Monetary System (Chairman: Sukhamoy Chakravarty), Reserve Bank of India.

RBI. (2013). Real Interest Rate impact on Investment and Growth–What the Empirical Evidence for India Suggests? RBI Project Research Study, Reserve Bank of India, Mumbai, India.

RBI. (2014). Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework (Chairman: Urjit R. Patel), Reserve Bank of India.

Risso, W. A., & Carrera, E. J. S. (2009). Inflation and Mexican economic growth: long-run relation and threshold effects. *Journal of Financial Economic Policy*, *1*(3), 246.Ronald I. McKinnon. (1973). *Money and capital in economic development*. Brookings Institution Press.

Rondan, N. R. R., & Chavez, J. C. A. (2004). High inflation, volatility and total factor productivity. *Banco Central De Reserva Del Peru*, (*5*), 1-18.

Samuelson, P. A., & Solow, R. M. (1960). Analytical aspects of anti-inflation policy. *The American Economic Review*, *50*(2), 177-194.

Sarel, M. (1996). Nonlinear effects of inflation on economic growth. *Staff Papers*, *43*(1), 199-215.

Serven, L., & Rangarajanmano, A. (1993). Economic adjustment and investment performance in developing countries: The experience of the 1980s. *Striving for Growth after Adjustment: The Role of Capital Formation*, 147-180.

Sidrauski, M. (1967a). Rational Choice and Patterns of Growth in a Monetary Economy. *American Economic Review*, 57 (5), 534-544.

Sidrauski, M. (1967b). Inflation and economic growth. *Journal of political economy*, *75*(6), 796-810.

Singh, K., & Kalirajan, K. (2003). The inflation-growth nexus in India: an empirical analysis. *Journal of Policy Modeling*, *25*(4), 377-396.

Singh, P. (2010). Searching threshold inflation for India. *Economics Bulletin*, *30*(4), 3209-3220.

Stockman, A. C. (1981). Anticipated inflation and the capital stock in a cash in-advance economy. J*ournal of Monetary Economics*, *8*(3), 387-393.

Thanh, S. D. (2015). Threshold effects of inflation on growth in the ASEAN-5 countries: A Panel Smooth Transition Regression approach. *Journal of Economics, Finance and Administrative Science*, *20*(38), 41-48.

Tobin, J. (1965). Money and economic growth. *Econometrica: Journal of the Econometric Society*, 671-684.

Tokuoka, K. (2012). *Does the Business Environment Affect Corporate Investment in India?* (No. 12-70). International Monetary Fund.

Vaona, A., & Schiavo, S. (2007). Nonparametric and semiparametric evidence on the long-run effects of inflation on growth. *Economics Letters*, *94*(3), 452-458.

Vasudevan, A., Bhoi, B. K., & Dhal, S. C. (1998). Inflation rate and optimal growth: Is there a gateway to nirvana. *Fifty Years of Developmental Economics: Essays in Honour of Prof. Brahmananda*, 50-67.

Vinayagathasan, T. (2013). Inflation and economic growth: A dynamic panel threshold analysis for Asian economies. *Journal of Asian Economics*, *26*, 31-41.

Appendix

Table A1: Lead-Lag Correlations between Inflation and Growth using Panel Annual Data

Sample: 1994 2018
Included observations: 1439
Correlations are asymptotically consistent approximations

CPI_YOY_WIN,RGDP_YOY_WIN(-i)	CPI_YOY_WIN,RGDP_YOY_WIN(+i)	i	lag	lead
		0	-0.0363	-0.0363
		1	0.0012	0.0291
		2	0.0474	0.0635
		3	0.0602	0.0730
		4	0.0709	0.0981
		5	0.0545	0.1495
		6	0.0563	0.1797
		7	0.0585	0.1854
		8	0.0497	0.2046
		9	0.0299	0.1969
		10	0.0081	0.1895
		11	0.0201	0.1612
		12	0.0194	0.1331
		13	0.0077	0.0767
		14	0.0113	0.0292
		15	0.0126	0.0092

Source: Authors' estimates.

Table A2: Investment Rate Models

Dep. Var. / *Exp. Var.*	inv_rate	inv_rate	inv_rate	inv_rate
inv_rate(-1)	0.938*** (0.0129)	0.933*** (0.0143)	0.939*** (0.0128)	0.933*** (0.0142)
Inflation^2	-0.000514** (0.000189)	-0.000452** (0.000218)	-0.000510** (0.000188)	-0.000447* (0.000216)
Inflation	0.00761 (0.0148)	0.00536 (0.0159)	0.00713 (0.0146)	0.00486 (0.0158)
CAD	0.0319** (0.0130)	0.0381*** (0.0102)	0.0318** (0.0129)	0.0383*** (0.0102)
FD	-0.134*** (0.0273)	-0.136*** (0.0263)	-0.133*** (0.0270)	-0.136*** (0.0261)
ToT		1.070 (1.081)		1.104 (1.073)
Δlnoilprice			0.0937 (0.118)	0.0884 (0.117)
Constant	1.786*** (0.374)	0.874 (0.977)	1.771*** (0.365)	0.831 (0.964)
Within-R^2	0.9317	0.9319	0.9317	0.9320
Country FE	Y	Y	Y	Y
Year FE	N	N	N	N
N	1244	1212	1244	1212

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: IOCR - Final Model

Dep. Var. / *Exp. Var.*	IOCR
IOCR(-1)	0.828*** (0.0312)
Inflation	0.000700** (0.000270)
CAD	-0.00341*** (0.000640)
FD	0.00102 (0.000933)
Constant	0.0150*** (0.00471)
Within-R^2	0.7438
Country FE	Y
Time FE	Y
N	1241

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: Redundant Variables and Wald Test

Redundant Variables Test			
	Value	df	Probability
F-statistic	2.321000	(2, 822)	0.0988
Likelihood ratio	5.107604	2	0.0778

Wald Test:			
Equation: FIXEDEFF Null Hypothesis: C(2)=C(3)=0			
Test Statistic	**Value**	**df**	**Probability**
F-statistic	2.321000	(2, 822)	0.0988
Chi-square	4.642000	2	0.0982

Table A5: Full Sample Panel GMM Estimates for Robustness Check

Dependent variable ***Explanatory variable***	GDPg
GDPg(-1)	0.2810082*** (0.0776342)
Inf^3(-1)	0.0001463** (0.0000782)
Inf^2(-1)	-0.0047006 (0.0062644)
Inf(-1)	-0.013463 (0.1229162)
CAD^2(-1)	0.0214922 (0.0134462)
FD^2(-1)	-0.118229*** (0.0297729)
FD(-1)*Inf^2(-1)	-0.0038194*** (0.0008908)
FD(-1)*Inf(-1)	0.1325647*** (0.0389756)
CAD(-1)*Inf^2(-1)	0.0009749*** (0.0002443)
CAD(-1)*Inf(-1)	-0.0789433*** (0.0170682)
FD(-1)*CAD(-1)	0.1081072*** (0.0417617)
FD(-1)	0.1706503 (0.2399486)
CAD(-1)	0.2650698* (0.142881)
Constant	2.01*** (0.35)
Wald Chi-2	707.52***
N	1241
AR(1) test (p > z)	4.03 (0.00)
AR(2) test (p > z)	1.03 (0.30)
Sargan test (p > chi2)	51.03 (0.013)

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;

Table A6: Threshold Inflation and Growth Rates based on GMM Estimates (Full Sample)

FD (as % of GDP)	**CAD** (as % of GDP)	**Threshold inflation** (%)	**Growth rate** (%)
3.00	2.00	9.36	4.76
3.00	2.50	7.84	4.80
3.00	3.00	6.27	4.90
4.00	2.00	11.65	5.30
4.00	2.50	10.54	5.32
4.00	3.00	9.39	5.38
5.00	2.00	12.99	5.69
5.00	2.50	12.14	5.72
5.00	3.00	11.27	5.79
6.00	2.00	13.84	5.87
6.00	2.50	13.17	5.93
6.00	3.00	12.47	6.02

Source: Authors' estimates.

Table A7: Alternative Specifications as Robustness Checks

	Full Sample (with ToT)	EME (with ToT)	Oil importing countries
Dep. Var. ***Exp. Var.***	GDPg	GDPg	GDPg
Inf^3(-1)	0.00000934 (0.0000161)	0.00000360 (0.0000210)	0.0000724*** (0.0000143)
Inf^2(-1)	0.00428 (0.00485)	0.00764 (0.00457)	-0.00988*** (0.00162)
Inf(-1)	-0.236 (0.302)	-0.569** (0.255)	0.252*** (0.0611)
CAD^2(-1)	0.00460* (0.00255)	0.0121*** (0.00272)	-0.00358 (0.00345)
FD^2(-1)	-0.00455 (0.00414)	-0.00480 (0.0126)	-0.00787 (0.00517)
FD(-1)*Inf^2(-1)	-0.0000274 (0.000126)	-0.0000941 (0.000119)	0.000216 (0.000150)
FD(-1)*Inf(-1)	-0.00908 (0.00792)	-0.00109 (0.00864)	-0.0161* (0.00837)
CAD(-1)*Inf^2(-1)	-0.0000118 (0.0000664)	0.0000764 (0.0000536)	-0.000166 (0.000147)
CAD(-1)*Inf(-1)	-0.00261 (0.00516)	-0.0127*** (0.00394)	0.0228** (0.00847)
FD(-1)*CAD(-1)	-0.0193*** (0.00585)	-0.0295*** (0.00683)	-0.00793 (0.00492)
FD(-1)	-0.773* (0.442)	-1.756*** (0.294)	-0.0662 (0.0757)
CAD(-1)	0.0248 (0.248)	0.612*** (0.134)	-0.218*** (0.0430)
ToT(-1)	-2.962 (2.314)	-10.22*** (2.376)	
ToT(-1)*Inf^2(-1)	-0.00683* (0.00395)	-0.00978*** (0.00318)	
ToT(-1)*Inf(-1)	0.357 (0.305)	0.732*** (0.252)	
ToT(-1)*CAD(-1)	-0.0624 (0.242)	-0.461*** (0.144)	
ToT(-1)*FD(-1)	0.628 (0.500)	1.454*** (0.336)	
Constant	6.394*** (2.182)	14.09*** (2.302)	4.122*** (0.395)
adj. R^2	0.37	0.49	0.37
N	1185	632	895

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Country FE = Yes; Time FE = Yes.