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Does Inflation Slow Long-Run Growth in India?

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Abstract

This paper examines the long-run relationship between consumer price index industrial workers (CPI-IW) inflation and GDP growth in India. We collect data on a sample of 14 Indian states over the period 1989–2013, and use the cross-sectionally augmented distributed lag (CS-DL) approach of Chudik et al. (2013) as well as the standard panel ARDL method for estimation—to account for cross-state heterogeneity and dependence, dynamics and feedback effects. Our findings suggest that, on average, there is a negative long-run relationship between inflation and economic growth in India. We also find statistically-significant inflation-growth threshold effects in the case of states with persistently-elevated inflation rates of above 5.5 percent. This suggest the need for the Reserve Bank of India to balance the short-term growth-inflation trade-off, in light of the long-term negative effects on growth of persistently-high inflation.

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I. INTRODUCTION

The inflation-growth trade-off and the role of monetary policy in India have received renewed interest among policy makers and academics in recent years as persistently-high inflation and weak growth happened to co-exist.¹ The conventional view is that inflation at low levels “greases the wheels” of the economy, while at high levels it negatively affects the economy’s allocative efficiency and growth (see Section II. for a brief survey). In other words, while the short-run Phillips Curve postulates that inflation tolerance could be associated with higher growth, persistently-high inflation, especially beyond a certain threshold, (by itself) could be a drag on economic growth in the long run. This paper re-visits the non-linear effects of inflation on growth in India, and investigates whether a persistently-elevated inflation rate (particularly above a certain threshold) could slow growth of the Indian economy in the long run. Given that estimating the inflation threshold in a cross-country framework runs the risk of being distorted due to cross-country heterogeneity (countries with extremely low levels of inflation and those with hyper-inflation are included in the same sample), we instead rely on Indian state-level GDP growth and inflation data, and a heterogenous panel technique, to estimate the inflation threshold for India. This allows for a more accurate/efficient inference of model parameters than from time-series regressions using all-India data or from cross-country panel data models.

Specifically, we adopt the cross-section augmented distributed lag (CS-DL) approach of Chudik et al. (2013) for estimation and contrast this with the panel ARDL approach. We estimate the long-run effects of inflation on economic growth in India using a panel of fourteen Indian states over the period 1989–2013. In contrast with the earlier literature surveyed in Section II., the CS-DL estimation strategy takes into account three key features of the panel data (i.e. dynamics, heterogeneity and cross-sectional dependence), with the ARDL approach also being robust to feedback effects. Furthermore, the panel techniques adopted in this paper allow for states to be affected differently by common factors (monetary policy, oil price spikes or weather-related shocks)² as slope coefficients differ across states and cross-state averages (and their lags) proxy for unobserved common factors. The relationship between growth and inflation is also state-dependent as high inflation can magnify the effects of supply bottlenecks in different states to varying degrees.

Our findings suggest that, on average, there is a statistically-significant negative long-run

¹Consumer Price Index-Industrial Workers (CPI-IW) inflation in India declined from 8.8 percent during India’s so called “monetary targeting regime” (1985–86 to 1997–98) to 5.6 percent during the first decade of the country’s “multiple indicator regime” (1998–99 to 2008–09). Since 2008, retail inflation has trended up and has persisted at double-digit levels.

²See Cashin et al. (2014) for the impact of oil-demand and oil-supply shocks on the world economy and Cashin et al. (2014) for the short-run effects of El Niño weather shocks on output growth and inflation on the global economy, including in India.

relationship between inflation and economic growth in India. We also find statistically-significant inflation-growth threshold effects in the case of states and periods with inflation rates above 5.5 percent. Specifically: (i) at low enough levels of inflation (below 3 percent) we do not observe any statistically-significant effects of inflation on output growth; (ii) average growth is higher for those states and periods which experienced inflation below 5.5%; and (iii) when inflation is greater than 3%, we observe a negative and statistically-significant effect of inflation on long-run growth (with this negative effect being much larger when inflation is above 5.5%). This result is in line with most of the estimates found in the literature on India. Mohanty et al. (2011) find evidence of an inflation threshold for India in the order of 5.5 percent. Ahluwalia (2011) notes that inflation above 6 percent is “regressive and also distortionary, damaging both inclusion and growth”. Using quarterly data from 1996–2011, IMF (2012) also finds evidence of an inflation threshold of about 5–6 percent in India. A distinguishing feature of this paper compared with most Indian-based writings is its focus on CPI inflation rather than wholesale price index (WPI) inflation, as well as its use of state level data rather than national data. Moreover, and in contrast to earlier studies, we show that inflation does not have to reach the minimum “threshold” before its growth effects turn negative.³

Turning to policy implications, despite the fact that inflation in India is driven by both supply and demand-side factors (including the National Rural Employment Guarantee Act, supply bottlenecks, food and energy price pressures, and elevated inflation expectations), inflation is one of the most important problems facing India’s economy. Therefore, the authorities (via supply-side reforms as well as monetary policy) should strengthen their anti-inflation efforts in order to avoid any negative long-run effects of excessive inflation on growth.

The remainder of the paper is organized as follows. Section II. reviews the literature on long-run effects of inflation on economic growth. Section III. presents the findings of this paper regarding the non-linear long-run effects of inflation on growth in India. The final section concludes and offers a few policy implications.

II. LITERATURE REVIEW

Economic theory provides mixed predictions as to the effects of inflation on economic growth. Depending on how money is introduced into the model and the assumptions about its functions, inflation can have either positive or negative effects on real variables such as output and investment. Within a money-in-the-utility-function model, Sidrauski (1967) presents a superneutrality result where changes in the rate of money growth and inflation have no effects

³Note that, on average, WPI inflation has been lower than CPI-IW inflation over our sample period, with the divergence between the two being more pronounced in the last decade. Therefore, if we were to replicate the analysis using WPI inflation, we would most likely have estimated a lower WPI inflation threshold.

on steady-state capital and output. The same result is obtained by Ireland (1994) within a cash-in-advance model where money is needed in advance to finance investment expenditures and at the same time capital accumulation affects money's role in the payments system. Tobin (1965) regards money as a substitute for capital, and shows that higher inflation enhances investment and causes a higher level of output. Bayoumi and Gagnon (1996) show that a positive relationship between inflation and investment can also arise if there are distortions in the tax system. Stockman (1981) examines the implications of a cash-in-advance constraint applying to investment and argues that higher inflation decreases steady-state real-money balances and capital stock, and hence produces a reverse Tobin effect. Dornbusch and Frenkel (1973) show that the effects of inflation on real variables are ambiguous if money is introduced into the model through a transaction cost function. However, this ambiguity disappears when money is introduced as a transaction device through a shopping-time technology, as in Saving (1971) and Kimbrough (1986).

Gillman and Kejak (2005) survey the theoretical literature on inflation and endogenous growth, and show that a broad range of models can generate a negative association between inflation and growth; see Gomme (1993) and De Gregorio (1993) among others. They also analyze whether the inflation-growth relationship is non-linear (that is, becomes weaker as the inflation rate rises). In such models, the inflation rate affects growth because it changes the marginal product of capital, either that of physical capital (AK models), or that of human capital (AH models), or that of both in combined capital models. Considering AK and AH models, inflation acts as a tax on physical or human capital which decreases the marginal product of capital and lowers growth. The non-linearity property of the inflation-growth relationship can be explained through models that explicitly account for unemployment; see Akerlof et al. (2000). According to these models, low inflation favors both employment and productivity, resulting in higher capacity utilization, a lower output gap and, as a consequence, higher growth. Therefore, the relationship between inflation and output growth may be positive for low levels of the inflation rate.

There also exists a large empirical literature on the relationship between inflation and growth. A brief summary of these empirical findings is as follows. First, inflation could reduce growth by lowering investment and productivity. Barro (2001) provides evidence for a strongly significant negative effect of inflation on growth, while Bruno and Easterly (1998) show that the inflation-growth correlation is present only when they base their cross-section regressions on annual observations, with the correlation weakening as longer-term time averages are used. There is also a strong inflation-growth relation with pooled annual data. Second, the relationship between inflation and growth is highly non-linear. Khan and Senhadji (2001) find a 'threshold' rate of inflation, above which the effect on growth is strongly significant and negative, but below which the effect is insignificant and positive. Gylfason and Herbertsson (2001) list some 17 studies for which all but one find a significant decrease in the growth rate from increasing the inflation rate from 5 to 50%; while Chari et al. (1996) review the

empirical results from increasing the inflation rate from 10 to 20%, and report a significant fall in the growth rate within the interval, 0.2% to 0.7%. Roubini and Sala-i-Martin (1992) study the relationship between inflation and growth in a panel of 98 countries over 1960–1985, and find that an increase in the annual rate of inflation from 5 to 50 percent reduces per capita growth, *ceteris paribus*, by 2.2 percent per annum. Rousseau and Wachtel (2001) report a smaller but still significant negative effect of inflation on growth in their panel study of 84 countries during 1960–1995. The negative and highly non-linear inflation–growth effect is also supported in Judson and Orphanides (1999), Ghosh and Phillips (1998), and López-Villavicencio and Mignon (2011). Third, inflation volatility is found to negatively affect production decisions, and hence growth; see Judson and Orphanides (1999).

The inflation-growth relationship is not always found to be robust though, often due to sample selection bias, temporal aggregation, and omission of consequential variables in levels. Trying to address these misspecifications, Ericsson et al. (2001), using 40 years of data (1953–1992), show that output and inflation are positively related. They find that, for most G-7 countries, annual time series of inflation and the log-level of output are cointegrated, thus rejecting the existence of a long-run relation between output growth and inflation. Following a different econometric approach, Bullard and Keating (1995), using a large sample of postwar countries, find that a permanent shock to inflation is not associated with a long-run change in real output for high-inflation economies. Using instrumental variables to account for inflation–growth endogeneity bias, Gillman and Nakov (2004) show that the negative non-linear effect is reinstated at all positive inflation levels for both developed and developing countries.

III. EMPIRICAL RESULTS

This section examines the long-term effects of inflation on economic growth in India, using both ARDL and CS-DL empirical specifications. We also look at the effects of inflation thresholds on long-run growth. However, we first begin with a description of the data used.

A. Data Sources

We obtain real gross state domestic product (GSDP) and consumer price index (CPI) data from the CEIC database and calculate growth and inflation based on these series. GSDP data is available for 32 states and union territories from the fiscal year 1980 onwards (with the exception of Chandigarh, Chattisgarh, Jharkhand, and Uttarakhand, for which data is available only from 1993). Excluding the most recent measure of the consumer price index (CPI) combined (CPI-Combined) for which official data is only available from January 2011, there are three measures of the CPI at the state-level that we could potentially use: (i) CPI industrial workers (CPI-IW); (ii) CPI agricultural laborers (CPI-AL); and (iii) CPI rural labourers

(CPI-RL). We collect monthly data on these three measures for as many states as possible. CPI-AL and CPI-RL data are available for twenty states from January 1995 to December 2013, thus the number of annual observations on inflation per state is 18, which gives $N_{\max} = 20$ and $T_{\max} = 18$. CPI-IW data on the other hand is available for 24 states and with the first observation in January 1988 for most states (except for Bihar, Goa, Himachal Pradesh, Kerala, Orissa, Pondicherry, and Tripura for which we only have data from January 1994), which gives $N_{\max} = 24$ and $T_{\max} = 25$.

Since our analysis allows for slope heterogeneity across Indian states, we need a sufficient number of time periods to estimate state-specific coefficients. We therefore use CPI-IW as our preferred measure for CPI, given that the total number of observations will be significantly larger than using either CPI-AL or CPI-RL (given that both N and T are larger). Moreover, we include only states in our sample for which we have at least twenty consecutive annual observations on inflation and the real GDP. Subject to this requirement, we end up with the fourteen states listed in Table 1, which together cover over 90 percent of India's current GDP. Overall, we have an unbalanced panel covering the sample period 1989-2013, with $T_{\min} = 21$, and $N = 14$ across all time periods.

Figure 1 illustrates a simple bivariate relationship between real GSDP growth and inflation for the 14 Indian states over the sample period (1989-2013). From this figure, it is clear that there is a negative correlation between the two variables. In fact plotting the two series for each of the states separately, we observe that this negative relationship exists in all states except for Madhya Pradesh and Rajasthan, for which there is a mild positive association between the two variables, see Figure 2.

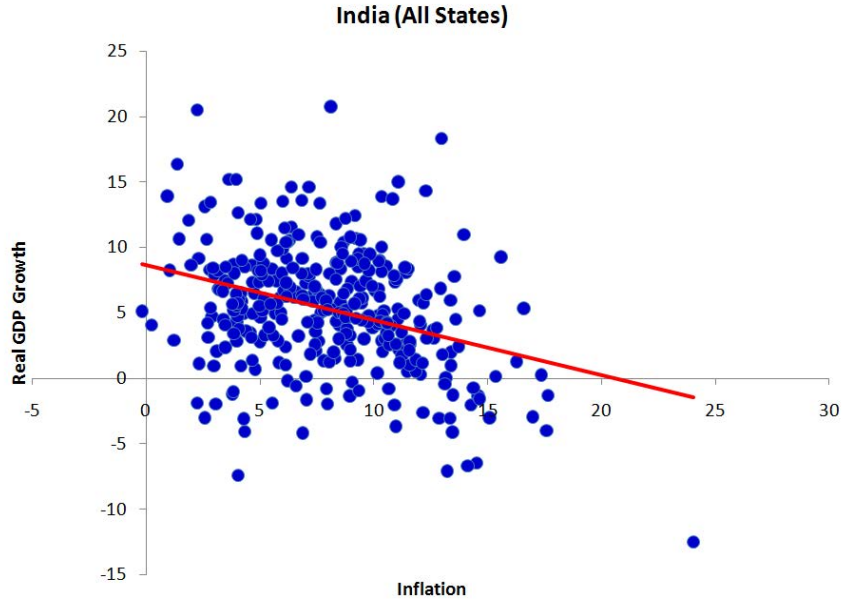
Table 1. List of the 14 States in Our Sample

Andhra Pradesh	Jammu and Kashmir	Rajasthan
Assam	Karnataka	Tamil Nadu
Delhi	Madhya Pradesh	Uttar Pradesh
Gujarat	Maharashtra	West Bengal
Haryana	Punjab	

B. Long-Run Estimates

We first investigate the long-run effects of inflation on output growth using the traditional panel ARDL approach, in which the long-run effects are calculated from OLS estimates of the

Figure 1. Real GDP Growth and Inflation, 1989-2013



Source: Authors' calculations using data from the CEIC database.

Notes: Inflation is based on consumer price index industrial workers (CPI-IW). For the 14 states in the sample see Table 1.

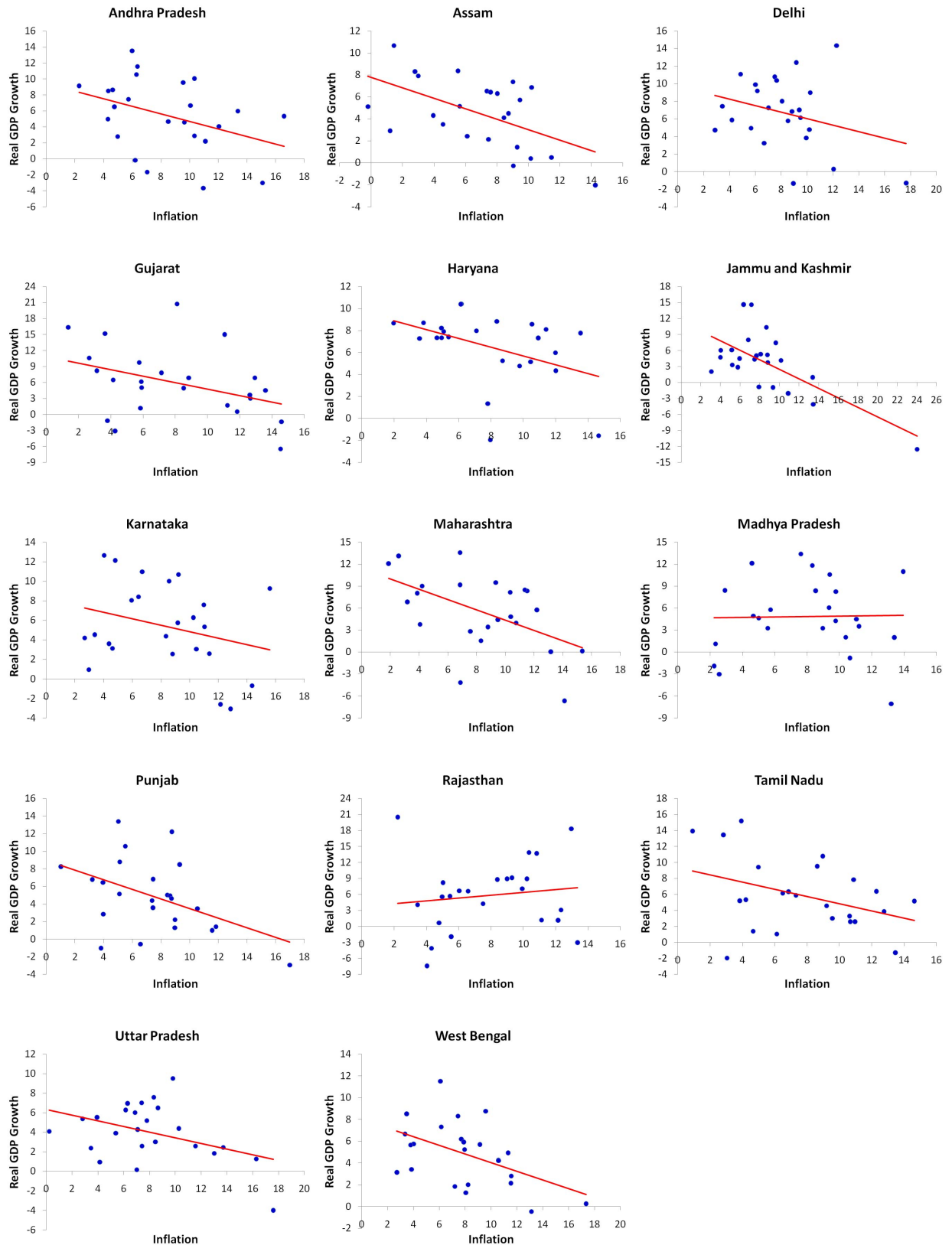
short-run coefficients in the following equation:

$$\Delta y_{it} = c_i + \sum_{\ell=1}^p \varphi_{i\ell} \Delta y_{i,t-\ell} + \sum_{\ell=0}^p \beta_{i\ell} \pi_{i,t-\ell} + u_{it}, \quad (1)$$

where Δy_{it} is the growth rate of real GSDP for state i in year t , and π_{it} is the inflation rate. The coefficient on the error correction term (λ_i) and the long-run effects (θ_i) are calculated from $\varphi_{i\ell}$ and $\beta_{i\ell}$, more specifically: $\lambda_i = 1 - \sum_{\ell=1}^p \varphi_{i\ell}$ and $\theta_i = \lambda_i^{-1} \sum_{\ell=0}^p \beta_{i\ell}$ respectively.

We use the same lag order, p , for all variables and states, but consider different values of p in the range of 1 to 3. Given that we are working with growth rates which are only moderately persistent, a lag order of 3 should be sufficient to fully account for the short-run dynamics and hence feedback effects. Equation (1) allows for a significant degree of cross-sectional heterogeneity and accounts for the fact that the effect of inflation on growth could vary across states (particularly in the short run). In a series of papers, Pesaran and Smith (1995), Pesaran (1997), and Pesaran and Shin (1999) show that the ARDL approach can be used for long-run analysis, and that the ARDL methodology is valid regardless of whether the regressors are exogenous, or endogenous, and irrespective of whether the underlying variables are $I(0)$ or $I(1)$. These features of the panel ARDL approach are both appealing and could be very important in our empirical application. Note that we do not include any control variables in

Figure 2. Real GDP Growth and Inflation by State, 1989-2013



Sources: Authors' calculations using data from the CEIC database.

Notes: Inflation is based on consumer price index industrial-workers (CPI-IW).

our specification following Pesaran and Smith (2014) who argue in favor of parsimonious models when the object of interest is not the "ceteris paribus" impact of a regressor.

The individual estimates of the long-run effects of inflation on growth, $\hat{\theta}_i$, can be averaged across i to obtain a consistent estimate of the average long-run effects, given by $\hat{\theta} = N^{-1} \sum_i^N \hat{\theta}_i$. These estimates together with the mean estimate of the coefficients of the error correction term, denoted by $\hat{\lambda}$, based on the panel ARDL specification above are reported in Table 2. For each lag order $p = 1, 2$ and 3, it is clear that the Fixed Effects (FE) estimates, assuming slope homogeneity, suggest an inverse relationship between inflation and economic growth, with this negative effect being significant at the 1% level in all cases. The results from the MG estimates, allowing for slope coefficients to vary across the Indian states, are generally supportive of this negative relationship. $\hat{\theta}$ is negative and significant at the 1% level when $p = 1$ and 2, but not for the ARDL(3,3) case. Overall, the long-run estimates based on the ARDL approach suggest that a one percent increase in average CPI inflation can reduce growth in India by between 0.35 to 0.55 percent in the long run. These estimates are much larger than those obtained by, for instance, Chudik et al. (2013) (being between -0.05 and -0.10) using the same ARDL specification as in equation (1) but for a panel of 40 countries. Our results therefore suggest that sustained high inflation levels are particularly detrimental for long-run growth in India (as compared to the average of other advanced, emerging and developing countries), and the authorities should strengthen their anti-inflation efforts through appropriate monetary policies as well as via supply-side reforms. Note also that the speed of adjustment to equilibrium is very quick in all regressions, which is to be expected given the low persistence of output growth (Table 2).

Table 2. Fixed Effects (FE) and Mean Group (MG) Estimates of the Long-Run Effects Based on the ARDL Approach, 1989-2013

	ARDL(1,1)		ARDL(2,2)		ARDL(3,3)	
	FE	MG	FE	MG	FE	MG
$\hat{\theta}$	-0.375*** (0.075)	-0.348*** (0.060)	-0.465*** (0.112)	-0.548*** (0.172)	-0.448*** (0.120)	-0.391 (0.270)
$\hat{\lambda}$	-1.066*** (0.057)	-0.993*** (0.074)	-0.850*** (0.088)	-0.861*** (0.094)	-0.885*** (0.108)	-0.865*** (0.162)
CD Test Statistics	2.33	2.72	6.01	6.61	5.85	4.74
$N \times T$	320	320	306	306	292	292

Source: Authors' estimations.

Notes: The ARDL specification is given by: $\Delta y_{it} = c_i + \sum_{\ell=1}^p \varphi_{i\ell} \Delta y_{i,t-\ell} + \sum_{\ell=0}^p \beta_{i\ell} \pi_{i,t-\ell} + u_{it}$, where Δy_{it} is the growth rate of real GSDP, π_{it} is the inflation rate, and $p = 1, 2$, and 3. $\lambda_i = 1 - \sum_{\ell=1}^p \varphi_{i\ell}$ and $\theta_i = \lambda_i^{-1} \sum_{\ell=0}^p \beta_{i\ell}$. Symbols ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

Table 2 reports the cross-section dependence (CD) test of Pesaran (2004, 2013), which is

based on the average of the pair-wise correlations of the OLS residuals from the individual-state regressions, and which under the null of cross-section independence is distributed as standard normal. For each $p = 1, 2$, and 3 , we observe that the error terms across states in our model exhibit a considerable degree of cross-sectional dependence as the reported CD statistics are highly significant with very large test statistics. The presence of cross-sectional dependence implies that estimates obtained using standard panel ARDL models might be biased. To overcome this problem, one could augment the ARDL regressions with cross-sectional averages of the regressors, the dependant variable and a sufficient number of their lags. However, as discussed in Chudik et al. (2013), even when including cross-sectional averages in equation (1), the panel ARDL approach still has other drawbacks. In particular, sampling uncertainty could be large when the time dimension is moderate (as is the case here) and the performance of the estimators also depends on a correct specification of the lag orders of the underlying ARDL specifications. The direct approach to estimating the long-run relationships proposed in Chudik et al. (2013)—the cross-sectionally augmented distributed lag (CS-DL) method—overcomes these issues and only requires that a truncation lag order is selected. Also, this direct method has better small sample performance for moderate values of T , which is the case here with $T_{\min} = 20$. Furthermore, it is robust to a number of departures from the baseline specification such as residual serial correlation, and possible breaks in the error processes.

Given the advantages of the direct approach over the ARDL method, we next estimate the long-run effects of inflation on Indian states' output growth based on the CS-DL approach for different truncation lag orders, $p = 1, 2, 3$; we therefore run the following regressions:⁴

$$\Delta y_{it} = c_i + \theta_i \pi_{it} + \sum_{\ell=0}^{p-1} \delta_{i\ell} \Delta \pi_{i,t-\ell} + \omega_{iy} \overline{\Delta y}_t + \sum_{\ell=0}^3 \omega_{i,\pi\ell} \overline{\pi}_{t-\ell} + e_{it}, \quad (2)$$

where the regressors are defined as in equation (1). We always include three lags of the cross-sectional averages of the regressors, $\overline{\pi}_t = N^{-1} \sum_{j=1}^N \pi_{jt}$, in all specifications together with the cross-sectional average of the dependent variable, $\overline{\Delta y}_t = N^{-1} \sum_{j=1}^N \Delta y_{jt}$.

The MG estimates based on the above CS-DL regressions are summarized in Table 3. Specifically, the mean group estimates, $\hat{\theta}$, are negative and statistically significant (in most cases at the 1% level). The estimated coefficients fall between -0.65 and -0.91 , being much larger than those obtained based on panel ARDL regressions (Table 2). Note also that the CD test statistics are now very small and we therefore cannot reject the null of cross-sectional independence. Overall, both the ARDL and the CS-DL results suggest that if inflation rises permanently and stays elevated, then it will negatively affect India's economic growth in the long run, with potential growth losses being very large. However, if the increase in inflation is

⁴The Matlab codes for the cross-sectionally augmented distributed lag (CS-DL) Mean Group and Pooled estimators developed in Chudik et al. (2013), are available from people.ds.cam.ac.uk/km418.

Table 3. Mean Group (MG) Estimates of the Long-Run Effects Based on the CS-DL Approach, 1989-2013

	CS-DL(1)	CS-DL(2)	CS-DL(3)
$\hat{\theta}$	-0.906*** (0.144)	-0.835*** (0.214)	-0.649** (0.271)
CD Test Statistics	-0.26	0.11	-0.64
$N \times T$	306	306	306

Source: Authors' estimations.

Notes: The cross-sectionally augmented distributed lag (CS-DL) regressions include the cross-sectional average of the dependent variable and three lags for the cross-sectional averages of the regressor. The CS-DL estimates are based on the following specification: $\Delta y_{it} = c_i + \theta_i \pi_{it} + \sum_{\ell=0}^{p-1} \delta_{i\ell} \Delta \pi_{i,t-\ell} + \omega_{iy} \overline{\Delta y}_t + \sum_{\ell=0}^3 \omega_{i,\pi\ell} \overline{\pi}_{t-\ell} + e_{it}$, where Δy_{it} is the growth rate of real GSDP, π_{it} is the inflation rate, and $p = 1, 2, \text{ and } 3$. Symbols ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

temporary (perhaps due to expansionary monetary policy to stimulate the economy or when the RBI sees through transitory exogenous shocks), then there is no long-run adverse effect on economic growth. This requires a credible monetary policy framework that only temporarily tolerates higher inflation.

To check the robustness of our results we did the same analysis as above but calculating inflation using CPI-AL and CPI-RL. No matter the measure of inflation our results consistently show that inflation has a negative and statistically-significant long-run adverse effect on growth in India. The results based on CPI-AL and CPI-RL are not reported here, but are available on request. However, as discussed earlier, note that both the time dimension, T , and the cross-sectional dimension, N , is smaller when using CPI-AL and CPI-RL, we therefore consider the estimates based on CPI-IW inflation as more reliable.

C. Inflation Threshold Effects on Growth

As discussed in Section II. there is some evidence in the empirical literature that the relationship between inflation and growth (using cross-country data) is highly non-linear. To investigate whether there is any threshold effect in the relationship between inflation and output growth for Indian states, we run a modified version of the CS-DL regression in (2) setting $p = 3$, namely:

$$\Delta y_{it} = c_{i\tau} + \gamma_{i\tau} I_{it}(\tau) + \theta_{i\tau} \pi_{it} + \sum_{\ell=0}^2 \delta_{i\ell,\tau} \Delta \pi_{i,t-\ell} + \omega_{iy,\tau} \overline{\Delta y}_t + \sum_{\ell=0}^3 \omega_{i,x\ell,\tau} \overline{\pi}_{t-\ell} + e_{it}, \quad (3)$$

where $I_{it}(\tau)$ is a "threshold dummy", defined by the indicator variable $I_{it}(\tau) = I(\pi_{it} < \tau)$ for $\tau = 3\%, \dots, 6\%$ and $I_{it}(\tau) = I(\pi_{it} \geq \tau)$ for $\tau = 7\%$ and 8% , which takes the value of 1 if inflation is below/above the given threshold value of τ , and zero otherwise. All other variables are as defined in equations (1) and (2).

The results of the inflation threshold effects on growth are reported in Table 4. Interestingly, when $\tau < 3\%$ the coefficient of the threshold dummy, $\hat{\gamma}_\tau$, is positive and significant, but $\hat{\theta}_\tau$ is negative and insignificant; therefore implying that when inflation is below 3% not only is inflation not detrimental for long-run growth, but also that average growth is 3.4% greater than when $\pi_t \geq 3\%$.⁵ For all other values of τ , we observe that the long-run effects of inflation on output growth (as denoted by $\hat{\theta}_\tau$ estimates) is significant and negative, with this effect being amplified with rising inflation (the higher the τ threshold is). More importantly, $\hat{\gamma}_\tau$ is positive and significant for all $\tau < 5.5\%$, suggesting average growth is higher when inflation remains at low levels. More specifically, our estimates suggest that average growth has been 1.9% higher when $\pi_t < 5.5\%$. In other words, at lower inflation rates (less than 5.5%) some of the negative growth effects of inflation (as represented by $\hat{\theta}_\tau$) are offset, given that the coefficient of the threshold dummy, $\hat{\gamma}_\tau$, is positive and statistically significant. On the other hand, for inflation rates above 5.5% we show that the negative growth effect of inflation is larger while at the same time the coefficient on the threshold dummy ($\hat{\gamma}_\tau$) is no longer statistically significant. The results in Tables 2 and 3 have consistently shown that the effect of inflation on long-run growth in India is negative, but we now also have some evidence for a threshold effect at an inflation rate of 5.5% and above, where the detrimental growth effect of inflation is more severe (see Table 4). This means that monetary policy would need to balance any short-term growth-inflation trade-off (i.e. the short-term Phillips curve) against the long-term negative effects of persistently-high inflation on growth, and maintain the allocative efficiency of the Indian economy by keeping inflation below the threshold.⁶

Our results are generally supported by existing studies on India, which to the best of our knowledge exclusively use time series national data rather than cross-state data and the wholesale price index (as opposed to the CPI-IW measure).⁷ More specifically, earlier work indicates that the Indian inflation threshold is typically between 6–7 percent—see for instance Kannan and Joshi (1998), Rangarajan (1998), and Samantaraya and Prasad (2001)—while Vasudevan et al. (1998) suggest a lower threshold of between 5–7 percent. More recent work by Singh (2010) and Pattanaik and Nadhanael (2013), using data from 1970 until 2009 and

⁵The dummy variable $I_{it}(\tau)$ divides the sample into two groups (states and periods when inflation is below τ and states and periods when inflation is above τ), and compares the average growth rates of the two groups.

⁶This paper does not suggest that the "optimal inflation rate" for India is 5.5%. Instead, it shows that the negative effects of inflation on output growth is substantially larger once the inflation rate is above 5.5%.

⁷See RBI (2014) for a summary of the estimates of inflation threshold effects on growth from earlier time-series studies.

Table 4. Estimates of the Average Threshold Effects on Output Growth Based on the Cross-Sectionally Augmented Distributed Lag (CS-DL) Approach with Three Lags, 1989-2013

τ	—	< 3%	< 4%	< 5%	< 5.5%	< 6%	$\geq 7\%$	$\geq 8\%$
$\hat{\gamma}_\tau$	—	3.356* (1.730)	2.346* (1.367)	2.185** (0.876)	1.899** (0.859)	-0.955 (1.603)	1.270 (1.668)	3.638 (2.352)
$\hat{\theta}_\tau$	-0.649** (0.271)	-0.475 (0.551)	-0.592* (0.323)	-0.609* (0.319)	-0.594* (0.339)	-0.598* (0.357)	-0.750* (0.391)	-1.089** (0.459)
$N \times T$	306	306	306	306	306	306	306	306

Source: Authors' estimations.

Notes: The estimates are based on the following specification $\Delta y_{it} = c_{i\tau} + \gamma_{i\tau} I_{it}(\tau) + \theta_{i\tau} \pi_{it} + \sum_{\ell=0}^2 \delta_{i\ell,\tau} \Delta \pi_{i,t-\ell} + \omega_{iy,\tau} \bar{\Delta y}_t + \sum_{\ell=0}^3 \omega_{i,\pi\ell,\tau} \bar{\pi}_{t-\ell} + e_{it}$, where $I_{it}(\tau) = I(\pi_{it} < \tau)$ for $\tau < 6\%$ and $I_{it}(\tau) = I(\pi_{it} \geq \tau)$ for $\tau \geq 7\%$, Δy_{it} is the growth rate of real GSDP, and π_{it} is the inflation rate. The cross-sectionally augmented distributed lag (CS-DL) regression include the cross-sectional average of the dependent variable and three lags for the cross-sectional averages of the regressors. Symbols ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

2011 respectively, also indicate that the inflation threshold is around 6 percent. In addition, based on quarterly data from 1996-2012 IMF (2012) finds evidence for an inflation threshold of about 5-6 percent in India, while Mohanty et al. (2011) estimate the inflation threshold effect being between 4-5.5 percent.

IV. CONCLUDING REMARKS

Based on annual data on fourteen Indian states over the period 1989-2013, we examined the growth-inflation relationship in India using the cross-sectionally augmented distributed lag (CS-DL) approach of Chudik et al. (2013), as well as the standard panel ARDL methodology. We also empirically tested for the existence of a threshold level of inflation beyond which growth is severely undermined. Our results indicated that the negative growth effects of inflation are more pronounced above an inflation threshold of about 5.5 percent. We recognize that inflation in India is a result of a number of factors, including: supply-driven food inflation feeding quickly into wages and core inflation; entrenched inflation expectations; binding sector-specific supply constraints (particularly in agriculture, energy, and transportation); and ongoing fuel prices increases, see Anand et al. (2014). Nevertheless, high and persistent inflation, no matter how it is created, is a key vulnerability and the Reserve Bank of India should strengthen its anti-inflation efforts in order to avoid any negative long-run effects of excessive inflation on growth.

REFERENCES

- Ahluwalia, M. S. (2011). Prospects and Policy Challenges in the Twelfth Plan. *Economic and Political Weekly* 46(21).
- Akerlof, G. A., W. T. Dickens, and G. L. Perry (2000). Near-rational Wage and Price Setting and the Long-run Phillips Curve. *Brookings Papers on Economic Activity* 2000(1), 1–44.
- Anand, R., D. Ding, and V. Tulin (2014). Food Inflation in India: The Role for Monetary Policy. *IMF Working Paper WP/14/178*.
- Barro, R. J. (2001). Human Capital and Growth. *American Economic Review* 91(2), 12–17.
- Bayoumi, T. and J. Gagnon (1996). Taxation and Inflation: A New Explanation for Capital Flows. *Journal of Monetary Economics* 38(2), 303–330.
- Bruno, M. and W. Easterly (1998). Inflation Crises and Long-run Growth. *Journal of Monetary Economics* 41(1), 3 – 26.
- Bullard, J. and J. W. Keating (1995). The Long-run Relationship between Inflation and Output in Postwar Economies. *Journal of Monetary Economics* 36(3), 477 – 496.
- Cashin, P., K. Mohaddes, and M. Raissi (2014). Fair Weather or Foul? The Macroeconomic Effects of El Niño. *Cambridge Working Papers in Economics* 1418.
- Cashin, P., K. Mohaddes, M. Raissi, and M. Raissi (2014). The Differential Effects of Oil Demand and Supply Shocks on the Global Economy. *Energy Economics* 44, 113–134.
- Chari, V. V., L. E. Jones, and R. E. Manuelli (1996). Inflation, Growth, and Financial Intermediation. *Federal Reserve Bank of St. Louis Review* May, 41–58.
- Chudik, A., K. Mohaddes, M. H. Pesaran, and M. Raissi (2013). Debt, Inflation and Growth: Robust Estimation of Long-Run Effects in Dynamic Panel Data Models. *CESifo Working Paper No. 4508*.
- De Gregorio, J. (1993). Inflation, Taxation, and Long-run Growth. *Journal of Monetary Economics* 31(3), 271–298.
- Dornbusch, R. and J. A. Frenkel (1973). Inflation and Growth: Alternative Approaches. *Journal of Money, Credit and Banking* 5(1), 141–156.
- Ericsson, N. R., J. S. Irons, and R. W. Tryon (2001). Output and Inflation in the Long Run.

Journal of Applied Econometrics 16(3), 241–253.

Ghosh, A. and S. Phillips (1998). Warning: Inflation May Be Harmful to Your Growth. *IMF Staff Papers* 45(4), 672–710.

Gillman, M. and M. Kejak (2005). Contrasting Models of the Effect of Inflation on Growth. *Journal of Economic Surveys* 19(1), 113–136.

Gillman, M. and A. Nakov (2004). Granger Causality of the Inflation-Growth Mirror in Accession Countries. *Economics of Transition* 12(4), 653–681.

Gomme, P. (1993). Money and Growth Revisited: Measuring the Costs of Inflation in an Endogenous Growth Model. *Journal of Monetary Economics* 32(1), 51–77.

Gylfason, T. and T. T. Herbertsson (2001). Does Inflation Matter for Growth? *Japan and the World Economy* 13(4), 405 – 428.

IMF (2012). India: 2012 Article IV Consultation Report. Box 5: The Output-Inflation Trade-Off in India: Implications for Disinflation. *IMF Country Report No. 12/96*.

Ireland, P. N. (1994). Money and Growth: An Alternative Approach. *The American Economic Review* 84(1), 47–65.

Judson, R. and A. Orphanides (1999). Inflation, Volatility and Growth. *International Finance* 2(1), 117–138.

Kannan, R. and H. Joshi (1998). Growth-Inflation Trade-Off: Empirical Estimation of Threshold Rate of Inflation for India. *Economic and Political Weekly* 33(42/43), 2724–2728.

Khan, M. S. and A. S. Senhadji (2001). Threshold Effects in the Relationship between Inflation and Growth. *IMF Staff Papers* 48(1), 1–21.

Kimbrough, K. P. (1986). The Optimum Quantity of Money Rule in the Theory of Public Finance. *Journal of Monetary Economics* 18(3), 277–284.

López-Villavicencio, A. and V. Mignon (2011). On the Impact of Inflation on Output Growth: Does the Level of Inflation Matter? *Journal of Macroeconomics* 33(3), 455 – 464.

Mohanty, D., A. B. Chakraborty, A. Das, and J. John (2011). Inflation Threshold in India: An Empirical Investigation. *RBI Working Paper Series (DEPR): 18/2011*.

Pattanaik, S. and G. Nadhanael (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.
- Pesaran, M. H. (1997). The Role of Economic Theory in Modelling the Long Run. *Economic Journal* 107, 178–191.
- Pesaran, M. H. (2004). General Diagnostic Tests for Cross Section Dependence in Panels. *IZA Discussion Paper No. 1240*.
- Pesaran, M. H. (2013). Testing Weak Cross-Sectional Dependence in Large Panels. *forthcoming in Econometric Reviews*.
- Pesaran, M. H. and Y. Shin (1999). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. In S. Strom (Ed.), *Econometrics and Economic Theory in 20th Century: The Ragnar Frisch Centennial Symposium*, Chapter 11, pp. 371–413. Cambridge: Cambridge University Press.
- Pesaran, M. H. and R. Smith (1995). Estimating Long-run Relationships from Dynamic Heterogeneous Panels. *Journal of Econometrics* 68(1), 79–113.
- Pesaran, M. H. and R. P. Smith (2014). Signs of Impact Effects in Time Series Regression Models. *Economics Letters* 122(2), 150–153.
- Rangarajan, C. (1998). Development, Inflation and Monetary Policy. In I. S. Ahluwalia and I. M. D. Little (Eds.), *India's Economic Reforms and Development*. Oxford University Press.
- RBI (2014). Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework. *Reserve Bank of India*.
- Roubini, N. and X. Sala-i-Martin (1992). Financial Repression and Economic Growth. *Journal of Development Economics* 39(1), 5 – 30.
- Rousseau, P. L. and P. Wachtel (2001). Inflation, Financial Development and Growth. In *Economic Theory, Dynamics and Markets: Essays in Honor of Ryuzo Sato*. Springer.
- Samantaraya, A. and A. Prasad (2001). Growth and Inflation in India: Detecting the Threshold. *Asian Economic Review* 43, 414–420.
- Saving, T. R. (1971). Transactions Costs and the Demand for Money. *The American Economic Review* 61(3), 407–420.
- Sidrauski, M. (1967). Rational Choice and Patterns of Growth in a Monetary Economy. *The American Economic Review* 57(2), 534–544.

- 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. *Journal of Monetary Economics* 8(3), 387–393.
- Tobin, J. (1965). Money and Economic Growth. *Econometrica* 33(4), 671–684.
- Vasudevan, A., B. K. Bhoi, and S. C. Dhal (1998). Inflation Rate and Optimal Growth: Is There a Gateway to Nirvana? In A. Vasudevan (Ed.), *Fifty Years of Developmental Economics: Essays in Honour of Prof. Brahmananda*, pp. 50–67. Himalya Publishing House.