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Articles

Threshold Inflation in Pakistan

Muhammad Farooq Arby
Amjad Ali[1]

Abstract: *Inflation is usually considered to have a non-linear relationship with economic growth: a positive relationship when inflation is low and a negative one when it is high. It is, therefore, an important research question: what is the threshold level of inflation beyond which it affects growth negatively. This paper addresses the question for the case of Pakistan. We have used two models: a quadratic model, and a regression kink model with unknown threshold for the period from 1976 to 2017, and found the threshold inflation rate for Pakistan around 6 percent. It has also been observed that, on average, one percentage point increase in inflation is associated with 0.74 percentage point increase in real GDP growth in Pakistan when inflation is below threshold level; and 0.53 percentage point decrease in real GDP growth, when inflation is above threshold level.*

JEL Classification: E31, O40, O47.

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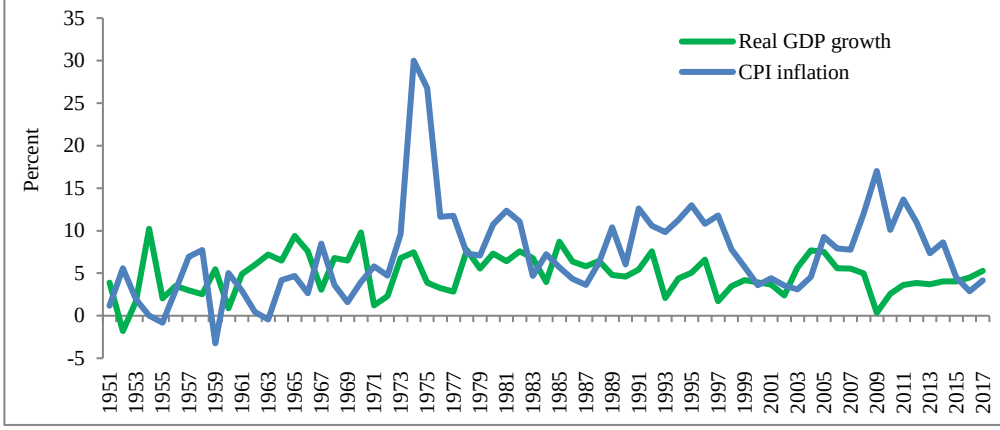
[1] The authors are Director (farooq.arby@sbp.org.pk), Research Department and Deputy Director (amjad.ali3@sbp.org.pk), Economic Policy Review Department, State Bank of Pakistan, Karachi. The authors would like to thank Riaz Riazuddin and two anonymous reviewers for their valuable comments on earlier draft of this paper. The authors would also like to thank Bruce Hansen for providing R-code for estimating regression kink model on Pakistani data.

1. Introduction

Nature of a relationship between economic growth and inflation has been widely examined in the economic literature. There is a consensus that a low inflation rate helps economic activities, while high inflation hurts economic growth. High inflation environment affects decision making of all economic agents in an economy, like investors, savers, consumers and producers through uncertainty about the expected payoffs from their decisions. Moreover, a persistently high inflation also causes erosion of the value of the local currency in terms of foreign currencies. Such uncertainties, in turn, have adverse implications for economic activities. On the other hand, low inflation helps economic agents to predict outcome of their economic decisions with fair level of certainty. Especially, producers follow their plans for business expansion with more confidence; and new investment is undertaken in the expectation of predictable returns. This is precisely the reason why policy makers, particularly central banks, strive for low inflation.

However, knowing the level of inflation beyond which it affects economic growth adversely is an important empirical question. A number of studies have addressed this question and estimated a threshold inflation rate for different countries. A summary of some selected studies is presented in a matrix given in the Annexure 1. In case of Pakistan, this question has recently become more important as its central bank is about to adopt a flexible inflation targeting regime.

Figure 1: Inflation and Real GDP Growth



This paper explores the nature of inflation and growth nexus in Pakistan, and attempts to estimate threshold inflation. In fact, a visual look at the growth and inflation trend shows that there are some episodes when very high inflation adversely affected growth (Figure 1). However, we also found a number of years of co-existence of high inflation

and high growth as well as low inflation and low growth (Table 1). Therefore, finding threshold inflation for Pakistan does not appear to be a straightforward task. The earlier studies like Mubarik (2005), Hussain (2005) and Iqbal and Nawaz (2009) have a number of methodological issues. For example, the growth curve estimated in Mubarik (2005) does not have a positively sloped line segment before a kink and a negatively sloped one after it. Instead, the growth curve estimated in Mubarik (2005) has negative slope everywhere – with a slight difference around 9 percent inflation. As the parameters estimated in Mubarik (2005) are negative, both in case of below 9 percent inflation and above 9 percent; it wrongly interprets 9 percent as threshold inflation. Hussain (2005) finds threshold in the range of 4 to 6 percent; Iqbal and Nawaz (2009) also find it to be 6 percent. However, these studies do not test the threshold regression against a non-threshold model. This paper addresses such methodological issues and present new estimates of threshold level.

Table 1: Inflation and Growth Nexus – (1951 to 2017)

		Real GDP Growth (average = 4.9%)	
		Below (or equal) average	**Above average**
Inflation (Average =7.2%)	**Below (or equal) average**	**(Total 17 years)** 1951, 1952, 1953, 1955, 1956, 1957, 1960, 1961,1971, 1972, 1990, 1999, 2000, 2001, 2002, 2015, 2016	**(Total 19 years)** 1954, 1959, 1962, 1963, 1964, 1965, 1966, 1968, 1969, 1970, 1979, 1983, 1985, 1986, 1987, 1988, 2003, 2004, 2017
	Above average	**(Total 17 years)** 1958, 1967, 1975, 1976, 1977, 1984, 1989, 1993, 1994, 1997, 1998, 2009, 2010, 2011, 2012, 2013, 2014	**(Total 14 years)** 1973, 1974, 1978, 1980, 1981, 1982, 1991, 1992, 1995, 1996, 2005, 2006, 2007, 2008

Source: Authors' classification

2. Methodology

We have used two approaches to estimate threshold inflation: a quadratic equation with inflation and its squared term as explanatory variables and a regression kink model with unknown threshold. We discuss each of these approaches in the following subsections.

2.1 Quadratic equation specification

We estimate the following linear regression model wherein inflation appears as second degree polynomial argument in the growth equation:

$$g_t = \alpha + \theta_1 \pi_t + \theta_2 (\pi_t)^2 + \theta_3' z_t + \varepsilon_t \quad (1)$$

Where, g_t is real GDP growth rate, π_t is CPI inflation, z_t is a vector of other explanatory variables, θ_3' is the vector of parameters associated with z_t, and ε_t is error term of the regression with usual assumptions. Models similar to this quadratic equation are widely used in the literature. Specifically, Pollin and Zhou (2006) and Benhabib and Spiegel (2009) used similar specification for investigating threshold relationship between inflation and growth. We evaluated empirically a number of candidate explanatory variables, traditionally used in a growth model, like population, investment, trade openness, terms of trade, and M2 to GDP ratio. We ended up with real investment growth as the only member of the vector z_t. The basis for this choice is intuitively correct sign and significance of the estimated parameters, and Akaike information criterion (AIC). The threshold inflation is calculated using the estimated parameters as follows:

$$\pi^* = -\frac{\hat{\theta}_1}{2\times\hat{\theta}_2} \tag{2}$$

It may be noted that this model gives a theoretically correct threshold inflation rate only when the sign of $\hat{\theta}_2$ is negative, which ensures an inverted U shape of the growth curve.

2.2 Regression kink model

A regression kink model (or continuous threshold model) is a threshold regression constrained to be continuous except at threshold level. We have followed the technique used by Hansen (2017) to find a threshold effect of inflation on growth. In this model the regression function is continuous but the slope has a discontinuity at the threshold point – which introduces a kink in the regression function. The technique used by Hansen not only estimates the parameters in the regression kink model with unknown threshold, but it also gives asymptotic distribution of the parameters and bootstrap confidence intervals for the regression function. This is required given conventional inference methods cannot be applied to this regression function due to its non-differentiability at the threshold point. However, the regression kink function is directionally differentiable at all points i.e. both left and right derivatives are defined. Hansen also performed a formal test for the significance of the threshold model against a linear (non-threshold) model. Functional form of the model is as below:

$$g_t = \alpha + \beta_1(\pi_t - \gamma)_- + \beta_2(\pi_t - \gamma)_+ + \beta_3' z_t + \varepsilon_t \tag{3}$$

Where, γ is threshold level of inflation. Note that inflation has been split in two parts: one below the threshold level $(\pi_t - \gamma)_-$ and the other above it $(\pi_t - \gamma)_+$. In this model threshold is unknown, and we have to determine it endogenously.

In order to determine an optimal threshold, a series of regressions are run by setting an appropriate interval for the threshold parameter, with a discrete grid.[2] At each grid point

[2] For technical details, please see Hansen (2017).

for γ the following least squares criterion is estimated and plotted against the values of the grid points.

$$S_n = (\beta, \gamma) = \frac{1}{n}\sum_{t=1}^{n}(g_t - \alpha - \beta_1(\pi_t - \gamma)_- - \beta_2(\pi_t - \gamma)_+ - \beta_3' z_t)^2 \quad (4)$$

The least square estimators $(\hat{\beta}, \hat{\gamma})$ that jointly minimize S_n are determined by a global minimum of this function.

In the next step, we re-estimate equation (3) by imposing the restriction that $\beta_1 = \beta_2$, which essentially gives a non-threshold or linear model. This model is then evaluated against the threshold model by using an F statistics. For this purpose, we estimate the error variance of the two models, and an F-statistics is computed as follows:

$$F_n = \frac{n(\tilde{\sigma}^2 - \hat{\sigma}^2)}{\hat{\sigma}^2} \quad (5)$$

Where $\hat{\sigma}^2$ is the error variance of the original threshold regression as given in (3) and $\tilde{\sigma}^2$ is the error variance of the new regression with restriction that $\beta_1 = \beta_2$. The F-statistic is used as a standard test for the null hypothesis of equality of β_1 and β_2, against the existence of a threshold effect. If F_n> critical value of F, we reject the null hypothesis in favor of the existence of the threshold effect. Hansen computed the distribution of estimated parameters through bootstrapping. We follow the same approach in this study for constructing confidence intervals.

2.3 Data description

In order to estimate these models, we have used growth rates of annual series of real GDP, CPI, and real investment for the period 1976 to 2017. The selection of candidate explanatory variables is based on the existing empirical literature. The source of data is Pakistan Bureau of Statistics. While the data for all the three variables is available for the years as old as 1960, we have deliberately excluded years prior to 1976 in estimation because we could not adequately model the relationship between inflation and growth for the full sample. This is because during this period Pakistan economy witnessed successive shocks and structural changes of varying nature, like green revolution of early 1960s, 1965 war, political turbulence of late 1960s (after war), breakup of East Pakistan in 1972, severe floods of early 1970s, nationalization of a wide range of businesses, global oil price shock of early 70s, exchange rate depreciation, etc. On the basis of this, we feel that a well behaved relationship between growth and inflation was hardly exhibited during 1960-1975. Including this period in the sample distorts the estimated model and there is a risk of drawing misleading conclusions. Therefore, it is appropriate to focus on 1976 to 2017.

Table 2 reports summary statistics for the variables: average inflation during 1951-2017 has been 7.2 percent, while the average real GDP growth is 4.9 percent. Pakistan has experienced highest inflation of 30 percent in 1974, followed by 26.8 percent in 1975 and 17.0 percent in 2009. In fact double digit inflation was witnessed during 19 years

out of 67 years of Pakistan – all of these years are characterized by some sort of cost push/supply side shocks (see Annexure 2 for a description of these shocks). Excluding these double digit inflation years, average inflation in Pakistan has been 4.7 percent.

Table 2: Summary Statistics

	Inflation	Real GDP growth	Real investment growth
Mean	7.2	4.9	4.6
Median	6.3	4.9	4
Maximum	30	10.2	27.4
(year)	(1974)	(1954)	(1963)
Minimum	-3.2	-1.8	-12
(year)	(1959)	(1952)	(1968)
Std. Dev.	5.5	2.3	7.7
		Average values	
1950s	2.7	3.1	-
1960s	3.2	6.8	8
1970s	12.5	4.8	3.7
1980s	7.2	6.1	5.9
1990s	9.7	4.4	2.2
2000s	8	4.6	3.6
2010-17	7.5	4.1	4.4

Source: Authors' estimates

Coming towards growth, there was only one year when real GDP growth was negative, i.e., 1952. However, in 2009 the country experienced a growth rate as low as 0.4 percent (in the aftermath of global financial crisis). The decade of 1960s features a high growth period, followed by another in 1980s. The supportive economic policies mainly get the credit for these high growth rates.

3. Results

Before running the regression, we have checked the variables for non-stationarity by using Augmented Dickey-Fuller and Phillips-Perron tests. The results are reported in Annexure 3, which show that all the variables are stationary in growth form, thus can be used in estimation in both the techniques we followed. The estimated equations of the two approaches are given and discussed below.

3.1 Quadratic equation specification

Compared to linear, cubic and quartic specifications, the quadratic model was found a good fit to the data. Moreover, the AIC value for the estimated quadratic model is

minimum compared to other models. The results of estimated quadratic equation gives threshold inflation of 6.05 percent (Tables 3).[3]

Table 3: Threshold Estimation from Quadratic Equation (annual data 1976 to 2017**)**

Dependent Variable: real GDP growth				
Regressors	Coefficient	Std. error	t-Statistic	Prob.
Constant	3.44	1.21	2.85	0.01
Inflation	0.49	0.29	1.68	0.10
Squared inflation	-0.04	0.01	-2.88	0.01
Investment growth	0.09	0.07	1.31	0.20
D_double	0.82	1.12	0.73	0.47
Observations:	42	R^2		0.27
RSS:	104.64	DW-statistic		1.47
F-Statistic:	3.40	AIC		4.00
Threshold inflation	**6.05**			

3.2 Regression kink model

We also employed a regression kink model to estimate the threshold inflation and tested this model against a linear model using a Wald F-test. Furthermore, the kinked model searches for an unknown threshold within a defined range and selects the threshold level, which is global minimum against a pre-defined criterion (equation 4). Local minima are not relevant in our case. In estimating equation (3), we have set a closed interval [1, 15] for the threshold parameter, with discrete grid increments of 0.01. Keeping in view the history of inflation in Pakistan, we expect the threshold to lie in this range. At each grid point for γ the least squares criterion $S_n^*(\gamma)$ was computed and plotted in Figure 2. This function has a global minimum at $\gamma = 5.67$, which is the estimated threshold level of inflation for Pakistan. The estimated parameters of the regression kink model are reported in Table 4.

The slope of the regression before threshold inflation is positive 0.74, whereas after threshold it is negative, -0.53 (Figure 3). It implies that a one-percentage point increase in inflation may lead to 0.74 percentage point rise in the real GDP growth as long as inflation remains below 5.67 percent. Beyond this threshold level, a one-percentage point increase in inflation may lead to 0.53 percentage point reduction in the real GDP

[3] In Table 3, D_double is a dummy variable having value 1 for the year when a supply/cost push shock(s) such as sharp depreciation of exchange rate, flood and sudden jump in international prices resulted in double digits inflation (see Annexure 2). Though this dummy is statistically insignificant in quadratic model, it improves the quality of the regression especially of the kinked one.

growth. The narrow width of the bootstrap confidence intervals suggests that the threshold effect is estimated with enough certainty.

Figure 1: Threshold Parameter: Bootstrap and Asymptotic Critical Values

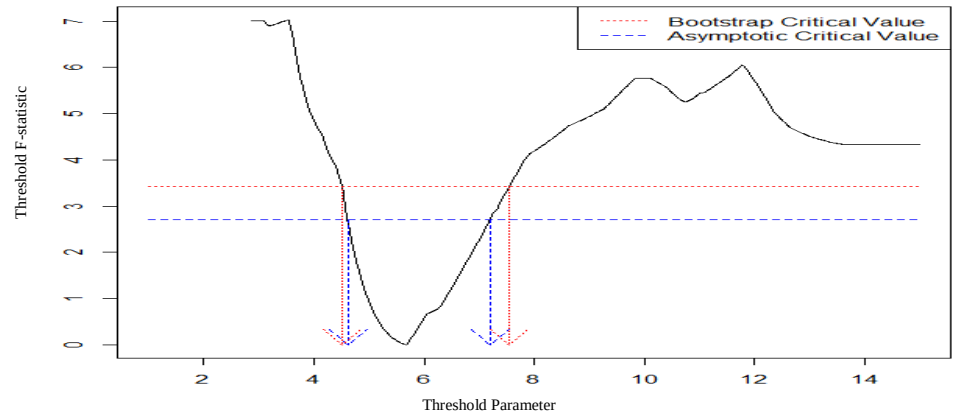
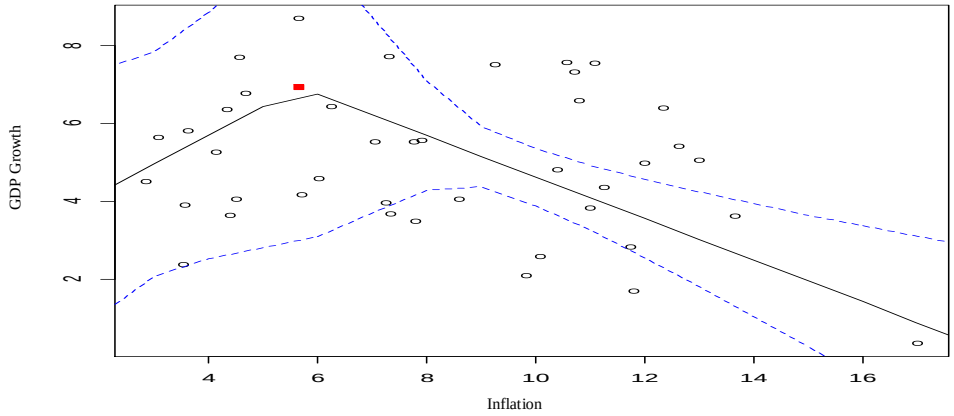


Table 4: Threshold Model Results – Regression Kink model (Annual data; 1976 to 2017)

			Bootstrap 90% confidence intervals	
	Estimates	Standard Errors	Lower	Upper
β1	0.74	0.55	-0.13	1.61
β2	-0.53	0.16	-0.83	-0.23
Investment growth	0.14	0.05	0.07	0.22
D_double	2.00	1.01	0.13	3.88
Constant	5.60	0.62	4.71	6.49
Threshold level	**5.67**	1.02	4.44	7.69
Number of observations				42
Error variance of regression kink				2.08
Error variance of linear regression (with no threshold)				2.50
Wald-F test value for existence of threshold effect				8.15
Critical value of F-statistics at 90%				6.12

Figure 2: Estimated Kinked Growth Line and Confidence Intervals



4. Conclusion

The study estimates the relationship between inflation and growth in Pakistan, focusing on finding the threshold level of inflation. There is a consensus in the literature on nonlinearity of the relationship between inflation and economic growth - inflation affects growth positively when it is low, and negatively when it is high. However, in case of Pakistan, we can find a number of years when high inflation and high growth co-existed and similarly low inflation was observed in the periods of low growth. Therefore, it becomes a difficult task to find threshold inflation in Pakistan using simple statistical techniques, especially when there are structural changes in the economy. We have used two different methodologies on annual data (from 1976 to 2017) and found very close results. First, we estimated a quadratic equation for growth and found that the growth rate is maximized at 6.05 percent inflation rate. Second, we estimated a regression-kink model which gave a threshold inflation rate of 5.67 percent. While estimating the threshold level using the later approach we also observed marginal effects of inflation on growth when inflation is below/above its threshold. A rise (fall) of 0.74 (0.53) percentage point in real GDP growth in Pakistan is associated with one percentage point increase in inflation when inflation is below (above) the estimated threshold level.

Keeping in view these very close estimated threshold inflation levels, we can safely conclude that as long as inflation rate in Pakistan remains around 6 percent it will be favorable for economic growth; inflation higher than 6 percent can hurt economic growth.

Historically, average real GDP growth rate has been more than 5 percent during the low inflation periods (i.e., inflation rate below 6 percent), and 4.7 percent during very high inflation periods (i.e., inflation rate above 6 percent). There was only one year (1990)

when inflation was at 6.0 percent and average real GDP growth was recorded 4.6 percent – lower than its historical average. Therefore, a more careful policy is required when inflation rate is projected to cross the threshold level.

References

Barro, R. J. (2013). "Inflation and Economic Growth." *Annals of Economics and Finance,* 14, 1: 85-109.

Benhabib, J. and M. M. Spiegel (2009). "Moderate Inflation and the Deflation: Depression Link." *Journal of Money, Credit and Banking*, 41, 4: 787-798.

Bittencourt, M. (2012). "Inflation and Economic Growth in Latin America: Some Panel Time-Series Evidence." *Economic Modelling*, 29, 2: 333-340.

Bruno, M. and W. Easterly (1996). "Inflation Crises and Long-Run Growth." *Journal of Monetary Economics,* 41, 1: 3-26.

Bollen, K. A. (1990). "Political Democracy: Conceptual and Measurement Traps." *Studies in Comparative International Development*, 25, 1: 7-24.

Burdekin, R. C. K., A. T. Denzau, M. W. Keil, T. Sitthiyot, and T. D. Willett (2004). "When Does Inflation Hurt Economic Growth? Different Nonlinearities for Different Economies." *Journal of Macroeconomics*, 26, 3: 519-532.

Clark, T. E. (1997). "Cross-Country Evidence on Long-Run Growth and Inflation." *Economic Inquiry,* 35, 1: 70-81.

Eggoh, J. C. and M. Khan (2014). "On the Nonlinear Relationship between Inflation and Economic Growth." *Research in Economics*, 68, 2: 133-143.

Gastil, R. D. and C. R. Beitz (1982). *Freedom in the World: Political Rights and Civil Liberties, 1982*. Westport: Greenwood Press.

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

Hansen, B. E. (2017). "Regression Kink with an Unknown Threshold." *Journal of Business & Economic Statistics*, 35, 2: 228-240.

Hussain, M. (2005). "Inflation and Growth: Estimation of Threshold point for Pakistan." *Pakistan Business Review*, 17, 3: 1-15.

Iqbal, N. and S. Nawaz (2009). "Investment, Inflation and Economic Growth Nexus." *The Pakistan Development Review*, 48, 4: 863-874.

Khan, M. S. and A. S. Senhadji (2001). "Threshold Effects in the Relationship between Inflation and Growth." *IMF Staff Papers,* 48, 1: 1-22.

Knack, S. and P. Keefer (1995). "Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures.' *Economics & Politics*, 7, 3: 207-227.

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

Mundell, R. A. (1963). "Inflation and Real Interest." *Journal of Political Economy*, 71, 3: 280-283.

Pollin, R. and A. Zhu (2006). "Inflation and Economic Growth: A Cross-Country Nonlinear Analysis." *Journal of Post Keynesian Economics*, 28, 4: 593-614.

Sarel, M. (1996). "Nonlinear Effects of Inflation on Economic Growth." *IMF Staff Papers*, 43, 1: 199-215.

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*, 33, 4: 671-684.

Vinayagathasan, T. (2013). "Inflation and Economic Growth: A Dynamic Panel Threshold Analysis for Asian Economies." *Journal of Asian Economics*, 26: 31-41.

Annexure 1: Review of Selected Previous Studies on the Subject

Author	Empirical approach	variables	Country(s)	Whether includes Pakistan?	Data	Findings
Sarel (1996)	Regression estimates through OLS	Population, GDP, consumer price indices, terms of trade, real exchange rates, government expenditures, and investment rate	87	Yes	1970-90	Inflation has slightly positive or no effect on growth below 8 percent.
Clark (1997)	Several specifications of the growth-inflation relationship, each of which simply augment the reduced form Solow growth equation	GDP per capita, investment to GDP ratio, average growth rate of population, primary and secondary school enrollment rates, average CPI, coefficient of variation of inflation over time, measuring inflation volatility from residual of equation,	85	Yes	1960-85	Growth-inflation results are highly sensitive to modification to the country sample and time period. The paper discourages the practice of quantifying the inflation effect with cross-country growth regressions.
Bruno and Easterly (1998)	Simple correlation between cross-section inflation and growth averages over 1961 1994. Historical description of what happened during high inflation crisis. Inflation crisis is defined by taking a threshold level of 40%.	Real GDP, CPI, Total Factor Productivity (TFP) and capital growth from Nehru and Dhareshwar (1993), investment to GDP	Not mentioned	Yes	1961-94	Inflation-growth correlation is only present with high frequency data and with extreme inflation observations; there is no cross-sectional correlation between long-run averages. Growth falls sharply during discrete high inflation crises, then recovers rapidly following decline in inflation.

Author	Empirical approach	variables	Country(s)	Whether includes Pakistan?	Data	Findings
Ghosh and Phillips (1998)	Different inflation-growth regressions using OLS, 2SLS	Investment ratio, first principal component of primary and secondary school enrollment rates and life expectancy as a measure of human capital (HK), the log of the ratio of U.S. per capita income to country j's per capita income in 1960 is measured in international prices (catch-up), revenues to GDP, public consumption to GDP, fiscal balance, ratio of exports plus imports to GDP (openness), log of black market exchange rate premium (economic mismanagement), trade volatility (external shocks), current and lagged terms of trade changes dummies for drought and war-related deaths	145	Not found in the paper	1960-96	A negative relationship observed between inflation and growth that is both statistically and economically significant. At very low inflation rates, the relationship is positive. At all other inflation rates, the apparent marginal effect of inflation on growth becomes less important as higher inflation rates are considered.
Khan and Sendhaji (2001)	Conditional Least Squares, Non Linear Least Square (NLLS)	Growth rate of real GDP, inflation, the initial income level measured as the five year, average of GDP per capita in 1987 PPP prices, gross domestic investment as share of GDP, population growth, the growth rate of terms of trade, and the five year standard deviation of terms of trade	140	Yes	1960–98	The threshold level of inflation above which inflation significantly slows growth is estimated at 1–3 percent for industrial countries and 11–12 percent for developing countries.

Author	Empirical approach	variables	Country(s)	Whether includes Pakistan?	Data	Findings
Burdekin et al (2004)	Panel GLS	Real GDP per capita and its first lag, inflation rate, different breaks specific inflation rate, first difference of inflation, population growth, real government expenditure to real GDP, ratio of black market exchange rate to official exchange rate, percentage growth in terms of trade	72	Yes	1965-92	A higher threshold for industrial countries (8%) than for developing countries (3%).
Hussain (2005)	Conditional Least Squares	Growth rate of real GDP, CPI inflation, population growth rate, investment to income ratio, M2-GDP ratio (financial deepening)	Pakistan	Yes	1973-05	Inflation exceeding a range of 4 - 6% deters economic growth.
Mubarik (2005)	Conditional Least Squares	Growth rate of real GDP, CPI inflation, population growth rate, investment growth rate	Pakistan	Yes	1973-00	Study estimates 9 percent as the threshold inflation level for Pakistan.
Bittencourt (2012)	Panel Time series analysis/models	Real gross domestic products per capita, inflation, general government debt share to GDP, ratio of exports and imports to GDP (Openness), ratio of investment to real GDP, ratio of the liquid liabilities to GDP (M2) (Financial Development), interaction term of average years of schooling of those aged 25 and over	Argentina, Bolivia, Brazil and Peru	No	1970-07	Inflation has had a detrimental effect on growth in the region. Excessive inflation has clearly offset the Mundell–Tobin effect and consequently the high costs that inflation has had on economic activity in the region.

		and percentage of the total urban population (structural development), instruments for democracy, constraints on executives and political competition, proxy for political regime characteristics, government share of GDP, external debt to GDP				
Baroo (2013)	Panel estimates of growth equations	CPI (in few cases GDP deflator), standard deviation of inflation rate, growth rate of real per capita GDP, investment to GDP, male/female schooling (education), life expectancy (health), human capital (overall estimated effect from the levels of school attainment and the log of life expectancy),fertility rate, government consumption ratio, public education expenses to total expenses, black market FX premium (market distortions), rule of law index (measured by Knack and Keefer's (1994) subjective index), terms of trade change, democracy index (Gastil and Beitz(1982) and Bollen (1990))	100	Yes	1960-90	An increase in average inflation by 10 percentage points per year results in a reduction of the growth rate of real per capita GDP by 0.2-0.3 percentage points per year and a decrease in the ratio of investment to GDP by 0.4-0.6 percentage points.

Author	Empirical approach	variables	Country(s)	Whether includes Pakistan?	Data	Findings
Vinayagathasan (2013)	Dynamic panel threshold model using Fixed Effects (FE), Bias-corrected Least Square Dummy Variable (LSDVC) and GMM.	Growth rate of GDP per capita, initial income, investment ratio, inflation rate, population growth rate, trade openness, terms of trade, standard deviation of terms of trade and openness.	32	Yes	1980–09	An inflation threshold of approximately 5.43%.
Eggoh and Khan (2014)	Panel Smooth Transition model (PSTR) and Dynamic GMM.	Real GDP growth rate and its lag, initial GDP per capita, CPI inflation rate, population growth, ratio of imports plus exports to GDP (openness), government expenditure to GDP (fiscal indicator), investment (gross fiscal capital formation to GDP), government expenditure, the ratio of liquid liability(M3) to GDP (financial depth)	102	Yes	1960-09	The inflation threshold is found to be 12.4% for the whole sample. When inflation is above its threshold level, increase of 1% in the inflation rate reduces the economic growth by 3.99%.
Thanh (2015)	Panel Smooth Transition Regression (PSTR) model and GMM-IV specification	Growth rate of GDP per capita, initial level of output, employment growth rate, investment growth rate, Growth rate of terms of trade, standard deviation of terms of trade, government spending growth rate, inflation rate, semi-log transformation of CPI.	Indonesia, Malaysia, Philippines, Thailand, Vietnam	No	1980–11	The study finds that there exists a statistically significant negative relationship between inflation and growth for the inflation rates above the threshold level of 7.84%, above which inflation starts impeding economic growth in the ASEAN-5 countries.

Annexure 2: Double Digit Inflation Periods in Pakistan

Year	CPI inflation	Factors
1974	30.0	Oil price shock (from $3.24 per barrel to $11.6 per barrel); floods (affected area = 41,472 sq km); and pest attacks
1975	26.8	Floods (affected area = 34,931 sq km)
1976	11.6	Floods (Affected area = 81,920 sq km); and pest attacks
1977	11.8	Floods (Affected area = 4,657 sq km); and pest attacks
1980	10.7	Oil price shock (from $12.8 per barrel to $29.8 per barrel)
1981	12.4	Floods (affected area = 4,191 sq km)
1982	11.1	Delinking of PKR from USD; increase in import prices; increase in administered prices (e.g petrol, gas tariffs for households, sugar)
1989	10.4	Floods (affected area = 6,144 sq km); exchange rate depreciation (12.4%)
1991	12.6	Oil price shock due to Gulf war (33%); exchange rate depreciation (8.8%); increase in unit value of imports; and increase in administered prices
1992	10.6	Depreciation of currency against USD (5.1%); increase in administered prices; floods (affected are = 38,758 Sq Km)
1994	11.3	Depreciation of currency against USD (8%); increase in POL prices; increase in procurement prices of wheat; decrease in imports of key food items such as palm oil, tea, sugar, pulses etc.; floods (affected area = 5,568 Sq km)
1995	13.0	Floods (affected area = 16,686 Sq Km); increase in administered prices; supply bottlenecks of essential items, including poor wheat crop; decline in rice output and unsatisfactory performance of minor crops; and increase in global price of palm oil
1996	10.8	Depreciation of currency against USD (12.3%); increase in administered prices
1997	11.8	Depreciation of currency against USD (12.2 %); increase in administered prices such as POL; increase in support prices of agricultural commodities; withdrawal of subsidies on basic food items; withholding tax on imports and supplies.
2008	12.0	Soaring global food and oil prices; exchange rate shock (13.7 percent depreciation)
2009	17.0	Peak of global oil prices just before Global Financial Crisis; exchange rate shock (13.8% depreciation)
2010	10.1	Floods all across Pakistan (affected area = 160,000 Sq Km); rising international prices of sugar, cotton, and oil; and domestic oil prices were also increased
2011	13.7	Floods (affected area = 27,581 Km); higher global prices of edible oils, sugar, cotton, crude oil and petroleum products, metals, and phasing out of power subsidies
2012	11.0	Floods (affected area = 4,746 Sq Km); exchange rate depreciation (7.6%)

Source: Economic surveys (various years), SBP annual reports, Federal Flood Commission.

Annexure 3:

A: Results of Unit Root tests (Period: 1976-2017)

	Augmented Dickey-Fuller Test Null Hypothesis: series has a unit root		**Phillips-Perron test statistic** Null Hypothesis: series has a Unit root	
	ADF-stat	Probability	Adj. t-stat	Probability
At level (with constant)				
CPI Inflation	-4.04	0.00	-3.15	0.03
Real GDP Growth	-5.24	0.00	-5.21	0.00
Real Investment Growth	-3.24	0.03	-5.16	0.00
At first difference				
CPI Inflation	-3.37	0.00	-8.13	0.00
Real GDP Growth	-5.46	0.00	-12.54	0.00
Real Investment Growth	-4.00	0.00	-9.06	0.00

Notes: (a) Lag length selection is based on AIC; and (b) Probability is based on MacKinnon (1996) one-sided p-values.