

Inflation and Growth: An Estimate of the Threshold Level of Inflation in Pakistan

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This study estimates the threshold level of inflation in Pakistan [à la Khan and Senhadji (2001)] using annual dataset from 1973 to 2000. The estimated model suggests 9 percent threshold level of inflation above which inflation is inimical for economic growth.

JEL Codes: E31, C13

Key Words: Inflation, Growth, Threshold

1. Introduction

This paper attempts to estimate the threshold level of inflation for Pakistan. Following the work of Khan and Senhadji (2001), the study estimates the 'threshold model' and suggests 9 percent as the threshold inflation level.

With the passage of time a general consensus developed that the moderate inflation helps in economic growth, unlike high price level that may create uncertainty and hamper economic performance. This consensus raises an interesting policy issue of how much of inflation is too much; that is, how much inflation impedes economic growth? Although work on modeling the nature of relationship between inflation and economic growth is under progress, a considerable amount of literature on this issue is available. Several studies address this issue for both developed and developing countries. However, Khan and Senhadji's (2001) work is seminal in that it actually calculates the threshold level of inflation for both developing and developed countries. For developing countries, including Pakistan, they suggest a threshold level range of 7-11 percent.

This study follows Khan and Senhadji (2001) methodology and exclusively focuses on Pakistan and suggests an exact threshold level, as opposed to a range. The strategy of this paper is as follows. Section 2 presents a brief literature review

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on inflation and growth. Section 3 attempts to find some consistent observations on inflation and growth in Pakistan. Section 4 outlines the threshold model. Estimation results of the threshold model are presented in Section 5. Concluding remarks follow in Section 6.

2. Inflation and Growth: A Brief Literature Review

Several studies have estimated a negative relationship between inflation and economic growth. Nevertheless, some studies have accounted for the opposite. Thirlwall and Barton (1971), in one of the earliest cross-country studies, report a positive relationship between inflation and growth in a cross section of industrial countries and a negative relationship in a cross section of 7 developing countries.

Gillman et al. (2002), based on a panel data of Organization for Economic Cooperation and Development (OECD) and Asia-Pacific Economic Cooperation (APEC) countries, indicate that the reduction of high and medium inflation (double digits) to moderate single digit figures has a significant positive effect on growth for the OECD countries, and to a lesser extent for the APEC countries. They further add that the effect of an expected deceleration of inflation might only be observed when the world economy is not facing a sudden growth rate deceleration due to shocks. If there are no such shocks, a reduction in inflation rate can produce considerably higher growth rate. Similarly, Alexander (1997) finds a strong negative influence of inflation on growth rate of per capita GDP using a panel of OECD countries.

Fischer (1993) results indicate that inflation reduces growth by reducing investment and productivity growth. He further notes that, low inflation and small fiscal deficits are not necessary for high growth even over long periods; likewise, high inflation is not consistent with sustained economic growth. Ghosh and Phillips (1998), using large panel dataset, covering IMF member countries over 1960 to 1996, found that at very low inflation rates (less than 2-3 per cent) inflation and growth are positively correlated. However, they are negatively correlated at high level of inflation. Similarly, the empirical results of Nell (2000) suggest that inflation within the single-digit zone may be beneficial, while inflation in the double-digit zone appears to impose slower growth.

Bruno and Easterly (1996) find no evidence of any relationship between inflation and growth at annual inflation rates of less than 40 percent. They find a negative, shorter to medium term relationship between high inflation (more than 40 percent) and growth. Furthermore, they report that there was no lasting damage to growth from discrete high inflation crises, as countries tend to recover back toward their

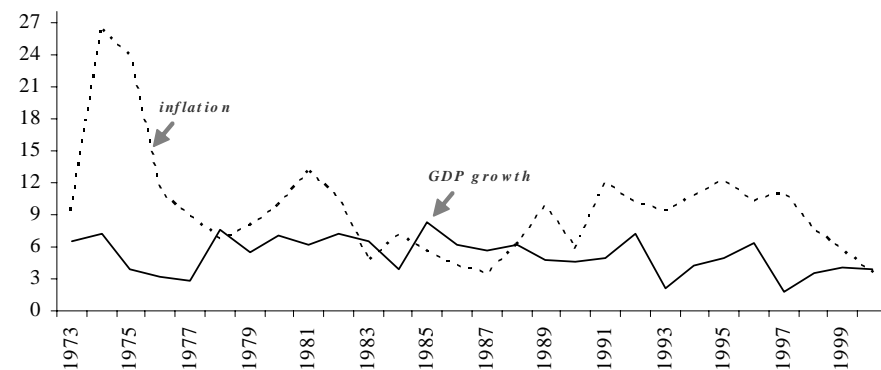
pre-crisis growth rates. Mallik and Chowdhury (2001) conducted cointegration analysis of inflation on economic growth for four South Asian countries (Bangladesh, India, Pakistan, and Sri Lanka) and report two interesting points. First, inflation and economic growth are positively related. Second, the sensitivity of inflation to changes in growth rates is larger than that of growth to changes in inflation rates.

One recent analysis suggests that there is a threshold level of inflation in the relationship between output growth and inflation. In this context, Khan and Senhadji (2001) have done the seminal work. They not only examine the relationship of high and low inflation with economic growth but also suggest the threshold inflation level for both industrialized and developing countries. They conduct a study using panel data for 140 developing and industrialized countries for the period of 1960-98. Their results strongly suggest the existence of a threshold beyond which the inflation exerts a negative effect on economic growth. In particular, the threshold estimates are 1-3 percent and 7-11 percent for industrial and developing countries, respectively.

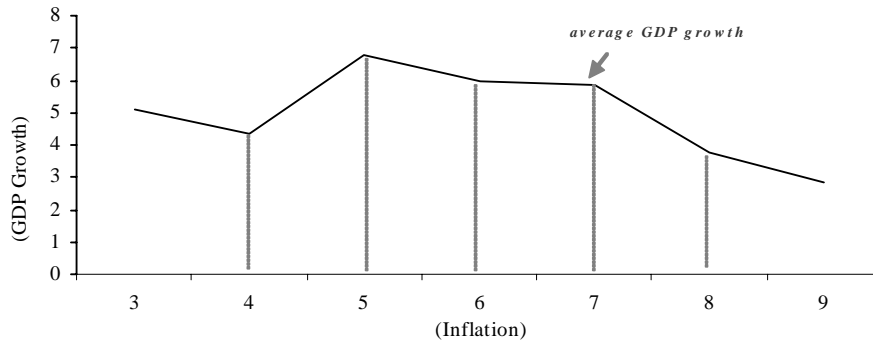
3. An Overview of Inflation and Growth

The literature review in the preceding section does suggest a negative relationship between inflation and economic growth. However, as a motivation, it is imperative to observe the relationship through visual examination. Figure 1 illustrates the

Figure 1. Inflation and Real GDP Growth Rates, 1973-2000



Source: *Economic Survey of Pakistan* (various issues)

Figure 2. Average GDP Growth and Inflation

trend in inflation and GDP growth rates of Pakistan.¹ The figure somehow indicates an inverse relationship between both these variables. As illustrated, growth rates remained below 5 percent until late 1970s during which inflation remained mostly double digit. Another double-digit episode of inflation was in 1990s during which the growth performance remained dismal.

However, for a more precise picture, it is worthy to understand the historical nature of relationship between the two variables. For this purpose, whole sample (1973-2000) is reduced into nine observations. How to arrive on nine observations? First of all, the range of inflation is chosen from the sample (minimum and maximum levels of inflation in the given sample). Within this band of inflation, average GDP growth rates are calculated against each linear level of inflation; for example, what is the average value of GDP when inflation rates are 3 percent during the period (1973-2000) and so on. Figure 2 shows that GDP growth and inflation have positive relationship up to 7 percent inflation; and beyond that level there is a negative relationship. This suggests that the threshold level is roughly around 7 percent that may affect economic growth.

This simple analysis suggests that inflation has a negative effect on economic growth. Here, policymakers would be interested in a threshold level of inflation above which inflation adversely affects economic growth while below that level inflation is favorable for economic growth. First part of this policy issue can be addressed with the help of a threshold model for inflation. However, the study is limited in the sense that it does not estimate the lower level of inflation favorable for economic growth.

¹ Note that inflation is growth in the log of CPI.

4. Threshold Model

The model is developed by Khan and Senhadji (2001) for the analysis of threshold level of inflation for industrialized and developing countries. Following the aforementioned work, this study is based on four-variable model consisting of economic growth, inflation, population, and total investment growth rates.²

Threshold level of inflation is based on the following equation:

$$GROWTH = \beta_0 + \beta_1(INF_t) + \beta_2 * D_t(INF_t - k) + \beta_3(POP_t) + \beta_4(INVST_t) + U_t \quad (1)$$

Economic growth and inflation are computed as:

$$GROWTH_t = 100 * DLOG(Y_t)$$

$$INF_t = 100 * DLOG(P_t).$$

Y_t : real GDP

P_t : consumer price index

$GROWTH_t$: growth rate of real GDP

INF_t : inflation

POP_t : population growth rate

$INVST_t$: investment growth rate

k : threshold level of inflation

U_t : error term

Growth rates of population and investment are computed using similar method. Whereas, the dummy variable is defined as:

$$D_t = \begin{cases} 1 : 100 * DLOG P_t > k \\ 0 : 100 * DLOG P_t \leq k \end{cases}$$

The parameter k represents the threshold inflation level with the property that the relationship between output growth and inflation is given by: (i) low inflation: β_1 ; (ii) high inflation: $\beta_1 + \beta_2$. High inflation means that when long-run inflation

² Population and total investment growth rates are used as control variables. The reason for choosing these variables is their authenticity in empirical literature on growth. Solow (1956) and Swan (1956) who developed the first neo-classical models of growth, take the rate of growth of population as one of exogenous variables in their model to show that the faster the rate of population growth, the poorer the country. Fischer (1993) includes investment in his model to show that inflation reduces growth by reducing investment and productivity growth. Moreover, Mankiw et al. (1992) also include investment growth and population growth in their growth model.

estimate is significant then both $(\beta_1 + \beta_2)$ would be added to see their impact on growth and that would be the threshold level of inflation. While the value of k is given arbitrarily for the estimation, the optimal k is obtained by finding that value that minimizes the residual sum of squares (RSS). Thus, the optimal threshold level is that which minimizes the sequence of residual sum of square (RSS). Inflation at this level has a significant impact on economic growth.

5. Threshold Model Estimation

The study uses annual dataset on Consumer Price Index (CPI based on 1990-91), real GDP (at constant factor cost of 1980-81), population, and total investment for the period of 1973 to 2000.³ The data is obtained from Economic Survey of Pakistan (various issues).

The growth rate of GDP, CPI, population, and total investment are computed by using log transformation method that eliminates, at least partially, the strong asymmetry in inflation distribution. The log transformation also, to some extent, smoothed time trend in the dataset. Khan and Senhadji (2001) calculate growth rates of macroeconomic variables using log transformation, which provides best fit in the class of non-linear models. Although the growth rates of all these variables are calculated using log transformation method, still there is a lot of volatility in the data (Figure 1). Therefore, the dataset is further smoothed using Hodrick-Prescott filter.

Before estimating the model, Granger Causality test is applied to measure the linear causation between inflation and economic growth. Test statistics in Table 1 show that the null hypothesis is rejected, which means that inflation is causing GDP growth. The causality between two variables is uni-directed. The second null hypothesis of output growth causes inflation is not rejected at 5-10 percent level of significance, which proves that there is no feedback from output growth to inflation. This result helps in the choice of dependent and independent variable for the threshold model specification.

Table 1. Pair wise Granger Causality Tests

Sample: 1973 2000			
Null Hypothesis:	Observations	F-statistics	Probability
INF does not Granger Cause GDP	26	3.15042	0.0636
GDP does not Granger Cause INF	26	0.39603	0.6779

³ The selection of sample is based on data availability and to avoid the structural shift in the series caused by the 1971 war.

Table 2. Estimation of non-Linear Model at K= 7 to 11
(Dependent Variable: GDP growth)

k	Variable	Coefficient	Std. Error	t-Statistic	Prob.	RSS
7%	INF	0.1182	0.1474	0.8021	0.4342	0.015
	(INF>7)*(INF-7)	-0.1657	0.1506	-1.1000	0.2876	
	Population growth	2.4455	0.0333	73.4890	0.0000	
	Investment growth	0.1196	0.0053	22.6036	0.0000	
	C	-3.8451	1.0401	-3.6970	0.0020	
8%	INF	-0.0002	0.0185	-0.0134	0.9894	0.012
	(INF>8)*(INF-8)	-0.0607	0.0248	-2.4509	0.0261	
	Population growth	2.4658	0.0310	79.6352	0.0000	
	Investment growth	0.1200	0.0047	25.6829	0.0000	
	C	-3.1037	0.1786	-17.3738	0.0000	
9%	INF	-0.0218	0.0096	-2.2578	0.0383	0.011
	(INF>9)*(INF-9)	-0.0590	0.0220	-2.6834	0.0163	
	Population growth	2.4939	0.0349	71.4783	0.0000	
	Investment growth	0.1174	0.0046	25.2551	0.0000	
	C	-2.9928	0.1291	-23.1825	0.0000	
10%	INF	-0.0334	0.0076	-4.3999	0.0004	0.013
	(INF>10)*(INF-10)	-0.0662	0.0337	-1.9667	0.0668	
	Population growth	2.4702	0.0344	71.7813	0.0000	
	Investment growth	0.1182	0.0050	23.6326	0.0000	
	C	-2.8494	0.1068	-26.6737	0.0000	
11%	INF	-0.0369	0.0071	-5.2121	0.0001	0.014
	(INF>11)*(INF-11)	-0.2226	0.1382	-1.6108	0.1268	
	Population growth	2.4587	0.0338	72.6749	0.0000	
	Investment growth	0.1188	0.0051	23.1281	0.0000	
	C	-2.7986	0.0990	-28.2576	0.0000	

The estimation of Equation (1) gives a precise value of threshold inflation level and also quantifies the impact of that level on economic growth (Table 2). For this purpose Equation (1) is estimated and the residual sum of square (RSS) for threshold level of inflation ranging from k_1 percent to k_n percent was computed.

In Granger Causality analysis, inflation is causing growth at lag two (lag = 2) for the given period of 1972-2000; therefore, inflation is kept at lag two in the estimate. The optimal threshold level is the one that minimizes the sequence of RSS (Table 2). The t-statistics and their p-values of following estimated equation are given in Table 2.

The p-values on $\hat{\beta}_1$ suggest that for low inflation levels ($k \leq 9$) there is an insignificant relationship between output growth and inflation. For higher inflation level ($k > 9$) there is a significant negative relationship between output growth and inflation. The insignificant relationship is translating into significant one as the

level of inflation (k) increases above 7 percent. Finally, 9 percent inflation level is a threshold level, which is obtained by finding that value of k that minimizes the residual sum of squares (RSS). If inflation increases above threshold level, growth is estimated to decline by 0.08 percent. Beyond that level, there might be a significant shock to economic performance of the country.

Sensitivity Analysis

There could be a specification bias of the estimated model [Equation (1)]; that is, exclusion of other relevant variables for a growth equation.⁴ To check this bias, inflation, real GDP growth, investment growth, and population growth are used as instruments.⁵ The results of 2SLS (Table 3) also suggest 9 percent threshold

Table 3. Estimation of non-Linear Model at K= 7 to 10
(Dependent Variable: GDP growth)

k	Variable	Coefficient	Std. Error	t-Statistic	Prob.	RSS
7%	INF	1.2311	1.2919	0.9529	0.3557	0.068
	(INF>7)*(INF-7)	-1.3026	1.3280	-0.9809	0.3422	
	Population growth	2.4840	0.0822	30.2031	0.0000	
	Investment growth	0.1195	0.0118	10.0889	0.0000	
	C	-11.6814	9.0483	-1.2910	0.2162	
8%	INF	0.0646	0.0583	1.1080	0.2853	0.038
	(INF>8)*(INF-8)	-0.1544	0.0884	-1.7472	0.1010	
	Population growth	2.4891	0.0472	52.7248	0.0000	
	Investment growth	0.1227	0.0070	17.6548	0.0000	
	C	-3.6846	0.5173	-7.1227	0.0000	
9%	INF	-0.0085	0.0137	-0.6243	0.5418	0.029
	(INF>9)*(INF-9)	-0.1131	0.0487	-2.3225	0.0347	
	Population growth	2.5177	0.0418	60.2545	0.0000	
	Investment growth	0.1174	0.0051	23.1995	0.0000	
	C	-3.1594	0.1790	-17.6509	0.0000	
10%	INF	-0.0209	0.0099	-2.1013	0.0529	0.030
	(INF>10)*(INF-10)	-0.3972	0.1792	-2.2168	0.0425	
	Population growth	2.5075	0.0411	61.0226	0.0000	
	Investment growth	0.1170	0.0053	21.9376	0.0000	
	C	-3.0334	0.1429	-21.2306	0.0000	

Instrument list: *INF(-3) INVST(-3) POP(-2) GDP(-3)*

⁴ Scope of the model and data unavailability is the main reason behind the exclusion of other relevant variables.

⁵ Since the original model is based on two lags, therefore all instruments were defined with three lags except for population that was significant at two lags. These instruments are only valid if the error term in Equation (1) is not autocorrelated (Both Augmented Dickey-Fuller and Phillips Perron tests reject autocorrelation in the error term at 5 percent level of significance).

inflation level (Table 3). The comparison of both estimated models [Table 2 (OLS) and Table 3 (2SLS)] show a similar threshold level of inflation and the values of estimated coefficients also remain close in both the models. Both results indicate 9 percent threshold inflation level for economic growth in Pakistan.

6. Concluding Remarks

The estimates of causality test, an application of threshold model and finally its sensitivity analysis using home country dataset of inflation and output growth suggest the following major findings. The Granger Causality test defines causality direction from inflation to economic growth and not vice versa (uni-directed). The threshold model estimation recommends 9 percent threshold inflation level for economic growth at which inflation is red alert for economic growth. The sensitivity analysis, conducted for the robustness of the model, also suggests the same level of threshold inflation. The empirical analysis suggests that the inflation below the estimated level of 9 percent is conducive for economic growth. The result might be useful for policymakers in providing some clue in setting an optimal inflation target. However, this study does not estimate that level of inflation that is too low for economic growth; indeed, this calls for further research on the topic.

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