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Inflation and Economic Growth in Bangladesh: 1981-2005

Shamim Ahmed and Md. Golam Mortaza[*]

December 2005

Abstract

It is widely believed that moderate and stable inflation rates promote the development process of a country, and hence economic growth. Moderate inflation supplements return to savers, enhances investment, and therefore, accelerates economic growth of the country. This paper empirically explores the present relationship between inflation and economic growth in the context of Bangladesh. Using annual data set on real GDP and CPI for the period of 1980 to 2005, an assessment of empirical evidence has been acquired through the co-integration and error correction models. Further, it explores an interesting policy issue of what is the threshold level of inflation for the economy. The empirical evidence demonstrates that there exists a statistically significant long-run *negative* relationship between inflation and economic growth for the country as indicated by a statistically significant long-run *negative* relationship between CPI and real GDP. In addition, the estimated threshold model suggests 6-percent as the threshold level (i.e., structural break point) of inflation above which inflation adversely affects economic growth. These results have important policy implications for both domestic policy makers and the development partners working for the country. Specifically, our conclusion is of direct relevance to the conduct of the monetary policy by the Bangladesh Bank.

Keywords: Inflation, Economic Growth, Granger Causality, Structural Break, Threshold level of Inflation

JEL Classification: C13, C22, E31

Inflation and Economic Growth in Bangladesh: 1981-2005

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1. Introduction

Over the past few decades, the nexus between inflation and economic growth have drawn extensive attention of macroeconomists, policy makers and the central bankers of both developed and developing countries. Specifically, the issue that whether inflation is necessary for economic growth or it is harmful generates a significant debate both theoretically and empirically. The issue originally evolves from the controversial notion between the *structuralists* and the *monetarists*.[1] In this connection, Mundell (1965) and Tobin (1965) predict a positive relationship between the rate of inflation and the rate of capital accumulation, which in turn, implies a positive relationship to the rate of economic growth.[2] They argue that since money and capital are substitutable, an increase in the rate of inflation increases capital accumulation by shifting portfolio from money to capital, and thereby, stimulating a higher rate of economic growth (Gregorio, 1996). Conversely, Fischer and Modigliani (1978) suggest a negative and nonlinear relationship between the rate of inflation and economic growth through the new growth theory mechanisms (Malla, 1997). They mention that inflation restricts economic growth largely by reducing the efficiency of investment rather than its level.

To date, although the relationship between inflation and economic growth remains controversial or somewhat inconclusive, several empirical studies confirm the existence of either a positive or negative relationship between these two major macroeconomic variables. Moreover, with time a general consensus evolved that low and stable inflation promotes economic growth and vice versa (Mubarik, 2005). This further raises the question how low inflation should be. The answer evidently depends on the nature and structure of the economy and varies across countries. In this regard, recently macroeconomists have adopted an econometric technique simply by looking at a nonlinear or structural break effect which states that the impact of inflation on economic growth could be positive up to a certain threshold level and beyond this level the effect turns to be negative (Sweidan, 2004). This supports both the view of the *structuralists* and the *monetarists* up to a certain extent, that is, low inflation is helpful for economic growth but once the economy achieves faster growth then inflation is detrimental for the sustainability of such growth.

The purpose of this paper is to empirically explore the present relationship between inflation and economic growth in Bangladesh. This has been motivated by the seminal work of Mallik and Chowdhury (2001) in which they have performed an econometric

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[1] The *structuralists* argue that inflation is necessary for economic growth, whereas the *monetarists* argue the opposite, that is, inflation as detrimental for economic growth (Mallik and Chowdhury, 2001).

[2] Economic growth rate is usually defined as the growth rate of real GDP.

(i.e., *Engle-Granger* two-step co-integration procedure) analysis of the relationship between inflation and economic growth for four South Asian countries: Bangladesh, India, Pakistan, and Sri Lanka.[3] Following the works of Khan and Senhadji (2001), Sweidan (2004), and Mubarik (2005), this paper further explores an interesting policy issue of how far the inflation rate is non-detrimental for the economic growth of Bangladesh, or in other words, what is the threshold level of inflation for the economy. All the empirical analysis of this paper has been conducted using annual data set on real gross domestic product (GDP) and consumer price index (CPI) for the period of 1980 to 2005. The results of the empirical analysis provide guidance for both domestic policy makers and the development partners. However, more might be learned on inflation and economic growth using a larger sample (i.e., quarterly data) over the same time period and control variables.

The remainder of this paper is organized as follows: Section 2 reviews the empirical literature on inflation and economic growth. Section 3 provides information about the historical trends of inflation and economic growth in Bangladesh. Section 4 discusses the model and methodology used to obtain the empirical findings reported in this paper. Section 5 provides data sources and estimated results on inflation and economic growth, and finally, section 6 presents a summary of the main conclusions, limitations of the paper, and discusses a possible future extension.

2. Literature Review on Inflation and Economic Growth

Both in the context of developed and developing countries, there have been extensive theoretical and empirical research to date that attempt to focus on the relationship between inflation and economic growth. This section presents a brief review.

Barro (1995) explores the inflation–economic growth relationship using a large sample covering more than 100 countries from 1960 to 1990. His empirical findings indicate that there exists a statistically significant negative relationship between inflation and economic growth if a certain number of the country characteristics (e.g., fertility rate, education, etc.) are held constant. More specifically, an increase the average inflation by 10 percentage points per year reduces the growth rate of real per capita GDP by 0.2 to 0.3 percentage points per year. In other words, his empirical analysis suggests that the estimated relationship between inflation and economic growth is negative when some reasonable instruments are considered in the statistical process. Finally, he added that there is at least some reason to consider that higher long-term inflation reduces economic growth.

Bruno and Easterly (1995) examine the determinants of economic growth using annual CPI inflation of 26 countries which experienced inflation crises during the period between 1961 and 1992. In their empirical analysis, an inflation rate of 40 percent and over is considered as the threshold level for an inflation crisis. They find inconsistent or somewhat inconclusive relationship between inflation and economic growth below this threshold level when countries with high inflation crises are excluded from the sample. In addition, the empirical analysis suggests that there exists

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[3] A related but not similar study has been carried out by Akhtaruzzaman (2005) where he examines the dominant factors explaining the inflationary process in Bangladesh. His results support that inflation is negatively related with real income.

a temporal negative relationship between inflation and economic growth beyond this threshold level. The robustness of the empirical results is examined by controlling for other factors such as shocks (e.g., terms of trade shocks, political crises, and wars). Finally, they find that countries recover their pre-crisis economic growth rates following successful reduction of high inflation and there is no permanent damage to economic growth due to discrete high inflation crises.

Sarel (1995) mentions that inflation rates were somewhat modest in most countries before the 1970s and after that rates started to be high. Therefore, most empirical studies conducted before the 1970s show the evidence of a positive relationship between inflation and economic growth and a negative relationship between the two beyond that time period due to the severe inflation hike.

Malla (1997) conducts an empirical analysis using a small sample of Asian countries and countries belonging to the Organization for Economic Cooperation and Development (OECD) separately. After controlling for labor and capital inputs, the estimated results suggest that for the OECD countries there exists a statistically significant negative relationship between economic growth and inflation including its first difference. However, the relationship is not statistically significant for the developing countries of Asia. The crucial finding of this empirical analysis suggests that the cross-country relationship between inflation and long-term economic growth experiences some fundamental problems like adjustment in country sample and the time period. Therefore, inconclusive relationship between inflation and economic growth can be drawn from comparing cross country time-series regressions with different regions and time periods.

Mallik and Chowdhury (2001) examine the short-run and long-run dynamics of the relationship between inflation and economic growth for four South Asian economies: Bangladesh, India, Pakistan, and Sri Lanka. Applying co-integration and error correction models to the annual data retrieved from the International Monetary Fund (IMF) *International Financial Statistics* (IFS), they find two motivating results. First, the relationship between inflation and economic growth is positive and statistically significant for all four countries. Second, the sensitivity of growth to changes in inflation rates is smaller than that of inflation to changes in growth rates. These results have important policy implications, that is, although moderate inflation promotes economic growth, faster economic growth absorbs into inflation by overheating the economy. Therefore, these four countries are on the turning point of inflation-economic growth relationship.

Faria and Carneiro (2001) investigate the relationship between inflation and economic growth in the context of Brazil which has been experiencing persistent high inflation until recently. Analyzing a bivariate time series model (i.e., vector autoregression) with annual data for the period between 1980 and 1995, they find that although there exists a negative relationship between inflation and economic growth in the short-run, inflation does not affect economic growth in the long-run. Their empirical results also support the *superneutrality* concept of money in the long run.[4] This in turn provides

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[4] Sidrauski (1967) mentions that in an optimal control framework if real money balances (M/P) is considered in the utility function, money is both *neutral* and *superneutral*.

empirical evidence against the view that inflation affects economic growth in the long run.

Sweidan (2004) examines whether the relationship between inflation and economic growth has a structural breakpoint effect or not for the Jordanian economy from the period between 1970 and 2003. He finds that this relation tends to be positive and significant below an inflation rate of 2-percent and the structural breakpoint effect occurs at an inflation rate equal to 2-percent. Beyond this threshold level inflation affects economic growth negatively.[5]

Mubarik (2005) estimates the threshold level of inflation for Pakistan using an annual data set from the period between 1973 and 2000. He employed the *Granger Causality* test as an application of the threshold model and finally, the relevant sensitivity analysis of the model. His estimation of the threshold model suggests that an inflation rate beyond 9-percent is detrimental for the economic growth of Pakistan. This in turn, suggests that inflation rate below the estimated level of 9-percent is favorable for the economic growth. Moreover, the sensitivity analysis performed for the robustness of the threshold model also confirms the same level of threshold inflation rate.
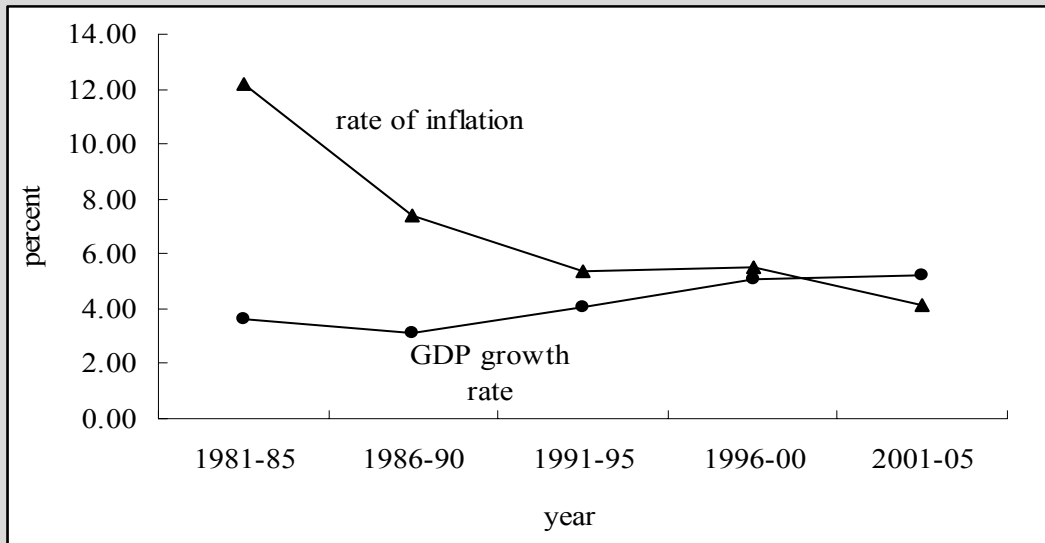
3. Historical Trends of Inflation and Economic Growth

Bangladesh is the youngest country in the South Asian region. Following the launching of a series of comprehensive stabilization measures, the economy of Bangladesh mostly restored both robust economic growth and macro-economic stability in early 1990s from the backdrop of the deep macro-economic crisis of the period since independence (Bhattacharaya, 2004). In particular, the economy has experienced accelerated economic growth during the early 1990s in comparison with the 1980s. However, after that period, the economy experienced most severe exigency states like increasing inflationary pressures, deteriorating government's budgetary balances and decreasing foreign exchange reserves (Mahmud, 1997).

During the first half of the 1980s the country experienced a double-digit episode of inflation while the growth rate of GDP was below 4-percent level as illustrated in Figure 1. The GDP growth rate declined moderately during the second half of 1980s when inflation rate gradually decreased to below 8-percent. However, a moderate rate of inflation and an increasing rate of GDP growth are observed throughout the 1990s. Throughout the first half of the 1990s, inflation rate was, on average, 5.37 percent, while GDP growth rate was 4.06 percent. Although inflation rate increased, on average, to 5.52 percent in the second half of the 1990s, the growth rate of GDP continued to increase. The increasing trend of inflation rate during the latter half of 1990s had been corrected since the beginning of the new decade after 1990s and was observed at 4.14 percent, on average, during 2001 to 2005, when growth rate of GDP was, on average, 5.19 percent.

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[5]   Over this period, the average inflation rate is approximately 7-percent.

Figure 1: Five Year Average GDP Growth and Inflation Rates (1981-2005)

Source: Data collected from BBS (2000, 2001, and 2005).

Figure 2 depicts the historical trends of inflation rate and real GDP growth rate of Bangladesh during the period of 1981 to 2005. Although it is unwise to conclude anything simply on the basis of a visual inspection of Figure 2, however, it illustrates more or less an inverse relationship between rate of inflation and GDP growth rate in Bangladesh throughout this period.

Figure 2: Inflation and Real GDP Growth Rates (1981-2005)
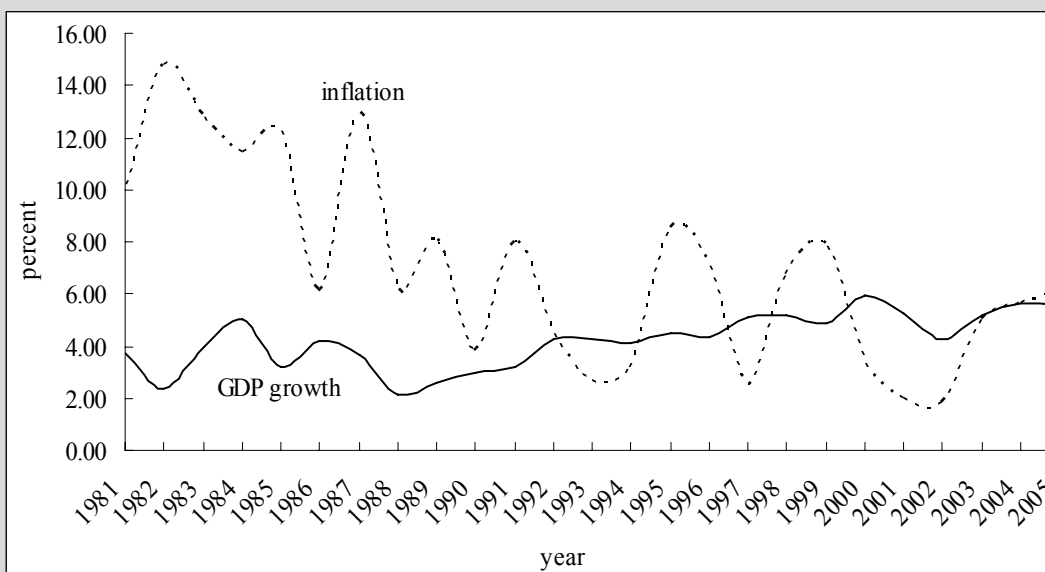
Source: Data collected from BBS (2000, 2001, and 2005).

Moreover, to understand the historical nature of the relationship between inflation and economic growth in Bangladesh more accurately, the sample covering 1981 to 2005 is grouped into 7 observations.[6] Initially, the range of inflation is selected on the basis of the maximum and minimum levels of inflation from the whole sample. For instance, if inflation rate is 3-percent or less, it is assigned at level 3. Similarly, the level is 5, if inflation rate is more than 3-percent but less than or equal to 5-percent. Subsequently, within this range of inflation, average GDP growth rates are calculated against each linear level of inflation. For illustration, what is the average GDP growth rate when inflation rates are 3 percent or less during the period from 1981 to 2005 and so on. In this context, Figure 3 illustrates a positive relationship between inflation and GDP growth up to the inflation rate of 7 percent (approximately) and a negative relationship is observed after that level of inflation rate.

Figure 3: Average GDP Growth and Linear Level of Inflation

Source: Data collected from BBS (2000, 2001, and 2005).
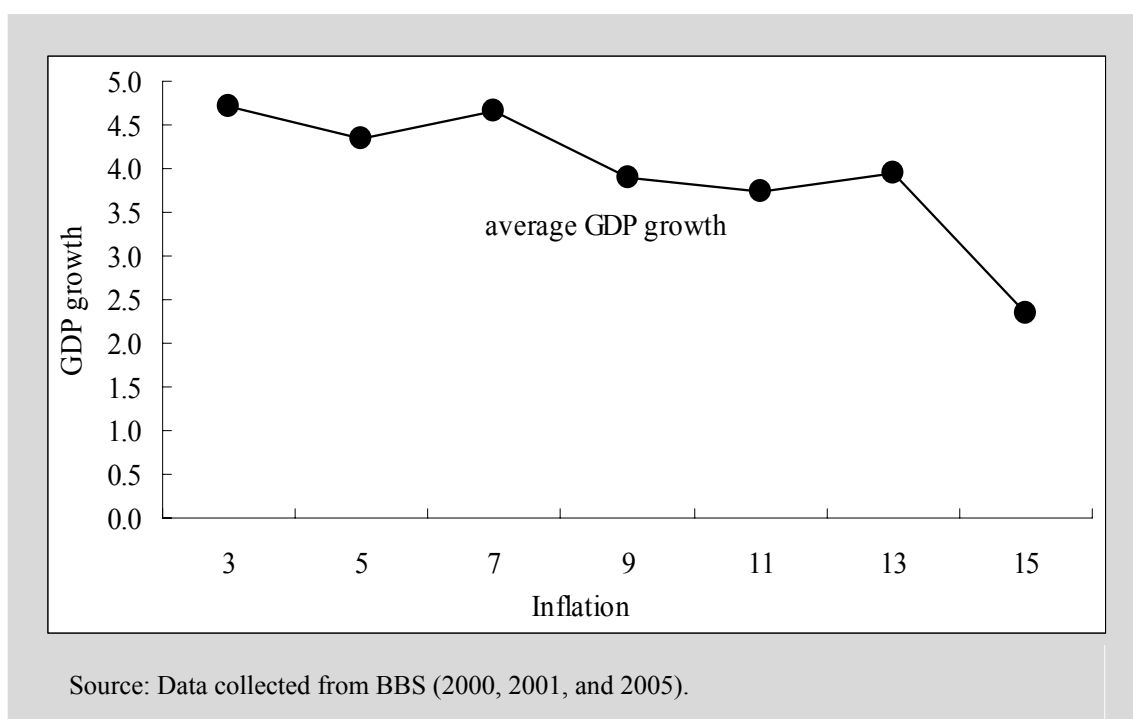
4. The Model and the Methodology

The paper basically employs two econometric models to achieve the empirical results: the first one examines the short-run and long-run relationships between real GDP and CPI by applying the *Engle-Granger* (1987) two stage co-integration procedure and the associated Error Correction Model (ECM).[7] In the first stage, to test for the unit roots of concerned time series variables, four most popular techniques have been used: the Dicky-Fuller (DF, 1979) test, the Augmented Dickey-Fuller (ADF, 1981)

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[6] This part of the analysis follows the approach adopted by Mubarik (2005).
[7] The relationship between real GDP and CPI in turn implies the relationship between inflation and economic growth.

test, the Phillips-Perron (PP, 1988) test, and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS, 1992) test. These tests have been performed in the levels (i.e., log of real GDP and log of CPI) as well as in the first difference (i.e., economic growth and inflation rate). If the two times series are integrated of the same order then the estimation of the following co-integration regression has been considered:

$$GDP_t^* = \alpha_{11} + \beta_{11}CPI_t^* + \varepsilon_t \tag{ia}$$

$$CPI_t^* = \alpha_{21} + \beta_{21}GDP_t^* + \mu_t \tag{ib}$$

where, GDP^* = log of real GDP, CPI^* = log of CPI, and ε_t and μ_t are random error terms or residuals. Further, economic growth and inflation rate have been defined as $\Delta GDP_t^* = GDPGR_t$ and $\Delta CPI_t^* = INF_t$ respectively in the subsequent parts of the paper.[8] In the second stage, the Error Correction Model (ECM) is employed to see whether the economy is approaching equilibrium in the long-run or not and the short-run dynamics of the co-integrated time series variables. The ECM is internally consistent if the two time series variables are co-integrated of the same order or if they are stationary (Greene, 2003: 654).

To determine the non-stationary property of these two time series variables both in the levels and in the first difference, at first, the relevant DF, ADF tests have been employed with and without a time trend. The DF test is based on the following model:

$$\Delta Z_t = \chi + (\rho - 1)Z_{t-1} + \gamma T + e_{1t} \tag{ii}$$

The ADF test is a modification over the DF test and lagged values of the dependent variables are added in the estimation of equation (ii) which is formed as follows:

$$\Delta Z_t = \chi + (\rho - 1)Z_{t-1} + \gamma T + \delta \Delta Z_{t-1} + e_{2t} \tag{iii}$$

Since it is widely believed that both DF and ADF tests do not consider the cases of heteroscedasticity and non-normality frequently revealed in raw data of economic time series variables, the PP test for unit root has been used in the empirical analysis. Moreover, it has an advantage over the ADF test when the concerned time series has serial correlation and there is a structural break. Therefore, the PP test provides robust estimates over the DF and ADF tests and is based on the following form of equation:

$$\Delta Z_t = \phi + (\rho - 1)Z_{t-1} + \gamma(t - \frac{T}{2}) + \psi \Delta Z_{t-i} + e_{3t} \tag{iv}$$

The appropriate critical values of the *t-statistic* for the null hypothesis of non-stationarity are given by MacKinnon (1991). Further, an alternative testing procedure, i.e., KPSS test has been performed where the concerned time series variables are assumed to be trend-stationary under the null hypothesis (Patterson, 2002: 265). The KPSS test starts from the basic local level model:

$$Z_t = \alpha_{t-1} + \beta + \eta_t + \xi_t \tag{v}$$

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[8] Here, Δ is defined as the first difference operator.

The KPSS test statistic is based on the following lagrangian multiplier (LM) statistic:

$$KPSS = \sum_t \left(\sum_{r-1}^t \hat{u}_r \right)^2 / T^2 f_0 \qquad \text{(vi)}$$

where, f is an estimator of the residual spectrum at frequency zero. The appropriate critical values for the LM statistic are given by Kwiatkowski-Phillips-Schmidt-Shin (1992). In equations (ii), (iii), and (iv), Δ is defined as the first difference operator and e_{1t}, e_{2t}, e_{3t} are the respective covariance stationary random error terms. All tests are carried out for both variables by replacing Z_t with GDP_t^* and CPI_t^* in equations (ii) (for the DF test), (iii) (for the ADF test), (iv) (for the PP test), and (v) (for the KPSS test). Finally, the DF, ADF, PP, and KPSS unit root tests have been employed for residuals of equations (ia) and (ib), i.e., ε_t and μ_t. When residuals are found to be integrated of order zero, I(0), then it can be concluded that the two series, GDP^* and CPI^*, are co-integrated and thus a valid and stable long-run relationship exits between them. This also implies the existence of a stable long-run relationship between inflation and economic growth. Similarly, the Johansen (1988) and Johansen and Juselius (1990) maximum likelihood test procedure is an efficient technique for testing the co-integrating relationship between the concerned time series variables. This procedure gives two likelihood ratio (LR) tests for the number of co-integrating vectors, namely, the *trace test* and the *maximum eigen value test*.

Engle and Granger (1987) show that if two variables are co-integrated, i.e., there is a valid long-run relationship, and then there exists a corresponding short-run relationship. This is popularly known as the *Granger's Representation Theorem.* Hendry's (1979, 1995) *general-to-specific* approach has been applied in this case where the model (i.e., ECM) is used in the following form:

$$\Delta GDP_t^* = \varphi_{10} + \sum_{j=0}^s \varphi_{11j} \Delta CPI_{t-j}^* + \sum_{i=1}^q \varphi_{12i} \Delta GDP_{t-i}^* - \theta_1 \varepsilon_{t-1} + e_{4t} \qquad \text{(vii)}$$

$$\Delta CPI_t^* = \varphi_{20} + \sum_{j=0}^s \varphi_{21j} \Delta GDP_{t-j}^* + \sum_{i=1}^q \varphi_{22i} \Delta CPI_{t-i}^* - \theta_1 \varepsilon_{t-1} + e_{4t} \qquad \text{(viii)}$$

where, Δ stands for the first difference operator, θ_1, θ_2 are the error correction terms, e_{4t}, e_{5t} are the random disturbance terms, and s and q are the number of lag lengths determined by the *Akaike's information criterion* (AIC). Here i begins at one and j begins at zero in order for the series to be related within a structural ECM (Engle and Yoo, 1991). Finally, $0 \le \theta_1, 0 \le \theta_2$ should hold for the series to converge to the long-run equilibrium relation. According to this approach, three lags of both the explanatory and dependent variables and one lag of the residual from the co-integrating regression have been included. Subsequently, the insignificant variables were dropped in order to get the most parsimonious model (Hendry, 1979, 1995). It is important to mention that the error correction terms (i.e., θ_1, θ_2) which are the residual series of the co-integrating vector normalized for GDP^* and CPI^* measure deviations of these series from the long-run equilibrium relations (Mallik and Chowdhury, 2001).

The second model estimated in the paper utilizes that developed by Khan and Senhadji (2001) to estimate the threshold level of inflation for Bangladesh above which inflation affects economic growth negatively. The equation to estimate threshold level of inflation has been considered in the following conditional form:

$$GDPGR_t = \beta_0 + \beta_1 INF_t + \beta_2 D(INF_t - K) + U_t \tag{ix}$$

where, K is the threshold level of inflation (i.e., the rate of inflation at which structural break occurs) and U_t is the random error term which represents measurement error in the explanatory variables.[9] The dummy variable D is defined in the following way:

$$D = \begin{array}{l} 1 \text{ if } INF > K \\ 0 \text{ if } INF \leq K \end{array}$$

The coefficient of the dummy variable (β_2) measures the effect of inflation rate on the economic growth when it is greater than the assumed structural break level (i.e. inflation is high) and the opposite for the coefficient of inflation rate (β_1). In the above threshold model, the sum of the two coefficients ($\beta_1 + \beta_2$) represents the annual growth rate of economic growth when inflation rate is doubled. By estimating regressions for different values of K which is chosen in an ascending order (i.e., 1, 2 and so on), the optimal value K is obtained by finding the value that maximizes the R^2 from the respective regressions. This also implies that the optimal threshold level is that which minimizes the residual sum of squares (RSS). This procedure has become widely accepted in the literature on this topic. However, this process is tedious since it requires the estimation of the equation several times for different values of K.

5. Data and Empirical Evidence

The empirical models have used annual data set on real GDP and CPI for the period of 1980 to 2005 retrieved from the Bangladesh Bureau of Statistics (BBS).[10] For the first part of the empirical analysis, i.e., the relationship between inflation and economic growth, logs of real GDP (GDP^*) and CPI (CPI^*) have been considered. Further, economic growth rates ($GDPGR$) are calculated from the difference of logs of real GDP and inflation rates (INF) are calculated from the difference of logs of CPI (i.e., $\Delta GDP_t^* = GDPGR_t$ and $\Delta CPI_t^* = INF_t$ respectively) for the second part of the analysis. The summary statistics for $GDPGR$ and INF are reported in Table 1 where the total number of observations used in the empirical analysis, means, standard deviations, minimum and maximum values of variables during the time period are given.

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[9]   In the empirical analysis, control variables such as investment and real gross capital formation have not been considered due to the unavailability of a consistent time series data for Bangladesh. Moreover, money supply (M2) and population growth prove statistically insignificant in relation to economic growth for the sample period of 1981 to 2005, and therefore, have been dropped from the final estimated equation. Finally, the number of observations for all the variables is limited, implying the inability to include many independent variables in order to maintain acceptable degrees of freedom.

[10]   Here, real GDP is calculated at 1995-96 constant market prices, while the base year for CPI is 1995-96, i.e., 1995-96 = 100.

Table 1: Summary Statistics of Inflation and Growth Rate (1981 – 2005)

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
GDPGR	25	4.47	1.11	2.2 (1988)	6.3 (2004)
INF	25	7.25	4.03	1.87 (2002)	15.9 (1982)

In Table 2, results of the unit root tests on concerned variables have been reported. The tests for non-stationarity show that *GDPGR* is stationary based on DF, ADF, PP, and KPSS tests and in case of *INF*, DF, PP, and KPSS tests succeed although the ADF test fails. Since the PP and KPSS tests are preferable to ADF it can be concluded that *INF* is also stationary, I(0). Thus the findings of unit root tests suggest that both the variables *GDPGR* and *INF* are integrated of order zero. Further, Table 2 shows that both GDP^* and CPI^* are integrated of order one based on the DF, ADF, PP, and KPSS tests. Therefore, they are non stationary, I(1).

Table 2: Unit Root Tests with DF, ADF, PP, and KPSS

	DF		ADF		PP		KPSS		Decision
Variables	Without trend	With trend	Without trend	With trend	Without trend	With trend	Without trend	With trend	
CPI^*	I(1)	I(1)	I(0)	I(1)	I(0)	I(1)	I(1)	I(1)	I(1)
GDP^*	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
GDPGR	I(0)	I(0)	I(1)	I(0)	I(1)	I(0)	I(0)***	I(0)	I(0)
INF	I(0)	I(0)	I(0)**	I(1)	I(0)**	I(0)	I(0)***	I(0)	I(0)

Notes: 1. * means the series in log level, *** and ** means significant at 1-percent and 10 percent levels respectively.
2. Lag length for ADF tests have been decided on the basis of AIC.
3. Maximum Bandwidth for PP and KPSS tests have been decided on the basis of *Newey-West* (1994).
4. All tests have been performed on the basis of 5-percent significance level using Econometric Views 4 Package.
5. The DF, ADF and PP tests are based on the null hypothesis of unit roots while the KPSS test assumes the null hypothesis of stationarity.

In Tables 3 and 4, the estimated results of the relationship between CPI^* and GDP^* have been reported. They show that there exists a long-run and strong inverse relationship between CPI and real GDP in Bangladesh which in turn implies a long-run *negative* relationship between inflation and economic growth for the country. The coefficients are statistically highly significant and negative for both regressions (ia) and (ib). Furthermore, Tables 3 and 4 illustrate that, on average, a 1-percent increase in CPI in Bangladesh leads to a decline in real GDP by 0.19 percent. On the other hand, on average, a 1-percent increase in the real GDP leads to a decline in CPI rate by 2.38 percent.

Table 3: Estimation of the Real GDP Model (ia)

Dependent Variable: GDP^*
Method: OLS
Sample: 1980 to 2005

Variable	Coefficient	Standard Error	t-statistic	Probability
Constant	14.17	0.15	92.38	0.00
CPI^*	-0.19	0.05	-4.01	0.00
Time	0.05	0.00	16.02	0.00

R-squared	0.99	Mean dependent variable	14.11
Adjusted R-squared	0.99	S.D. dependent variable	0.27
S.E. of Regression	0.02	AIC	-4.81
Sum squared residual	0.01	Schwarz criterion	-4.67
Log-likelihood	58.37	F-statistic	1888.58
Durbin-Watson statistic	0.24	Probability (F-statistic)	0.00

Table 4: Estimation of the CPI Model (ib)

Dependent Variable: CPI^*
Method: OLS
Sample: 1980 to 2005

Variable	Coefficient	Standard Error	t-statistic	Probability
Constant	35.55	8.05	4.41	0.00
GDP^*	-2.38	0.59	-4.01	0.00
Time	0.16	0.02	6.89	0.00

R-squared	0.98	Mean dependent variable	4.24
Adjusted R-squared	0.98	S.D. dependent variable	0.48
S.E. of Regression	0.07	AIC	-2.27
Sum squared residual	0.11	Schwarz criterion	-2.12
Log-likelihood	29.11	F-statistic	453.99
Durbin-Watson statistic	0.27	Probability (F-statistic)	0.00

The findings of the estimated equations (ia) and (ib) are as follows: (a) there is a linear causation between CPI and real GDP in Bangladesh. The estimated coefficients are highly statistically significant and negative implying that both CPI and real GDP affect each other negatively, and (b) inflation is harmful for economic growth and economic growth helps to reduce inflation in the country.

Table 5 shows the DF, ADF, PP, and KPSS unit root tests for residuals of equations (ia) and (ib), i.e., ε_t and μ_t. The results suggest that the residuals are integrated of order zero, I(0). Therefore, it can be concluded that the two series, GDP^* and CPI^*,

are co-integrated and thus a valid and stable long-run relationship exits between them . Therefore, a stable long-run relationship between inflation and economic growth exists.

Table 5: Unit Root Tests for the Residuals of (ia) and (ib)

Error term	DF	ADF	PP	KPSS	Decision
ε_t	I(0)	I(0)	I(0)	I(0)	I(0)
μ_t	I(0)	I(0)	I(1)	I(0)	I(0)

Notes: 1. Lag length for ADF tests have been decided on the basis of AIC.
2. Maximum Bandwidth for PP and KPSS tests have been decided on the basis of *Newey-West* (1994).
3. All tests have been performed on the basis of 5-percent significance level using Econometric Views 4 Package.
4. The DF, ADF and PP tests are based on the null hypothesis of unit roots while the KPSS test assumes the null hypothesis of stationarity.

Moreover, the results for Johansen maximum likelihood test reported in Table 6 again confirm the rejection of the null hypothesis of no co-integration between GDP^* and CPI^*. In particular, the computed *trace*, the *maximum eigen value* statistics and their corresponding critical values indicate that the null hypothesis of no co-integration (r = 0) can be rejected under both of these tests at both 5-percent and 1-percent levels of significance. Both *maximum eigen value* and *trace* tests indicate one co-integrating equation at both 5-percent and 1-percent levels of significance. This again implies a long-run relationship between inflation and economic growth in Bangladesh.

Table 6: Johansen Test for Co-integration

Null Hypothesis	Alternative Hypothesis	Test Statistics	5-percent Critical Value	1-percent Critical Value	Conclusion
Maximum eigen value Test					
r = 0	r = 1	24.48	18.96	23.65	One co-integrating equation
r ≤ 1	r = 2	9.55	12.25	16.26	
Trace Test					
r = 0	r = 1	34.03	25.32	30.45	One co-integrating equation
r ≤ 1	r = 2	9.55	12.25	16.26	

Note: The results reported in the above table are based on the assumptions of a constant and a linear trend in the data with optimal lag length 3. AIC and LR tests have been used to determine the optimal lag length that makes the residuals white noise.

The second stage of the *Engle-Granger* procedure comprises of the estimation of the ECM. Sargan (1984) uses the error correction mechanism and later it has been popularized by Engle and Granger who corrected that for disequilibrium. The ECM has several advantages: first, the ECM incorporates both the short-run and long-run effects assuming that the variables are co-integrated. The second one is that assuming co-integration; all the terms in the model are stationary so that standard regression

techniques are valid (Harris, 1995). The estimated coefficients of the error correction term (long-run effects) and the lagged values of the two series (short-run effects) are presented in Table 7.

Table 7: The Error Correction Model

Variables Equation	ΔGDP_t^*	ΔCPI_t^*
Constant	-0.01	0.06
	(-0.37)	(1.51)
EC term (lag = 1)	-0.23*	-0.32*
	(-3.14)	(-2.11)
ΔGDP_t^*	---	-1.66**
		(-1.74)
ΔGDP_{t-1}^*	0.49*	0.64
	(3.34)	(0.77)
ΔGDP_{t-2}^*	---	---
ΔGDP_{t-3}^*	0.52*	---
	(3.18)	
ΔCPI_t^*	---	---
ΔCPI_{t-1}^*	-0.07**	0.32
	(-1.76)	(1.67)
ΔCPI_{t-2}^*	---	0.42*
		(2.15)
ΔCPI_{t-3}^*	---	---
Adjusted R-squared	0.65	0.33
DW-statistic	1.54	2.00
Serial Correlation	0.28	3.66
Functional Form	0.50	1.17
Normality	0.77	0.10
Heteroscedasticity	1.23	1.53

Notes: 1. Figures in parentheses are *t-statistics* and * and ** indicates significant at 5-percent and 10 percent levels respectively comparing critical *t-statistics* from standard t-tables.

2. For diagnostics, Godfrey's (1978a, 1978b) LM test for serial correlation, Ramsey's (1969, 1970) RESET test for functional form, White's (1980) general heteroscedasticity test for heteroscedasticity and for normality, Jarque-Bera (1980) and Bera-Jarque (1981) tests have been performed.

The empirical results show the existence of short-run and long-run relationships between CPI and real GDP in Bangladesh. This also implies short-run and long-run relationships between inflation and economic growth in the country. The estimated coefficients of the error correction terms (θ_1, θ_2) are significant at 5-percent level from CPI to real GDP and vice versa with appropriate (i.e., negative) signs. That means that in the long-run if the two series are out of equilibrium, real GDP will

adjust to reduce the equilibrium error and vice versa. In other words, it shows that 23 percent (error correction term -0.23) of the deviation of the real GDP from its long run equilibrium level is corrected each year. On the other hand, 32 percent (error correction term -0.32) of the deviation of the CPI from its long-run equilibrium level is corrected each year. The estimated results in the ECM also show that short-run changes in CPI affect real GDP negatively, and vice versa. Therefore, inflation rates affect economic growth rates negatively, and vice versa.

By using ordinary least squares (OLS), Table 8 gives the exact value of the threshold inflation level and also shows the impact of that inflation level on economic growth by estimating equation (vi). The estimated value of R^2 is taken into consideration by estimating equation (vi) for the threshold level of inflation considering $K = 1$ to $K = 11$. However, considering the value of R^2, the estimated results have been reported in the Table 7 for K values ranging from 4-percent to 8-percent. For the period between 1981 and 2005, a significant and consistent result can be found if only inflation, lagged by three periods, (i.e., lag = 3) is considered to estimate the exact threshold level of inflation. Therefore inflation is kept at lag three in the estimate. As reviewed in the previous section, in this approach, the threshold level is one that maximizes the value of R^2.

Table 8: Economic Growth Model with the Structural Break Term
Dependent Variable: *GDPGR*

K	Variable	Coefficient	Standard Error	t-statistic	Probability	R-squared
4-percent	INF	-0.12	0.05	-2.35	0.03	0.32
	D(INF-K)	-0.61	0.42	-1.44	0.16	
	C	5.74	0.48	11.99	0.00	
5-percent	INF	-0.12	0.05	-2.43	0.02	0.34
	D(INF-K)	-0.69	0.40	-1.71	0.10	
	C	5.77	0.46	12.54	0.00	
6-percent	INF	-0.09	0.05	-1.97	0.07	0.43
	D(INF-K)	-0.93	0.38	-2.46	0.02	
	C	5.64	0.39	14.53	0.00	
7-percent	INF	-0.12	0.05	-2.46	0.02	0.40
	D(INF-K)	-0.90	0.39	-2.28	0.03	
	C	5.61	0.39	14.26	0.00	
8-percent	INF	-0.10	0.05	-2.00	0.06	0.34
	D(INF-K)	-0.87	0.52	-1.68	0.10	
	C	5.38	0.40	13.40	0.00	

From the estimated results, it is observable that at low threshold inflation levels ($K < 6$) there is a statistically insignificant relationship (at 5-percent level) between the dummy of threshold level of inflation and economic growth. As K increases starting from 6-percent, a statistically significant relationship (at 5-percent level) is observed between economic growth and the dummy of threshold level of inflation which continues up to 7-percent inflation rate. However, in the estimation process, the threshold level of inflation is observed at 6-percent level where the value of R^2 is maximized i.e. RSS is minimized. While inflation below this threshold level has no

significant effect on economic growth (i.e., statistically insignificant at 5-percent level), inflation rates above it has a significant negative effect on economic growth. Therefore, the empirical analysis suggests that if inflation rate is above 6-percent, then the economic growth performance of Bangladesh might experience a jeopardized situation.

6. Conclusion

This paper empirically explores the present relationship between inflation and economic growth in the context of Bangladesh. An assessment of the empirical evidence has been acquired through the co-integration and error correction models. Further, the paper explores an interesting policy issue of what is the threshold level of inflation for the economy. The empirical evidence demonstrates that there exists a statistically significant long-run *negative* relationship between inflation and economic growth for the country as indicated by a statistically significant long-run *negative* relationship between CPI and real GDP. This result is more or less consistent with the predictions of Mallik and Chowdhury (2001). Particularly, they have mentioned that Bangladesh was already on the turning point (i.e., from positive to negative) of inflation-economic growth relationship in the late 1990s. In addition, the estimated threshold model suggests 6-percent threshold level (i.e., structural break point) of inflation above which inflation adversely affects economic growth.

These results have important policy implications for both domestic policy makers and the development partners. First, taking into consideration that the inflation rate is not indexed in the wages and salaries, inflation will lead to a decrease in the purchasing power and an increase in the cost of living. Second, given that the country frequently has to balance the credit requirements by the private and public sector against both inflationary and balance of payments pressures, it is not always possible for the monetary authority to increase (or adjust) the nominal interest rate above the expected (or actual) inflation rate through contractionary monetary policy.[11] In this regard, the monetary authority can think of an alternative way by working on the expectations channel to reduce inflation. This requires credibility of the monetary authority in following through its monetary program as communicated in advance to the stakeholders.

Some caveats are in order. For example, in the context of Bangladesh, the empirical results provided in this paper do not address the following important issues:

1. It does not estimate how the economic growth rate will behave as the rate of inflation rises, but remaining contained within the threshold level.

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[11] The New Keynesian model suggests that to reduce inflation, the Central Bank should lean against the wind. That is, to increase the nominal interest rate above the expected (or actual) inflation rate through the contractionary monetary policy. The model is basically summarized by the following two equations:

$$x_t = E_t x_{t+1} - \frac{1}{\sigma} \left[i_t - E_t \pi_{t+1} \right] + u_t$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + e_t$$

where, x_t = output gap, π_t = inflation rate, and i_t = nominal interest rate.

2. Does higher inflation lead to greater inflation uncertainty? In particular, what is the relationship between inflation and inflation uncertainty?
3. Whether inflation uncertainty adversely affects economic growth.
4. What are the determinants of high inflationary pressure?

Future research should extend in the above directions in order to derive firm policy relevant conclusions.

References

Akhtaruzzaman, Md. "Inflation in the Open Economy: An Application of the Error Correction Approach to the Recent Experience in Bangladesh," Working Paper Series, WP 0602 (2005), Policy Analysis Unit (PAU), Research Department, Bangladesh Bank.

Bangladesh Bureau of Statistics. National Accounts Statistics of Bangladesh (Revised Estimates, 1989-90 to 1998-99), Strengthening National Accounts and Poverty Monitoring Project (SNAPMP), National Accounting Wing (NAW), BBS, Ministry of Planning: Statistics Division (2000).

_____. National Accounts Statistics (Gross Domestic Product, 2000-2001), NAW, BBS, Ministry of Planning: Statistics Division (2001).

_____. National Accounts Statistics (Provisional Estimates of GDP, 2004-05 and Final Estimates of GDP, 2003-04), SNAPMP, NAW, BBS, Ministry of Planning: Planning Division (2005).

Barro, R. J. "Inflation and Economic Growth," National Bureau of Economic Research (NBER) Working Paper No. 5326 (October 1995).

Bera, A. K. and C. M. Jarque. "An Efficient Large-Sample Test for Normality of Observations and Regression Residuals," Australian National University Working Papers in Econometrics, Vol. 40 (1981), Canberra.

Bhattacharaya, D. "Bangladesh Economy: Macroeconomic Performance," mimeo, Centre for Policy Dialogue, Dhaka (2004). Available at www.cpd-bangladesh.org (access date: 1, December 2005).

Bruno, M. and W. Easterly. "Inflation Crises and Long-Run Growth," World Bank Policy Research Working Paper No. 1517 (1995).

Culver, E. S. and H. D. Papell. "Pitfalls and Opportunities: What Macroeconomics Should Know about Unit Roots," in O. J. Blanchard and S. Fischer, eds., *NBER Macroeconomics Annual 1991*, Cambridge: MIT Press (1997).

Dickey, D. A. and W. A. Fuller. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association*, Vol. 74 (1979), pp. 427-431.

_____. "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root," *Econometrica*, Vol. 49 (1981), pp. 1057-1072.

Engle, R. F. and C. W. J. Granger. "Co-integration and Error Correction: Representation, Estimation and Testing," *Econometrica*, Vol. 55 (1987), pp. 1-87.

Engle, R. F. and B. S. Yoo. "Co-integrated Economic Time Series: An Overview with New Results," in R. F. Engle and C. W. J. Granger, eds., *Long-Run Economic Relationships*, Oxford: Oxford University Press (1991), pp. 237-266.

Faria, J. R. and F. G. Carneiro. "Does High Inflation Affect Growth in the Long and Short-run?," *Journal of Applied Economics*, Vol. IV, No. 1 (2001), pp. 89-105.

Fischer, S. and F. Modigliani. "Towards and Understanding of the Real Effects and Costs of Inflation," *Weltwirtschaftliches Archiv*, 114 (1978), pp. 810-833.

Godfrey, L. G. (a). "Testing Against General Autoregressive and Moving Average Error Models When the Regressors Include Lagged Dependent Variables," *Econometrica*, Vol. 46 (1978), pp. 1293-1301.

_____ (b). "Testing for Higher Order Serial Correlation in Regression Equations When the Regressors Include Lagged Dependent Variables," *Econometrica*, Vol. 46 (1978), pp.1303-1310.

Gregorio, Jose de. "Inflation, Growth, and Central Banks: Theory and Evidence," World Bank Policy Research Working Paper 1575, Policy Research Department, Macroeconomics and Growth Division (February 1996).

Greene, W. H. *Econometric Analysis*. 5th ed. New Jersey: Prentice-Hall (2003).

Harris, R. I. D. *Using Co-integration Analysis in Econometric Modeling*, London: Prentice Hall, Harvester Wheatsheaf (1995).

Hendry, D. F. "Productive Failure Econometric Modelling in Macroeconomics: The Transmission Demand for Money," in *Economic Modeling: Current Issues and Problems in Macroeconomic Modeling in the UK and the USA, (ed.),* London: P. Ormerod (1979).

_____ . *Dynamic Econometrics*, London: Oxford University Press (1995), pp. 577-629.

Jarque, C. M. and A. K. Bera. "Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals," *Economics Letters,* Vol. 6 (1980), pp. 255-259.

Johansen, S. "Statistical Analysis of Co-integration Vectors," *Journal of Economic Dynamics and Control*, Vol. 12 (1988), pp. 231-254.

Johansen, S. and K. Juselius. "Maximum Likelihood Estimation and Inference on Co-integration with the Application to the Demand for Money," *Oxford Bulletin of Economics and Statistics*, Vol. 52 (1990), pp. 169-210.

Kwiatkowski, D., P. Phillips, P. Schmidt and Y. Shin. "Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root," *Journal of Econometrics*, Vol. 54 (1992), pp. 159-178.

Khan, M. S. and A. S. Senhadji. "Threshold Effects in the Relationship between Inflation and Growth," IMF *Staff Papers*, Vol. 48, No. 1 (2001).

MacKinnon, J. "Critical Values for Co-integration Tests," In R. F. Engel and C. W. J. Granger, eds., *Long Run Economic Relationships: Readings in Co-integration,* Oxford: Oxford University Press (1991).

Mahmud, W. *Growth or Stagnation?: A Review of Bangladesh's Development 1996*, Macroeconomic Update, Centre for Policy Dialogue, Dhaka: University Press Limited (1997).

Malla, S. "Inflation and Economic Growth: Evidence from a Growth Equation," mimeo, Department of Economics, University of Hawai'I at Monoa, Honolulu (1997). Available at www.hawaii.edu/~malla (access date: 25, November 2005).

Mallik, G. and A. Chowdhury. "Inflation and Economic Growth: Evidence from South Asian Countries," *Asian Pacific Development Journal*, Vol. 8, No.1. (2001), pp. 123-135.

Mubarik, Y. A. "Inflation and Growth: An Estimate of the Threshold Level of Inflation in Pakistan," *State Bank of Pakistan – Research Bulletin*, Vol.1, No. 1-2 (2005), pp. 35-44.

Mundell, R. "Growth, Stability and Inflationary Finance," *Journal of Political Economy*, 73 (1965), pp. 97-109.

Newey, W. and K. West. "Automatic Lag Selection in Covariance Matrix Estimation," *Review of Economic Studies,* Vol. 61 (1994), pp. 631-653.

Patterson, K. *An Introduction to Applied Econometrics: A Time Series Approach*. New York: Palgrave (2002).

Phillips, P. C. B. and P. Perron. "Testing for a Unit Root in Time Series Regression," *Biometrika,* Vol. 32 (1998), pp. 301-318.

Ramsey, J. B. "Test for Specification Errors in Classical Linear Least Square Regression Analysis," *Journal of the Royal Statistical Society B* (1969), pp. 350-371.

_____. "Models, Specification Error and Inference: A Discussion of Some Problems in Econometric Methodology," *Bulletin of the Oxford Institute of Economics and Statistics,* Vol. 32 (1970), pp. 301-318.

Sarel, M. "Nonlinear Effects of Inflation on Economic Growth," IMF Working Paper WP/95/56, Washington (May 1995).

Sragan, J. D. "Wages and Prices in the United Kingdom: A Study in Economic Methodology," Originally published in 1964 and reproduced in K. F. Wallis and D. F. Hendry, eds., *Quantative Economics and Econometric Analysis,* Oxford: Basil Blakewell (1984).

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

Sweidan, O. D. "Does Inflation Harm Economic Growth in Jordan? An Econometric Analysis for the Period 1970-2000," *International Journal of Applied Econometrics and Quantitative Studies*, Vol.1-2 (2004), pp. 41-66.

Tobin, J. "Money and Economic Growth," *Econometrica*, 33 (1965), pp. 671-684.

White, H. "A Heteroscedasticity Consistent Variance Matrix Estimator and a Direct Test of Heteroscedasticity." *Econometrica*, Vol. 48 (1980), pp. 817-818.