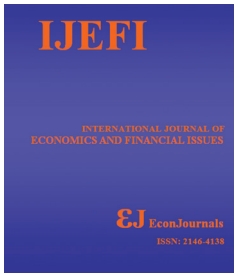

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Inflation and Economic Growth: An Empirical Evidence of Bangladesh (1986-2016)

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ABSTRACT

The study is conducted to examine empirically the relationship between inflation and economic growth in Bangladesh using annual data set from 1986 to 2016. Moreover to formulate policy issue, it was needed to find the threshold level of inflation for Bangladesh. Based on the results of two steps Engle-Granger and Johansen co-integration test, it confirms that there is statistically significant positive relationship between inflation and economic growth. The results of the error correction model, specifically the sign of the one period lagged error correction term confirm that inflation adjust itself to long-run path approximately at the speed of 79% in each year. Finally based on the conditional least square method the forecasted threshold level of inflation is 8%; any rate beyond this, does not significantly influence the growth rate

Keywords: Economic Growth, Inflation, Threshold Level Of Inflation, Co-Integration, Error Correction Model, Conditional Least Square
JEL Classifications: C13, C32, C51, C52, E31, O42

1. INTRODUCTION

From the second half of the last century, the relationship between inflation and economic growth catch the eyes of the economists, central bankers, policy makers and practitioners of all over the world. Particularly, whether inflation is essential for economic growth or not creates a significant contoversary among the related parties. The controversy starts from the views of the structuralists and the monetarists[1]. This controversial issue confirm from the findings of empirical study of Mundell (1965) and Tobin (1965), where they found a positive relationship between the inflation and the rate of capital accumulation, that means a positive relationship to the rate of economic growth[2]. Their point is that as money and capital substitutable, increasing inflation means increasing capital accumulation by changing money to capital and thereby increasing economic growth (Gregorio, 1996). Dornbusch et al. (1993; 1996) found that in short run the relationship between inflation and economic growth is positive as the producers are followed to produce for rising in price which translates to economic growth. On the other hand, Fischer and Modigliani (1978) found a nonlinear and negative relationship between the rate of inflation and economic growth by the new growth theory mechanisms (Barro, 1995), (Bruno and Easterly, 1995) and (Malla, 1997) (Faria and Carneiro, 2001) and (Michael, 2008). They stated that inflation confines economic growth largely by reducing the efficiency of investment compare to its scale. At the household stage, inflation imposes a heavy burden on those with fixed earnings; inflation comparatively favors debtors at the expense of creditors; at the firm level, the effect of inflation is called the "menu cost."

Rotemberg (1982; 1983), Dmaziger (1988), Benabou and Konieezny (1994), Yap (1996), Valdovinoz (2003), and Guerrero (2006) said that, as inflation increase the output price of the firm, so a new price level would be determined for the customers.

A lot of empirical studies failed to find any conclusive evidence of either a positive or a negative relationship between inflation and economic growth, among these studies - Wai (1959), Bhatia (1960), Dorrance (1963; 1966), Johansen (1967) are mentionable.

1 The structuralists advocate for necessity of inflation for economic growth, whereas the monetarists advocate the opposite.

2 Economic growth rate is commonly known as the growth rate of real gross domestic product.

Still now, the relationship between inflation and economic growth remain controversial or unsettle to some extent. However (Mubarik, 2005) found a relationship that low and less volatile price levels increases the economic growth and vice versa. Again it raises a question that how low inflation should be for economic development? The answer of the question depends on the structure and the nature of the economy and it differs across the countries.

On this issue, modern economists have developed an econometric tool that is simply by seeing the non-linear or structural breakup, where the effect of inflation growth is positive up to a specific level, known as threshold level and above it the relationship is negative which is closely similar to the views of structuralists and monetarists.

This paper tries to find the empirical presents of long-run relationship and short-run dynamics between inflation and economic growth in Bangladesh, motivated by the working paper of Ahmed and Mortaza (2005) in which they have performed two stage co-integration (i.e., Engle-Granger, 1987) procedure and the associated error correction model (ECM) analysis of the relationship between inflation and economic growth of Bangladesh from 1981 to 2005.

Again, considering the works of Ahmed and Mortaza (2005), Khan and Senhadji (2001), Sweidan (2004), and Mubarik (2005), this paper tries to explore a policy issue of how far the inflation rate is not harmful for the economic growth of Bangladesh, conversely what is the threshold level of inflation for the economy? All the historical analysis of this paper has been conducted using annual data on real gross domestic product (RGDP) and consumer price index (CPI), investment growth rate (INV), population growth (POP), openness of trade ratio (OPEN) and real effective exchange rate (REER) for the period of 1986-2016.

As the macroeconomic and development conditions of the world are not same over the time, moreover it is changing in nature that's why the relationship between inflation and growth are not one time solution but continuous. As the relationship is inconclusive in nature, again and again it demands investigation. More recently there exists a high level of consensus among the economists and researchers that positive and lower inflation is positively related to economic growth while high and unstable level of inflation has negative impact on growth of the economy. The findings of the empirical analysis will be helpful for all development partners and policy makers of Bangladesh.

2. REVIEW OF RELATED LITERATURE

A lot of theoretical and empirical research works have been executed on the relationship between inflation and economic growth considering scenario of developing and developed countries. Here, some of the related reviews are.

Malla (1997) examined an empirical study on Asian organization for economic co-operation and development countries using a small sample and found a negative relationship between inflation and economic growth but this relationship is not statistically significant in developing countries of Asia.

Mallik and Chowdhury (2001) used co-integration technique for analyzing the effect of inflation on economic growth for Bangladesh, India, Pakistan, and Sri Lanka and found two important points. First, inflation and economic growth has positive relation. Second, the sensitivity of inflation to changes in growth rates is larger than that of growth to changes in inflation rates.

Khan and Senhadji (2001) conducted a study on the relationship of inflation with economic growth considering the panel data of 140 developed and developing countries for the period of 1960-1998. They explore a threshold level of inflation of 1-3% and 7-11% for developed and developing countries respectively which exert negative effect beyond the threshold level of inflation.

Mubarik (2005) tried to found the threshold level applying the Granger Causality test in Pakistani economy considering the annual data of 1973-2000. He suggested that crossing the 9% inflation rate is harmful for the Pakistani economy. The robustness of this threshold model also confirms the same result.

Ahmed and Mortaza (2005) investigate the relationship between inflation and economic growth empirically for the period of 1981-2005 for Bangladesh using the co-integration and ECM. They found an important policy issue for the economy (i.e. what is the threshold level of inflation for the economy). The findings exerts that there is a statistically significant long-run negative relationship between inflation and economic growth.

Erbaykal and Okuyan (2008) investigate the relationship between inflation and economic growth in Turkey covering data 1987:1-2006:2 periods using the bound test and autoregressive distributed lag models and found no statistically significant long run relationship but a negative short run relationship. They found no causal relationship from economic growth to inflation but there is causality from inflation to economic growth.

Munir et al. (2009) explored a non linear relationship between inflation and economic growth using data of 1970-2005 in Malaysia where they predict 3.89% is the threshold level beyond this rate the inflation affects growth negatively but under the level shows positive relation between them.

Iqbal and Nawaz (2009) conducted a study on the relationship among inflation, investment and economic growth and tried to find whether a second threshold point exists or not for the Pakistan economy using annual time series data from 1961 to 2008. They found the existence of two threshold points at 6% and 11% level where below 6% (the first threshold) a positive relationship between inflation and growth; when inflation is in between the two thresholds (6-11%), it becomes negative. However, if inflation exceeds the second threshold, it affects growth negatively but the effect diminishes. They suggest keeping the inflation below the first threshold level will promote investment and sustainable growth minimizing uncertainty.

Frimpong and Oteng-Abayie (2010) examined to find the threshold level of inflation for Ghana using time-series annual data period 1960-2008. Using the inflation threshold regression they found

R^2 is maximized at 11% which is also examined by the two stages least square estimation. Finally the authors recommended to the Bank of Ghana and the government to rethink its target of inflation as the government targeted 7% inflation is less than the threshold level inflation.

Hasanov (2011) examined the inflation and growth nexus by estimating the threshold point for a CIS member country Azerbaijan using annual data period 2001-2009. Least square and two stages least square estimation models shows close estimation results indicating 13% of inflation as a threshold level. The author concludes that in Azerbaijan, a positive relationship between inflation and growth exists when the inflation rate is below 13% and above this level of inflation the relationship turns to be negative.

Pahlavani and Ezzati (2011) studied the relationship between inflation and economic growth of Iran for a period of 1957-2007 to check the structural break point effect and found the threshold level of inflation between 9% and 12%.

Lupu (2012) tried to evaluate the interrelationship between inflation and economic growth in Romania for the period 1990-2009. The researcher classified the study period into two decades where in the first decade, i.e. 1990-2000, high and volatile inflation was the major cause of macro-economic instability which reduces the GDP. Subsequently in year 2000, Romania focuses on its monetary and fiscal policy to control inflation volatility and for this reason the country has witnessed lower level of inflation accompanied by higher economic growth in the decade 2001-09. Finally he found a negative relationship between inflation and economic growth in Romania.

Raza and Naqvi (2013) studied the short-run and long-run relationship between inflation and economic growth of Pakistan. They used co-integration and ECM and found statistically significant long-run positive relationship between the two macroeconomic variables.

Kasidi and Mwakanemela (2013) investigate the controversial relationship between economic growth and inflation of Tanzania for period 1990 to 2011 using correlation coefficient and co-integration technique. Coefficient of elasticity found negative impact of inflation on economic growth and interestingly found no co-integration and long run relationship between inflation and economic growth of Tanzania.

Hussain and Saaed (2014) studied the relationship between inflation and economic growth of Qatar from 1980 to 2011 using co-integration and ECM and found significantly negative relationship in long-run.

Umi and Izuchukwu (2016) conducted study on the relationship between inflation and economic growth from 1985 to 2013 for Nigeria using Engle-Granger two step co-integration method and ECM. By both methods they found long run relationship between inflation and economic growth. Finally found that moderate inflation in the economic system can accelerate the economic growth.

Ahmed and Zaid (2016) examine the threshold level of inflation in the US during the period 1960-2011. They used same model which introduced by Khan and Senhadji; the model suggests the quarterly threshold level of inflation in the US is between 0% and 1.5%. Above that threshold level, inflation has significant negative effect on the real GDP growth, while below that threshold level, the effect of inflation on the real GDP growth is ambiguous.

3. HISTORICAL STRUCTURE AND TRENDS OF INFLATION AND ECONOMIC GROWTH IN BANGLADESH

Bangladesh is a South Asian developing country. After a series of comprehensive stabilizing measures the country reached a solid economic growth and macroeconomic stability in the early 1990s. For this, the country performed a steady economic growth over the early 1990s than that of 1980s. However, at the end of the decade the economy fallen a deep critical state in the form of increasing inflationary pressures, reducing foreign exchange reserves and deteriorating government's budgetary balances and unfavorable balance of payment situation (Mahmud, 1997).

Figure 1 shows that in the second half of 1980s, the country witnessed two-digit inflation where the growth rate of real GDP was on average below 4%. However, over the first half of the 1990s, inflation rate on average was 5.72% while GDP growth rate was 4.53% and in the second half of the 1990s the inflation rate was reduced on- average to 5.13% while the growth rate of GDP continued to increase on-average to 4.83%. Again, inflation rate increased on average to 5.52% and 7.66% in the first and second half of the 2000s respectively, the growth rate of GDP also continued to increase on-average to 5.10% and 6.07% respectively. In 2011 to 2015 the growth rate of real GDP was increased on-average to 6.33% but the inflation rate decreased on average to 7.53%. However, on the basis of a visual observation of Figure 2,

Figure 1: Five years average inflation and real gross domestic product growth rates (1986-2016)

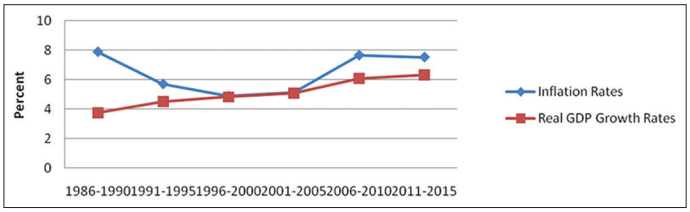
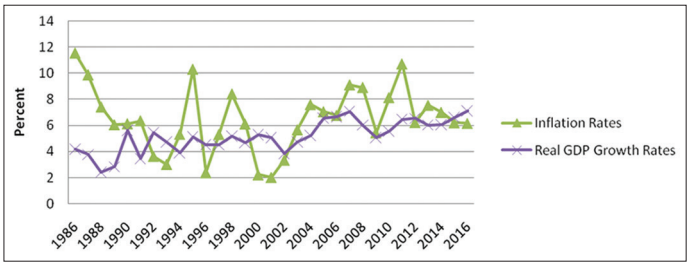


Figure 2: Inflation and real gross domestic product growth rates (1986-2016)



it shows an almost similar trend between inflation and economic growth in Bangladesh throughout the period of 1986-2016.

4. METHODOLOGY AND MODEL SPECIFICATION

To address the objective of the study two econometric models are used; first one is to examine the relationship between growth and inflation and second one is applied to estimate the threshold level of inflation.

$$CPI_t = f(RGDP_t, REER_t, CPI_{t-1}) \quad (1)$$

Where, CPI_t = consumer price index at time t; $RGDP_t$ = real gross domestic product at time t; $REER_t$ = real effective exchange rate at time t.; CPI_{t-1} = inflation inertia (inflation expectation).

$$Growth_t = \beta_0 + \beta_1(Inf_t) + \beta_2 * D_t(Inf_t - K^*) + \beta_3(Pop_t) + \beta_4(Inv_t) + \beta_5(Open_t) + \epsilon_t \quad (2)$$

Where, Growth = growth rate of real gross domestic product, Inf_t = inflation rate at time t measured by the consumer price index, Pop_t = population growth rate at time t, Inv_t = investment growth rate at time t, K* = the threshold level of inflation, $Open_t$ = openness of the economy to the rest of the world, β's = slope coefficient of explanatory variables.

In the process of estimating the threshold level of inflation, all the variables in the equation are computed as:

$Growth_t$ = Dlog ($RGDP_t$)%; Inf_t = Dlog (CPI_t)%; Pop_t = Dlog (Pop_t)%; Inv_t = Dlog (Inv_t)%; $Open_t$ = Dlog ($Open_t$)%.

Where, D = dummy variable that takes the value of one when inflation level becomes greater than the threshold and zero otherwise.

$D_t = 1$: 100*D log CPI > K*

0: 100*D log CPI ≤ K* (2a)

Equation (1) has been transformed into natural logarithm (log), it enables to get slope of the coefficients (α's) to measure the change of mean and the elasticity of the dependent variable with respect to the percentage change in the independent variables and to reduce the problem of heteroscadasticity.

$$logCPI_t = \alpha_0 + \alpha_1\ logRGDP_t + \alpha_2\ logREER_t + \alpha_3\ logCPI_{t-1} + \mu_t \quad (1a)$$

Where, log stands for natural logarithm; α's - coefficients of the explanatory variables; μ_t - residual term.

The long run and short run relations between inflation and growth is examined using inflation model. The co-integration test and related ECM of Engle and Granger (1987) approach is used in one hand and again the Johansen (1988; 1991) approach is used to examine the long run and short run relationship between the two macro-economic variables. Again growth model is used to estimate the threshold level of inflation as used by Khan and Senhadji (2001) with the technique of conditional least square (CLS).

Before proceeding further for co-integration test, it is needed to address the time series issues and related unit root test. As it is said that most of the macro-economic time series variables follow a random walk model; i.e. exhibiting a unit root behavior.

In order to test the unit root problem of data, the most popularly used techniques: The Dickey-Fuller (DF, 1979) test, the augmented Dickey-Fuller (ADF, 1981) test, the Phillips-Perron (PP, 1988) test, and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS, 1992) test have been used. All of the test will be performed at level and first order with and without intercept considering the critical values of t-statistics for null hypothesis of non-stationarity (MacKinnon, 1991). For KPSS, null hypothesis of trend-stationarity (Patterson, 2002) will be used.

DF, ADF, PP, and KSPP test models are as follows respectively:

$$\Delta Z_t = x + (\rho - 1)\ Z_{t-1} + \gamma T + e_{1t} \quad (3a)$$

$$\Delta Z_t = x + (\rho - 1)\ Z_{t-1} + \gamma T + \delta \Delta Z_{t-1} + e_{2t} \quad (3b)$$

$$\Delta Z_t = \phi + (\rho - 1)\ Z_{t-1} + \gamma\left(t - \frac{T}{2}\right) + \psi \Delta Z_{t-1} + 5_{3t} \quad (3c)$$

$$\Delta Z_t = \alpha_{t-1} + \beta + \eta_t + \mathbb{Q}_t \quad (3d)$$

After unit root test, if the variables are not stationary at level but if it become stationary at first difference, that is if the variable under study found stationary at same order, say in their first difference it is possible to run the regression. After running the regression, if the error terms are found stationary at level, then the linear combination of the individually non stationary variables are said to be stationary. In this case it can be said to be integrated and economically interpretable as long run relationship between the two variables.

As long- run relationships are mostly explained in static equilibrium form. So, it is difficult to explain the dynamics of structural and institutional changes occur in the economy within short run. By considering this short come, it is necessary to study the short run relationship and short run dynamism of the variables under study. The ECM is the best possible way to assess the short run dynamic structure of the model. The "Granger Representation Theorem" explains, if two time series variables are co-integrated then the relationship between the co-integrated variables can be expressed by an ECM model. So, after having the co-integrated long run relationship the basic structure of ECM looks like:

$$logCPI_t = \text{Ꙍ}_0 + \text{Ꙍ}_1 logRGDP_t + \text{Ꙍ}_2 logREER_t + \text{Ꙍ}_3 logCPI_{t-1} + \delta_1 ECT_{t-1} + \varepsilon_t \quad (4)$$

Where, Ꙍ's capture the short-run effects of the explanatory variables on the dependent variable, δ_1 captures the rate at which

the dependent variable (inflation) adjusts to the equilibrium state after structural or institutional shocks that occur.

The ECM is based on the classical linear regression model that residuals are normally distributed, no autocorrelation on the residuals and absence of correlation among the explanatory variables.

As mentioned by Utkulu (1997), although the Engle-Granger is easy but is has its own drawbacks that even if the estimators of long-run static regression are consistent it does not mean that they are necessarily efficient and there is no specific rule of sensible judgment about the parameters to identify variables as endogenous and exogenous.

Johansen's procedure will be applied to overcome the problems of Engle-Granger two steps procedure. The single equation ECM given in equation (4) can be extended as an endogenous variable in multivariate model as follows:

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \ldots + AKZ_{t-k} + \mu_t \quad (5)$$

Where, $Z_{t=}[Y_t, X_t]$ and the model is assumed to have two variables both endogenous.

Similar to the Engle-Granger approach, here also stationary of data will be checked. If all variables are found to be integrated stationary at the same order then the co-integrating analysis continues without suffering from spurious regression (Johansen, 2006. p. 2). Then lag length will be selected by Akaike information criteria (AIC) and Schwartz information criteria (SIC) to determine the optimal lag length. After the lag length, it will identify whether the constant term or trend enters the long run and short run models. After that by maximum Eigen-value statistics and Trace statistics, it will determine the number of co-integrating vectors.

Finally the second objective of the study is to estimate the threshold level of inflation in the Bangladeshi economy using growth model equation (2). Where OLS i.e. non linear least square (NNLS) would have been used if the threshold level of inflation (K) was known in advance, but it doesn't so. In such a case, the best technique to estimate threshold level is CLS used by Khan and Senhadji (2001). In CLS method the threshold level is where the sum of squared residuals (RSS) minimum or the R^2 maximum by putting different values of K.

5. DATA AND EMPIRICAL EVIDENCE

This paper has used annual data set of RGDP, CPI, INV, OPEN, POP and REER for all the empirical models from the period of 1986 to 2016. All data has been collected form world bank's data bank, except REER and INV. INV is collected from IMF and REER has been developed by using formula[3]. For the empirical analysis, all data has been converted into natural logarithm form. All the estimation and diagnostic tests are carried out using Econometric views (E-views) version 9.5 statistical software.

The descriptive summary represented in Table 1 depict the total number of observations, means, median, standard deviation, minimum and maximum values of the variables during the period of study.

The mean and median rows for all series are very close to each other indicates minor symmetry. The maximum, minimum and standard deviation row also indicates the dispersion of data set and Table 1 depict that the data are not widely scattered. From the row of skewness and kurtosis, there are no data of extreme skewed and peaked variable. Finally the Jarque-Bera (JB) test for normality says that it fails to reject the null hypothesis of normality, because of sufficiently higher P values of the JB statistic.

In the Table 2 unit root test of all studied variables has been presented. All the variable tested for non-stationary using the DF, ADF, PP test and failed to reject the null hypothesis of unit root test at level, although LREER can reject null hypothesis only with trend but it fails to reject null hypothesis without trend, on the other hand KPSS test can reject the null hypothesis of data are stationary for LCPI and LRGDP but LREER, LPOP, LINV, LOPEN fail to reject the null hypothesis and again only with trend not without trend. So it is taken that all data under study are non-stationary at level. This result has lead it to further investigation into unit-root test but at this time it will use the first difference of the variables and will use all the test as previously.

In the Table 3 result of unit-root test about the concern variables based on DF, ADF, PP can reject the null hypothesis of non-stationarity in all cases, both in with and without trend except LCPI at DF without trend, LRGDP at PP without trend, LREER at ADF without trend. The variable LPOP, LINV fail to reject null hypothesis at DF with trend and PP test in both case. The result of KPSS test for all variables fails to reject the null hypothesis except LCPI, LRGDP without trend and LREER with trend. Since the ADF test is better estimator than DF and so is in case of PP and KPSS. So it can be said the all variables are stationary at first difference. In order to continue with the analysis, all the variables under study should be integrated in same order. As shown in the Table 3, all variables are integrated at the first order not at level.

With the light of all results found in the unit-root, it can be approached further for studying the long run relationship with co-integration technique. In order to study the long-run relationship the Engle-Granger co-integration test has been used. Before approaching further it is worthwhile to mention the theoretically expected signs of coefficients in the model. Theoretically there is no unanimous relation between general price and output growth that is in this study the relationship between CPI and real GDP could be negative or positive.

In case of REER it is expected a positive sign, as a steady increase in exchange rate is expected to increase the price level. Similarly inflation expectation is supposed to increase the price level.

3 $$REER_t = \frac{NEER * CPI_t}{CPI_t^{(foreign)}}$$

Table 1: Descriptive summary

	LCPI	LRGDP	LREER	LOPEN	LINV	LPOP
Mean	4.021005	28.92619	3.380238	2.865557	3.117899	0.572296
Median	3.987300	28.89208	3.325699	2.668195	3.184326	0.667546
Maximum	4.967468	29.74107	3.684168	3.798782	3.366330	0.989366
Minimum	3.236938	28.25036	3.022019	2.045855	2.823163	0.103514
Standard deviation	0.523418	0.455187	0.204110	0.660451	0.188912	0.314504
Skewness	0.237324	0.207743	−0.016115	0.239920	−0.339322	−0.246350
Kurtosis	1.924520	1.828120	1.762600	1.419891	1.593452	1.549726
Jarque-Bera	1.785015	1.996829	1.979088	3.522363	3.150289	3.030312
Probability	0.409627	0.368463	0.371746	0.171842	0.206978	0.219774
Sum	124.6512	896.7120	104.7874	88.83227	96.65487	17.74119
Sum standard deviation	8.218985	6.215856	1.249822	13.08586	1.070631	2.967381
Observations	31	31	31	31	31	31

Table 2: Unit root tests at level

Variables	DF		ADF		PP		KPSS		Decision
	Without trend	With trend	Without trend	With trend	Without trend	With trend	Without trend	With trend	
LCPI	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
LRGDP	I(1)	I(1)	I(0)	I(1)	I(0)	I(1)	I(1)	I(1)	I(1)
LREER	I(1)	I(0)	I(1)	I(0)**	I(1)	I(1)	I(1)	I(0)	I(1)
LPOP	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)
LINV	I(1)	I(1)	I(1)	I(0)**	I(1)	I(1)	I(1)	I(0)	I(1)
LOPEN	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)

DF: Dickey-Fuller, ADF: Augmented Dickey-Fuller, PP: Phillips-Perron, KPSS: Kwiatkowski-Phillips-Schmidt-Shin

Table 3: Unit root test at first difference

Variables	DF		ADF		PP		KPSS		Decision
	Without trend	With trend	Without trend	With trend	Without trend	With trend	Without trend	With trend	
LCPI	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)	I(1)	I(0)	I(0)
LRGDP	I(0)	I(0)	I(0)	I(0)	I(1)	I(0)	I(1)	I(0)	I(0)
LREER	I(0)	I(0)	I(1)	I(0)	I(0)	I(0)	I(0)	I(1)	I(0)
LPOP	I(0)**	I(1)	I(0)**	I(0)	I(1)	I(1)	I(0)	I(0)	I(0)
LINV	I(0)**	I(1)	I(0)	I(0)	I(1)	I(1)	I(0)	I(0)	I(0)
LOPEN	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	(0)

DF: Dickey-Fuller, ADF: Augmented Dickey-Fuller, PP: Phillips-Perron, KPSS: Kwiatkowski-Phillips-Schmidt-Shin

Table 4: Regression results of equation (1a)

Dependent variable: LOGCPI Method: Least squares Sample (adjusted): 1987-2016 Included observations: 30 after adjustments				
Variable	**Coefficient**	**Standard error**	**t-statistic**	**Prob.**
C	−15.05487	5.590877	−2.692756	0.0122
LOGRGDP	0.595577	0.224338	2.654814	0.0134
LOGREER	−0.062626	0.093534	−0.669551	0.5090
LOGCPI(−1)	0.519261	0.179201	2.897651	0.0075
R^2	0.997981			
Adjusted R^2	0.997748			
S.E. of regression	0.024394			
F-statistic	4284.084			
Prob (F-statistic)	0.000000			
Durbin-Watson stat	1.046909			

According to the results of OLS in Table 4 the P value of the independent variables are very small, which means that the regression coefficient are statistically significant both at 1% and 5% levels, except the REER. On the other hand the adjusted R^2 is 0.998 which implies that the change in inflation is well explained by change in RGDP, REER and inflation expectation.

From the estimated results in Table 4 among the important outcomes the first one is positive sign of the coefficient of RGDP and which is statistically significant that implies the existence of a long-run positive relationship between inflation and growth. The finding is similar to the Keynesian theoretical findings that these two macro-economic variables are positively related. The magnitudes of the relationship, the coefficient of RGDP suggest that the one percent of increase in RGDP increases the inflation by 0.596% point. The relation between the REER and CPI is negative, which is inconsistent with the theoretical expectation, but this coefficient is statistically insignificant. Talking about the inflationary expectation, which is capture by one period lag of the CPI almost explain the 50% of the variation of inflation. If inflation expectation increases by one percent point, the CPI will increase by 0.512% point.

From the first step of Engle-Granger co-integration technique, it is shown that there exist a positive long-run relationship between inflation and growth. The co-integration estimate result not only shows the direction of relation but also annual rate of change.

Having the positive long-run association between inflation and growth, the short-run dynamics of the model on whether the economy converges to equilibrium or not and if converges

Table 5: Unit root tests on the error correction term

Variable	Types of the unit root test	Test equation				Decision
		Intercept	Critical values at 5%	Intercept and trend	Critical values at 5%	
ECT_t	DF	−1.719950	−1.953858	−4.075861	−3.190000	Reject the null Hypothesis
ECT_t	ADF	−5.157486	−2.967767	−4.441974	−3.580623	Reject the null Hypothesis
ECT_t	PP	−5.157486	−2.967767	−5.072383	−3.574244	Reject the null Hypothesis
ECT_t	KPSS	0.092280	0.463000	0.091362	0.146000	Not to reject the null Hypothesis

DF: Dickey-Fuller, ADF: Augmented Dickey-Fuller, PP: Phillips-Perron, KPSS: Kwiatkowski-Phillips-Schmidt-Shin

then at what rate of adjustment is to be studied using the ECM equation (4).

In order to carrying the ECM, it is checked the stationarity of the residual of the last regression model. From the Table 5, it is found that the error term is stationary at level with DF, ADF, PP and KPSS. And once again it can be said the two variables are co-integrated.

This stationarity of the error correction term (ECT) allows to continue the short- run analysis of the behavior of inflation using the ECM. The estimate result of the ECM is given in Table 6.

The result of ECM, specially the coefficient of the lagged ECT (−0.790653) has a negative sign which satisfies the theoretical expectation that in the short-run the rate of inflation converges to its equilibrium point. That is, the negative coefficient of (−0.790653) says that in case of disequilibrium the inflation rate will back towards its long-run path. The speed of adjustment is 0.79 that is 79% in each year. The coefficient of RGDP in the ECM shows the immediate impact of change in RGDP to CPI, here it is 13.9% with same sign of first step of Engle-Granger technique but statistically not significant. On the other hand, coefficient of REER is 0.0478 or 4.7% and change the sign, which is theoretically expected but one again it is not statistically significant. It is worthwhile to discuss that again inflation expectation explain 68% of the short run variation in the inflation rate. Once again inflation inertia is key variable and largely explains the changes in the general price level both in long-run and short-run. In both cases its coefficient is statistically significant.

The R^2 and the adjusted R^2 value show that the explanatory variable did not adequately explain the model of ECM, but D.W statistics and F-statistics says there is no serial correlation and heteroscedasticity.

The diagnostic test has been performed to check the adequacy of the ECM model in the (Table 7). The JB test of normality with test statistics 0.845461 and corresponding P value of 0.655255 says its fail to reject the null hypothesis of normality. Similarly the Breusch-Godfrey Lagrange multiplier (LM) test is used to check the problem of serial correlation. The observed R^2 value is used to make decision, which is 1.0035 and the corresponding P value is 0.6055, so once again it confirms that data are not serially co-related. The heteroscedasticity test is carried using autoregressive conditional heteroscedasticity (ARCH) LM test. The observed R^2 value is used to decision making, here it is 1.0064 with a P value of 0.3158, so it can be said that by ARCH LM there is

Table 6: Estimation result of error correction model

Dependent variable: D (LOGCPI) Method: Least squares Sample (adjusted): 1988-2016 Included observations: 29 after adjustments				
Variable	**Coefficient**	**Standard error**	**t-statistic**	**Prob.**
C	0.014119	0.016641	0.848443	0.4046
D(LOGRGDP)	0.139717	0.385731	0.362214	0.7204
D(LOGREER)	0.047854	0.085319	0.560884	0.5801
D(LAGLCPI)	0.678784	0.226935	2.991099	0.0063
ECT_1	−0.790653	0.256637	−3.080818	0.0051
R^2	0.380283			
Adjusted R^2	0.276997			
S.E. of regression	0.018299			
F-statistic	3.681839			
Prob (F-statistic)	0.017851			
Durbin-Watson stat	1.782765			

Table 7: Diagnostic error tests

Test	Test statistic	P value
Jarqua-Bera	0.845461	0.655255
Breusch-Godfrey LM	1.003553	0.6055
ARCH LM	1.006421	0.3158
Ramsey RESET	0.147263	0.7012

ARCH: Autoregressive conditional heteroscedasticity

no heteroscedasticity in the residual terms of the model. Finally according to Ramsey RESET test confirms that multiplicative model is rejected based on the log-likelihood ratio of 0.147263 and P value of 0.7012. So, the data support the additive model and therefore the ECM has no specific error.

According to the two step error correction procedure of Engle-Granger co-integration, these tests are dependable and reliable. However this procedure is salient about the determination of dependent and independent variable. So in order to address this problem it will use the Johansen Co-integration model.

As in this paper, it has tested unit root of all the variables and found them as stationary at first difference and in order to approaching further two optimal lag length is selected by using AIC and SIC method. Considering the result of unrestricted vector autoregression (VAR) in Table 8 the regression of log(CPI) individually lag one and two are statistically significant. In case of log(RGDP) regression none of the log(CPI) is significant only

the first difference of log(RGDP) is significant. Now if it deals with the significant coefficient then the first lag of the log(CPI) has positive effect on log(CPI), which is similar with the previous OLS, that means inflation inertia has positive effect on inflation. In case of log(RGDP), first lag of log(RGDP) is positively affect the real GDP. After having the VER estimate, the result of the VER diagnostic test is given in Table 8.

The results of the joint diagnostic tests in Table 9 say that data in the multivariate model is normally distributed; there is no serial correlation and heteroscedasticity in the multivariate residual.

Now it times to run Johansen test of co-integration with intercept and trend, in the Table 10. The value of trace test and maximum Eigen-value test is given. It is important to mention here that log (REER) is not treated as an endogenous variable because it is found insignificant at E-G model.

The results of Johansen maximum likelihood test presented in Table 10, asserts that null hypothesis of no co-integration between log (RGDP) and log(CPI) is rejected considering the trace and maximum Eigen value statistics and their corresponding critical values at 5% and 1% level of significance. So, once again it indicates that there is a long-run relationship between inflation and economic growth.

Hence, the results of Johansen's approach confirm the results of the Engle-Granger co-integration approach. As the co-integrating vector is determined then it is possible to proceed on the VAR based ECM, i.e., vector error correction model.

In the Table 11, the co-integrating equation (cointEq1) which is considered as the ECT has a negative significant adjusted effect on d(log(CPI)) based on the t-statistic of −2.3958. The significant negative coefficient of the co-integrating equation is considered as an ECT satisfies the theoretical expectation that the model converge to its long-run equilibrium path. Which is similar to the ECT used in the two steps Engle-Granger co-integration equation. The co-integration equation also has significant impact on d(log(RGDP)) based on t-statistic −2.282. The one period lagged value of d(log(CPI)) has positive effect on d(log(CPI)) but not in case of d(log(RGDP)), on the other hand two period lagged value of d(log(CPI)) is significantly affect the d(log(RGDP)) with positive effect.

So finally, it can be said that the Johansen's approach of co-integration and vector error correction are similar to the findings of Engle-Granger Co-integration test and ECM. Both techniques explore that there exist a long-run relation between inflation and economic growth. The ECM of single equation and multivariate equation also show that in short-run the economy converges to the equilibrium in both cases.

The positive long-run relationship between inflation and growth does not mean that inflation is good for economic growth which is mention in the literature review. Many of the recent studies indicate that the positive relationship between two macro-economic variables has a limit, when inflation increases beyond that limit, it has a negative effect.

CLS technique develop by Khan and Senhadji (2001) has been used to carry out the estimation of threshold level of inflation and to investigate the impact of inflation level on economic growth by using the equation (2). The estimated value of R-squared is taken into consideration from the estimation of equation (2a). By taking into account the value of R^2, it has been decided to represent value of K from 3-11%, within the study period of 1986-2016, the lagged period is determined automatically by the E-views 9.5. According to the Khan and Senhadji (2001), the threshold level of is one that maximizes the value of R^2.

Table 8: VAR estimation result at 2nd lag

VAR estimates Included observations: 29 after adjustments Standard errors in ( ) and t-statistics in [ ]		
	LOGCPI	LOGRGDP
LOGCPI(−1)	0.921309	0.068182
	(0.14890)	(0.06260)
	[6.18754]	[1.08919]
LOGCPI(−2)	−0.300145	−0.027667
	(0.14907)	(0.06267)
	[−2.01343]	[−0.44146]
LOGRGDP(−1)	0.068243	1.071389
	(0.48742)	(0.20492)
	[0.14001]	[5.22832]
LOGRGDP(−2)	0.383339	−0.101356
	(0.47903)	(0.20139)
	[0.80024]	[−0.50327]
C	−11.47809	0.747527
	(3.93107)	(1.65269)
	[−2.91984]	[0.45231]
R^2	0.998806	0.999722

VAR: Vector autoregression

Table 9: Joint diagnostic tests on the VAR model

Test	Test statistic	P value
Normality test	1.210370	0.8764
LM serial correlation	1.492793	0.8279
White heteroscedasticity test	28.70112	0.2316

VAR: Vector autoregression, LM: Lagrange multiplier

Table 10: Johansen test for co-integration

H_0	H_1	Eigen-value	Test statistics	5% critical value	Prob.	Conclusion
		Trace test				
r=0	r=1	0.427617	26.40478	25.87211	0.0429	One co-integrating equation
r≤1	r=2	0.297116	10.22432	12.51798	0.1174	
		Maximum Eigen value test				
r=0	r=1	0.427617	16.18046	15.38704	0.0437	One co-integrating equation
r≤1	r=2	0.297116	10.22432	12.51798	0.1174	

The results given in the above table are based on (Johansen, 1990) the assumption of constant and a linear trend. With an optimal lag length 2 using AIC and SIC test. AIC: Akaike information criteria, SIC: Schwartz information criteria

Table 11: The estimated result of the VECM

VECM estimate Included observations: 28 after adjustments Standard errors in ( ) and t-statistics in [ ]		
Cointegrating Eq:	**CointEq1**	
LOGCPI(−1)	1.000000	
LOGRGDP(−1)	−1.296848	
	(0.06286)	
	[−20.6291]	
C	33.49445	
Error correction:	D (LOGCPI)	D (LOGRGDP)
CointEq1	−0.214907	−0.080783
	(0.08970)	(0.03539)
	[−2.39587]	[−2.28246]
D(LOGCPI(−1))	0.277469	0.090497
	(0.18617)	(0.07346)
	[1.49041]	[1.23195]
D(LOGCPI(−2))	−0.139527	0.152386
	(0.14489)	(0.05717)
	[−0.96301]	[2.66557]
D(LOGRGDP(−1))	−0.437178	0.050333
	(0.51764)	(0.20425)
	[−0.84456]	[0.24643]
D(LOGRGDP(−2))	−0.280396	−0.080892
	(0.51116)	(0.20169)
	[−0.54855]	[−0.40107]
C	0.086661	0.038071
	(0.03170)	(0.01251)
	[2.73348]	[3.04342]
R^2	0.336843	0.603293

VECM: Vector error correction model

From the result of Table 12 it shows that all the explanatory variables except "LOPEN" of the growth model are significant at 5% level at K = 8% level. It is also observable that at low threshold inflation levels (K < 8) there is statistically insignificant relationship between dummy of threshold level of inflation and economic growth. Again, as K started to increase from 8%, the statistically significant relationship at 5% remain up to 9% inflation rate. Finally in the estimation process, the threshold level inflation is observed at 8% level where the value of R^2 is maximized, (i.e.) RSS is minimized. In order to check the Gaussian error terms, a diagnostic test is carried out. The diagnostic test include JB normality test, the Breusch-Godfrey LM test to check serial correlation, the ARCH test to check the problem of heteroscedasticity and finally CUSUM test is used to check recursive residuals.

From the Table 13 the results indicate that its fail to reject the null hypothesis for all the test and it can be said the residuals are normally distributed, there is no serial correlation and data are homoscedastic. From the result of the CUSUM test data line is within the boundary, so it can be said that data are stable.

6. CONCLUSION

This paper has used co-integration and ECMs to examine empirically the long and short run dynamics of inflation and economic of Bangladesh from 1986-2016. Main objective of the

Table 12: CLS estimation of the threshold level of inflation

K	Variables	Coefficient	Standard error	t-stat	Prob.	R^2
3	C	25.66440	0.854784	30.02442	0.0000	0.969416
	LINFLATION	−0.039985	0.057218	−0.698816	0.4911	
	DUMMY2	−0.073031	0.083111	−0.878717	0.3879	
	LINV	1.120895	0.266246	4.209992	0.0003	
	LOPEN	0.072094	0.136884	0.526680	0.6031	
	LPOPULATION	−0.629445	0.261329	−2.408632	0.0237	
4	C	25.94415	0.873244	29.71007	0.0000	0.969032
	LINFLATION	−0.043236	0.070615	−0.612271	0.0459	
	DUMMY3	−0.053896	0.080120	−0.672696	0.0373	
	LINV	1.095285	0.268380	4.081091	0.0004	
	LOPEN	0.026060	0.129800	0.200774	0.8425	
	LPOPULATION	−0.732086	0.241352	−3.033267	0.0056	
5	C	25.94415	0.873244	29.71007	0.0000	0.969032
	LINFLATION	−0.043236	0.070615	−0.612271	0.0459	
	DUMMY4	−0.053896	0.080120	−0.672696	0.0473	
	LINV	1.095285	0.268380	4.081091	0.0004	
	LOPEN	0.026060	0.129800	0.200774	0.8425	
	LPOPULATION	−0.732086	0.241352	−3.033267	0.0056	
6	C	26.23237	0.838051	31.30165	0.0000	0.971113
	LINFLATION	−0.077996	0.056121	−1.389785	0.0768	
	DUMMY5	−0.116662	0.064571	−1.806723	0.0829	
	LINV	1.210916	0.260085	4.655851	0.0001	
	LOPEN	−0.122257	0.149464	−0.817969	0.4211	
	LPOPULATION	−0.965612	0.265473	−3.637329	0.0012	
7	C	25.49966	0.829135	30.75454	0.0000	0.971651
	LINFLATION	0.048902	0.050290	0.972386	0.0402	
	DUMMY6	0.073868	0.044114	1.674481	0.0065	
	LINV	1.117684	0.256065	4.364850	0.0002	
	LOPEN	0.063662	0.125468	0.507401	0.6163	
	LPOPULATION	−0.650157	0.234360	−2.774181	0.0103	
8	C	25.76606	0.803655	32.06108	0.0000	0.972082

(*Contd...*)

Table 12: (*Continued*)

K	Variables	Coefficient	Standard error	t-stat	Prob.	R^2
	LINFLATION	0.051443	0.049571	1.037758	0.0093	
	DUMMY7	0.080312	0.044665	1.798094	0.0443	
	LINV	1.122459	0.254168	4.416213	0.0002	
	LOPEN	−0.011955	0.125350	−0.095373	0.9248	
	LPOPULATION	−0.795711	0.232365	−3.424398	0.0021	
9	C	25.75025	0.846434	30.42206	0.0000	0.969191
	LINFLATION	0.014645	0.047632	0.307465	0.0510	
	DUMMY8	0.039137	0.051215	0.764165	0.0519	
	LINV	1.096696	0.267394	4.101421	0.0004	
	LOPEN	0.036001	0.129382	0.278250	0.7831	
	LPOPULATION	−0.707097	0.240982	−2.934239	0.0071	
10	C	25.73615	0.869295	29.60578	0.0000	0.968635
	LINFLATION	0.004211	0.047413	0.088809	0.0999	
	DUMMY9	0.020729	0.057470	0.360690	0.0714	
	LINV	1.118798	0.270596	4.134576	0.0004	
	LOPEN	0.029564	0.130483	0.226572	0.8226	
	LPOPULATION	−0.714040	0.243300	−2.934816	0.0071	
11	C	25.72657	0.858100	29.98086	0.0000	0.968868
	LINFLATION	0.005428	0.044363	0.122360	0.9036	
	DUMMY10	0.043566	0.077186	0.564433	0.5775	
	LINV	1.110190	0.268292	4.137999	0.0003	
	LOPEN	0.031936	0.129915	0.245819	0.8078	
	LPOPULATION	−0.705804	0.243107	−2.903266	0.0076	

CLS: Conditional least square

Table 13: Diagnostic test for the optimal level of inflation

Test	Test statistic	P value	Conclusion
Normality test (JB test)	2.911157	0.233265	Residual are normally distributed
Serial correlation (LM test)	30.63485	0.1038	No serial autocorrelation
Heteroscedasticity test (ARCH test)	16.88514	0.2624	No heteroscedasticity
Stability (CUSUM)	Within the brands		Stable

JB: Jarque-Bera, LM: Lagrange multiplier, ARCH: Autoregressive conditional heteroscedasticity

study to examine whether there exist any relationship between inflation and economic growth and if any, then what is the direction? The results show that there exist statistically significant long run positive relationship between inflation and economic growth which is confirmed by the statistically significant long run relationship between CPI and real GDP which is similar to the findings of the Mallik and Chowdhury (2001), Hossain (2011). Mubarik (2005) also found positive relationship between inflation and economic growth in long run but he found a threshold at 9% and once again this paper's results for threshold at 8% finds a supportive result to its findings.

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