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Asaduzzaman, Md

Dept. of Economics, Ministry of education, Bangladesh civil service

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# Relationship Between Threshold Level of Inflation and Economic Growth in Bangladesh: A Multivariate Quadratic Regression Analysis.

Md Asaduzzaman <sup>1</sup>

## Abstract

The main objective of this study is to empirically examine the relationship between inflation and economic growth in Bangladesh, and to investigate the ongoing possible threshold effect. This study draws on diverse tables and charts, correlation matrices, pair-wise Granger Causality tests, ADRL (General to Specific Approach) test and a quadratic regression equation estimated by OLS using time series annual data covering the sample period from 1980 to 2017. The results demonstrate that the relationship between inflation and GDP growth is non-linear with a subsistence of a break point, that's means the inverted U-shape curve. Moreover, the Granger Causality shows that economic growth does granger cause inflation. The empirical result indicates that when the inflation level reaches the threshold level at 7.84 percent then the economic growth is in peak position. This study proposed that the Bangladesh Bank should maintain the precautions and growth friendly monetary policy structure by keeping inflation targeting below 7.84 percent, or else the growth might be held back.

**Keywords:** Threshold Inflation, GDP growth, Quadratic Regression Model, Bangladesh Economy.

<sup>1</sup> Lecturer, Department of Economics; BCS (Education); OSD; DSHE; Ministry of Education.  
Email: asadju34@gmail.com  
<https://orcid.org/0000-0003-0038-3892>

## **1. Introduction**

### ***1.1 Background***

The relation between inflation and economic growth in the field of economics is highly debatable issue. Economists have shown diverse views on the subject of the relationship between inflation and economic growth. Therefore, the findings of researchers concerning the relationship between inflation and economic growth are mixed. Still now most of the economist, policy makers and central banks believe that by sustaining low inflation rate will achieve the higher and sustainable economic growth. Also, randomly it does believe that high inflation is the disadvantageous to medium and long run economic growth. Therefore, the debate between inflation and economic growth has produced widely discussion and has resulted in both theoretical and empirical findings. Friedman (1973:41) stated inflation with and without development, no inflation with and without development.

### ***1.2 Research Problem and Motivation***

A few numbers of studies have been carried out on the relationship between inflation and economic growth in threshold effect of Bangladesh. In the perspective of Bangladesh, Ahmed and Mortaza (2005), Bishnu Pada Biswas et al. (2016) and Sayera Younus (2013) all estimate the threshold inflation level in between 6-7.5 percent.

Devarajan, Swaroop and Zou (1996), Hermes and Lensink (2001), Pattillo, Poirson and Ricci (2002), Clements, Bhattacharya and Nguyen. (2005), and Pollin and Zhu (2005) this approach has been used for the international arena earlier. However, for Bangladesh, first time I used this approach to calculate the relationship between inflation and economic growth. Although several works have already been done in Bangladesh about this topic related. Ahmed and Mortaza, (2005) and Younus. S, (2013) are in the sort of line with my current study. They used annual data sets spanning the period 1972–2012. Other researchers like; Rahman. Z, (2014); Ayyoub. M, (2011); Hossain. S, (2015) they used more or less from 1976 to 2011 data sets which is not very recent. Moreover, their findings do not mention about aggregate monetary supply, interest rate long run or short run relation and threshold level. In a nut shell it said that previous analysis did not clarify the determination of the main source of growth indicators (for example, growth factors). However, this study used some additional endogenous variables and different variables compare to them such as; Population, Investment, and Broad Money (M2) growth for examine the relationship between inflation and GDP growth and the threshold effect in Bangladesh in period 1980-2017. This is the first time that is used this type of variables for examine the inflation threshold level of Bangladesh economy.

### 1.3 Objective of the Study

The objective of this paper is to empirically re-examine the relationship between inflation and economic growth in Bangladesh by using Quadratic Regression model. The specific objectives of this research are; the nature of inflation, threshold level of inflation and an appropriate monetary policy with the contrast with inflation level.

The rest of this study is arranged as several sections. Section 2 represents a brief overview of both theoretical and empirical literature about the relationship between inflation and economic growth; section 3 offers an outline of inflation and growth trend analysis of Bangladesh in the period of 1980-2017; section 4 described the methodological structure of this research, while section 5 demonstrate the empirical estimation results of the research data used; and finally, conclusion and summarized policy recommendation is added in section 6.

## 2. Literature review

To investigate the relationship between inflation and economic growth both in the context of developed and developing countries there have been a comprehensive body of theoretical and literature works. In this section I would like to represents a brief review of the literature.

### 2.1 Theoretical Literature

#### a) *The Classical Quantity theory of money (QTM)*

Fisher (1911) gives the quantity theory of money equation by  $(MV=PY)$  ..... (i)  
Where M is the Money Supply; V is the Velocity of Money; P is the General Price and Y is the Real GDP. Monetarists assume that in the long run V and Y are determined by real variables and also these tow variables are unaffected by change in nominal variables such as money supply. So, the theory claims that (percentage of M= percentage of P), implying the existence of equiproportional relationship between monetary growth and the rate of inflation (Robert L. Hetzel. 2007; Johnson, L.E., et al. 2001; Friedman, M. 1971). Milton Friedman (1992) stated that, "Inflation is always and everywhere a monetary phenomenon." That means no other factor could have a role as money plays in the determination of inflation process (Rahman, Ziaur. 2014; Minyahil, Alemu. et al. 2016).

#### b) *Classical Growth model*

The famous classical economist Adam Smith was considered the following production function as a growth model:

$Y = f(L, K, T)$  .....(ii)

Where Y is for output, L is for Labor, K is for capital and T is for Land inputs. Its shows that the output is not only depend on labor but also capital and land. According to Gokal and Hanif (2004), the relationship between inflation and output growth is not mentioned in the classical growth model (Rahman, Ziaur. 2014)

**c) Keynesian view**

Keynes (1936), developed a simple National Income model in where he showed the relationship between inflation and economic growth. Model shows that, in short run, Aggregate Supply (AS) curve is upward slopping which implies the changes in AD affect both prices and output. It's also Indicate people's expectations; labor force; factor prices; fiscal and monetary policy conducts both inflation and output in the short run. He also said that at full employment level of the economy; the excessive demand for goods and services increases the general price level which leads to inflation also Rahman, Ziaur. 2014). Keynes's version reveals that the elasticity price elasticity ( $e_p$ ) with respect to any monetary shock will be equal to zero (i.e.  $e_p = 0$ ) in an idle resource of utilize. According to him in such condition monetary injection would enable utilize idle resources and employment which increase output that is aggregate demand (AD), hence there will be no on prices on the short run (Johnson, L.E., et al. 2001). Keynes argued that velocity of money is a positive function of interest rate. He claimed that considering the impact of interest rate on demand for money the velocity of money is pro-cyclical (Subject to shocks).

i.e.  $(V = \frac{PY}{f(i,Y)})$  ..... (iii)

**d) Neo Classical Theory**

Solow (1956) growth model is considered one of the important models in new classical growth theory. Solow states that labor and capital is diminishing returns to scale whereas it is constant returns to scale (CRS) in production function (Solow, M. 1956). In development economics view Todaro (2000) stated that technological advancement replaces as capital investment which is an important factor for long run economic growth (Todaro, M. P. 2000). However, the level of technological advances was assumed exogenous variable including inflation by the growth theorists. Mundell (1963) developed a growth model about to inflation and GDP growth. His model shows that raises in inflation or inflation expectations directly decreases in people's wealth which leads to fall in real money balances. Therefore, more savings leads to more capital accumulation which enforces economic growth (Mundell, R. 1963). Tobin (1965) stated that either money holding or acquiring capital; people substitute current consumption into future consumption. He suggests that inflation causes individual substitute money into interest earning assets; leads to better capital accumulation which stimulates economic growth (Tobin, J. 1965).

**e) Structuralism's views**

Oludele, Akinloye and Akinboade, (2002) has identified three structural factors basically explaining inflation in LDC's or under developed economies. The factors are; (1) Inelastic supply of agricultural products, (2) Insufficient national resource (government budget constraint) and (3) Foreign exchange bottlenecks (Oludele, Akinloye and Akinboade. 2002). Besides, due to weak domestic capacity complemented with loss of trust by external lenders, most LDCs resort to monetization of their deficits which is inflationary in practice in line with the traditional *QTM*.

## 2.2 Some Empirical Evidence

The relationship between inflation and economic growth in the field of monetary economics is highly debatable issue. Economists have shown various opinions corresponding to the relation between inflation and economic growth. The researcher findings between inflation and economic growth are mixed. Both in the context of developed and developing countries, there have been extensive theoretical and empirical research to date that endeavor to focus on the linkage between inflation and economic growth. Some studies (Abidemi and Maliq, 2010; Malik and Chowdhury, 2001; Jaganath Behera, 2014; Dr. Md. Elias Hossain, 2012) found a positive relationship between inflation and economic growth. Some studies (Barro, 1995; Faria and Carneiro, 2001; Malla, 1997; Saaed, 2007; Rahman. Z, 2014; Ayyoub. M, 2011; Ahmed and Mortaza, 2015; Hossin. S (2015) found a negative relationship between inflation and economic growth. while Hussain, 2011; Khan and Senhadji, 2001; Mubarik, 2005; Musoni J. Rutayisire, 2015; B. P. Biswas, *et al.* 2016; Henryk Gurgul, 2011, found a threshold level inflation, below that level of inflation is good for economy and above that level of inflation is bad for economy.

Mallik and Chowdhury (2001) conducted a study to examine both the short run and long run relationship between inflation and GDP growth of 4 South Asian countries (Bangladesh, India, Pakistan and Srilanka). They used Error Correction Model (ECM) to examine the relationship between these two variables and found a significant positive link between inflation and GDP growth (Mallik, G., & Chowdhury, A. 2001). Barro (1995) investigate inflation and economic growth relationship using a large sample from 1960 to 1990, covering more than 100 countries, the result indicates that there exists a significant negative relationship between them. He argued, an increase the average inflation by 10 percentages per year reduces the growth rate of real per capita GDP by 0.2 to 0.3 percentages 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 few reasons to consider higher long-term inflation reduces economic growth (Barro, R. J. 1995). Abidemi and Maliq (2010) examined the relation between inflation and determinants of inflation such as growth rate of real output, money supply, import, exchange rate, interest rate and fiscal deficit. They found that both inflation and interest rate have a positive impact on economic growth (Abidemi, O. I., & Maliq, S. A. 2010).

Erbaykal and Okuyan (2008) examined the same issue in Turkey covering data from 1987: Q1-2006: Q2 periods. They found the co-integration relationship between the two series. In the long run there was no statistically significant relationship was found with the ARDL models, but has been found a negative and statistically significant short-term relationship. The causality relationship also tested which was developed by Toda Yamamoto (1995) and no causality was found from economic growth to inflation, but the causality relationship was found from inflation to economic growth (Erbaykal, E. and Okuyan, H.A. 2008). Elias, et al. (2012) investigates the long run of relationship between inflation and economic growth in Bangladesh in period 1978-2010. The result of the Co-integration test showed no co-integrating relationship between inflation and economic growth for Bangladeshi data. They also check the causality relationship by employing the VAR-Granger causality at two different lag periods. The results showed at the same at different lags (Elias, et al. 2012).

Ahmed and Mortaza (2005); Hossin. S, (2015), examined with same issue in Bangladeshi context. Their empirical evidence demonstrates that there exists a long-run negative relationship between inflation and economic growth. In addition, the estimated threshold model suggests 6 percent as

the threshold level (for example, structural break point) of inflation above which inflation adversely affects economic growth (Ahmed and Mortaza. 2005; Hossin, Shakhaowat. 2015). Rahaman (2014) is too examine the empirical relationship between inflation and economic growth in Bangladesh for the time period 1976 to 2011 used Vector Auto-regression (VAR) methodology to investigate the linkage between inflation and economic growth; trade openness and economic growth; and remittances and economic growth in Bangladesh. He demonstrates that inflation and economic growth have a statistically significant negative relationship; remittances and economic growth have a statistically significant positive relationship, whereas trade openness and economic growth have a statistically negligible relationship in Bangladesh (Rahman, Ziaur. 2014). Saaed (2007) examined the relation between inflation and economic growth in Kuwait by using the Engle- Granger causality test and ECM. He found a short run and long run strong negative relationship between CPI inflation and real GDP growth in Kuwait economy (Saaed, A. 2007). Faria and Carneiro's (2001), by using the time series data in Brazil, found short run and long run negative relationship between inflation and economic growth in Brazil (Faria, J. R. and Carneiro, F.G. 2001). Malla (1997) conducted an empirical study on some Asian countries and OECD (Organization for Economic Cooperation and Development) countries. Malla demonstrates that there is a negative relationship between inflation and economic growth in case of OECD countries, but an insignificant relationship in the case of Asian countries (Malla, S. 1997). Iqbal and Sattar (2012) conducted a study to find out the relationship between inflation and economic growth in Pakistan economy. They found statistically significant negative relationship between inflation and economic growth in Pakistan. Fischer (1993) was the first to investigate the possibility of non-linearities in the relationship between inflation and output growth using of 93 countries both cross-sectional and panel data, including developing and developed countries. At a low inflation rate he found a positive relationship between inflation and economic growth, but at the high inflation rate the relationship became negative. Moreover, using 15 percent and 40 percent two structural breakpoints, he showed that not only the presence of non-linearity in the relationship between the two variables, but also the strength of the relationship weakens for inflation rates above 40 percent (Fischer, S. 1993). Johnson (1967) conducted a study of 30 high inflation countries by using panel data. He didn't find any definite empirical evidence regarding the relationship between inflation and economic growth of these countries (Johanson, H.G. 1967). Khan and Senhadji (2001) examined 140 samples of both developing and industrially developed countries by using panel data examined the relation between inflation and real GDP growth. They showed different inflation threshold level, for developing countries it was (7 percent to 11 percent) and for industrially developed countries it was (1 percent to 3 percent). They also stated that beyond that threshold level of inflation, inflation would adversely affect the economic growth (Khan, M.S. and S.A. Senhadji. 2001). Bruno and Easterly (1998) examined the determinants of economic growth for the period 1961-1992 using cross-sectional data from 26 countries. They explained that the negative relationship between inflation and growth exists only in high frequency data and with extreme inflation observations. In their empirical analysis, they detected a threshold level of 40 percent, above which the relationship between inflation and growth was negative (Bruno, M. and W. Easterly. 1998). In case of India, the result of the different studies on threshold levels of inflation gives different views. A more recent study by Singh (2010) which used both yearly and quarterly data for India found threshold level of inflation is at 6 percent (Singh, Prakash. 2010). Another finding by Pattanaik and Nadhanael (2011) examined the persistent high inflation in India. They identified three factors causing inflation to appear well above the threshold level are; inflationary expectations; the increase in wages and decreases in earnings with respect to wage

increases (Pattanaik Sitikantha and Nadhanael, G.V. 2011). Mubarik (2005) estimated the threshold level of inflation for Pakistan. He suggests that an inflation rate below 9 percent is favorable for the Pakistan economic growth (Mubarik, Y. A. 2005). Another Pakistanis, Hussain (2005) found no threshold level of inflation for Pakistan economy (Hussain, M. 2005). Lee and Wong (2005) estimated the threshold levels of inflation and using quarterly data during 1965-2002 for Taiwan and 1970-2001 for Japan. They suggest that an inflation rate beyond 7.25 percent is detrimental for the Taiwan economic growth. On the other hand, For Japan, they found two threshold levels are; 2.52 percent and 9.66 percent which suggests that inflation rate below the estimated threshold levels is favorable to economic growth and it is harmful beyond this threshold level (Lee, C. C. and S. Y. Wong. 2005). Munir *et al.* (2005) from Malaysia examined the threshold effects. His empirical results strongly suggest the threshold level at 3.89 percent which implies the non-linear relationship between inflation and economic growth for Malaysia (Munir,Q. et al. 2009).

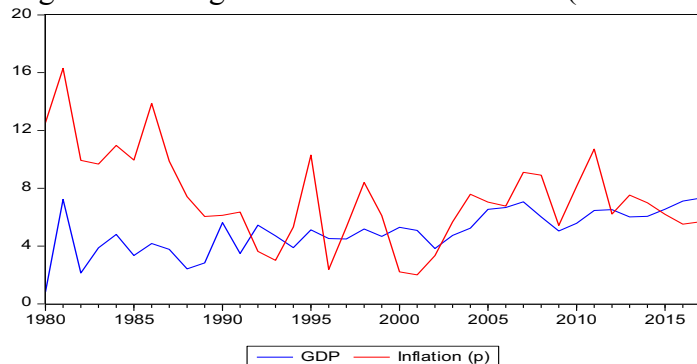
Bangladesh has a very few studies about the relationship between inflation and economic growth in the threshold effect. Among them, Ahmed and Morataza, (2005); Younus. S, (2013) are in the sort of line with my current study. Their empirical evidence demonstrates that there exists a statistically significant long-run negative relationship between inflation and economic growth for Bangladesh. They used on OLS estimation; also suggest a threshold level of inflation is at 6 percent (Ahmed and Mortaza. 2005). Younus (2013) examined that inflation and growth is non-linear with an existence of a threshold level of inflation within the range of 7-8 percent (Younus, S. 2013).

From the above analysis it can be seen that the empirical findings concerning the relationship between Inflation and economic growth are miscellaneous. Therefore, I endeavor to re-examine the empirical relationship between inflation and economic growth in threshold effect in the context of Bangladesh economy by using quadratic regression model provided evidence supporting the hypothesis of a nonlinear relationship in the inflation-growth nexus in Bangladesh and the existence of a threshold level of inflation above which inflation is detrimental to economic growth.

### 3. Inflation and GDP Growth Trend in Bangladesh

Exploring the bivariate relationship between growth and inflation,

Figure 1: GDP growth and Inflation trends (1980-2017);



Source: Author's own calculation by using Eviews software version 9.0



Figure-1 illustrates the historical trends from 1980-2017 of the two macroeconomic variables. The annual average real economic growth rate for the whole sample period was 0.607 percentages, while the average inflation rate was 0.802 percentages.

Table 1: Some Economic Indicators trends.

<b>Indicators</b>	<b>1985- 1986</b>	<b>1995- 1996</b>	<b>2005- 2006</b>	<b>2015- 2016</b>
<b>GDP</b>	3.4	4.93	5.96	7.11
<b>Inflation rate</b>	9.95	6.65	7.17	5.92
<b>FDI (% of GDP)</b>	-0.0299	0.0049	1.0951	1.4513
<b>M2 (% of GDP)</b>	19.593	28.828	4.421	64.507
<b>Govt Expenditure (% of GDP)</b>	15.74	13.93	15.47	13.5
<b>Trade Openness (% of GDP)</b>	18.222	28.209	34.397	42.086
<b>Savings (% of GDP)</b>	15.384	21.659	32.075	36.049

Source: Author's own calculation based on Bangladesh economic Review.

Table-1 shows some Economic Indicators. Regarding the nature of the figure, it cannot be certainly drawn any final decision. This relationship might also be hypothetically representing the following manner. Although Mubarik (2005) and Ghosh and Phillips (1998) uses these kinds of approach earlier. Inflation rate has been categorized in ascending order (Mubarik, Y. A. 2005; Ghosh, A. and S. Phillips. 1998). Average inflation and average growth rates corresponding to each inflation range have also been calculated in Table-2.

Table 2: Inflation ranges and Economic growth.

<b>Inflation Range</b>	<b>Number of Observation</b>	<b>Average Inflation</b>	<b>Average GDP growth</b>
Up to 3.00	6	3.100	5.893
3.01-5.00	5	4.008	4.048
5.01-7.00	9	6.300	5.916
7.01-9.00	10	8.034	5.359
9.01- above	12	12.240	4.288

Source: Author's own calculation.

#### 4. Methodology and Model specification

The investigation has been carried out by means of a quadratic regression model which is estimated as second-degree polynomial and using Eviews software, version 9.0 for empirical estimation. This widely used technique for estimating non-linear relationships allowed the identification of the turning point in the inflation-growth nexus. From 1973 to 2017 the annual data sets of Bangladesh economy have been used for the empirical analysis in this research. To investigate the relation between inflation and economic growth and the threshold effect of Bangladesh the model takes the form of a growth regression equation augmented with inflation.

$$y_t = \beta_0 + \beta_1\pi_t + \beta_2X_t + \varepsilon_t \dots\dots\dots (1)$$

Where  $y_t$  is the Gross Domestic Product growth (GDP);  $\beta_0$  is the constant;  $\beta_1$  and  $\beta_2$  are explanatory variables. It is expecting that  $\beta_1 > 0$  and  $\beta_2 < 0$ ;  $X_t$  is the vector of explanatory variable and  $\varepsilon_t$  is the error term.

In the literature we saw that in growth theory of all explanation demonstrated the determination of the main sources of growth the explanatory variable  $X_t$ . According to Neoclassical (Solow, 1956; Swan, 1956) growth theory they highlighted the capital stock, labor force and technological advancement as their main forces of growth model (Solow, M. 1956). Whereas (Romer, 1990; Grossman and Helpman, 1991) stated the endogenous growth model in which they had shown that human capital, Knowledge and new technology are the prime forces of economic growth (Romer, D. 2001; Grossman, G. and E. Helpman. 1991). This research draws upon the neoclassical model to examine the choice of fundamental explanatory variables ( $X_t$ ). Slow growth model has been widely used for both developed and developing economics empirical analysis (Mankiw, Romer and Weil, 1992) (Mankiw, N., D. Romer and D. Weil. 1992). However due to data constraints, this empirical research will substitute investment for capital stock and population for labor forces. Levine and Renelt (1992) and Sala-i-Martin (1997) argue that despite a large number of explanatory variables that can be used for growth regression model, only a few of them may be significant (Levine, R. and D. Renelt. 1992). They identified most important explanatory variables for economic growth; these are investment, population growth, inflation rate, government expenditure, trade openness and the growth rate of the term of trade. King and Levine, (1993); and Levine and Zervos, (1998) stated that financial development is another important variable (King, R. and R. Levine. 1993; Levine, R. and S. Zervos. 1998). Hence in this research I would like to introduce monetary aggregate growth (M2) as a substitute for the financial development. Therefore, apart from the inflation, the empirical research of Bangladesh will depend on the above result and the following basic model;

$$y_t = \beta_0 + \beta_1\pi_t + \beta_2INV_t + \beta_3POP_t + \beta_4TOPN_t + \beta_4M2_t + \varepsilon_t \dots\dots\dots (2)$$

Where  $\Delta y_t$  is as define in equation 1;  $\pi_t$  is inflation representing the annual percentage change of the Consumer Price Index (CPI);  $INV_t$  is for investment which is percentage share of GDP;  $POP_t$  is the annual population growth.  $TOP_t$  for Trade Openness calculated as the ratio of the sum of exports and imports to nominal GDP;  $M2_t$  is for broad money supply calculated by the percentages of change of money growth with respect to the previous year on the economy and  $\beta_0$  and  $\varepsilon_t$  have the same definition as in Equation-1.

Theoretically, the expected effects of the different explanatory variables in the growth Equation-2 are as follows: According to both neoclassical and endogenous growth models Investment as the basic principal of economic growth, and it is expected to be positive relation with economic growth. Harrod-Domer model argues that the growth rate of output depends on the level of savings and share of investment spending in GDP. The growth rate of population may be either positive or negative relation on output growth. According to Todaro (1996), larger population provides greater aggregate demand which is to generate the scale effect of the production, leads to lower production cost which leads to higher output level (Todaro, M. 1996). On the other hand, Kelly (1988) mention that population growth could have negative impact on the economy if the number of dependency people increases more than the number of young people (Kelley, A.C. 1988). The central Bank of Bangladesh “Bangladesh Bank” uses M2 money supply as an intermediate instrument and uses reserve money as an operating tool to achieve the expected growth, price and exchange rate stability. Mc Candless and Weber (1995) examine the average rate of inflation, output, growth rate and growth rate of various measures of money over a long period of time of many different countries and the relationship that were unlikely to depend on unique country specific events that might influence the actual evolution of money, prices and output in a particular country (Carl E. Walsh, Monetary policy and Theory. 3<sup>rd</sup> Edition). Finally, the Trade Openness ( $TOP_t$ ), theoretically and empirically the studies have shown that trade does not have a simple and straightforward relationship with economic growth. There are two types of arguments in both sides. It follows from these contrasting views that the final effect of openness on growth in an empirical issue.

#### 4.1 Inflation threshold modeling effects on growth

To examine the existence of a non-linear relationship between inflation and economic growth, most empirical studies use the threshold endogenous model developed by Sarel (1996) and Khan and Senhadji (2001). However, this model requires a large set of data to results valid statistical inferences. Therefore, for small sample in here I am using Pollin and Zhu (2005) and Quartey (2010), quadratic function for estimate threshold effect in Bangladesh economy. The quadratic function approach has also been the share of overall government spending that maximizes economic growth. The function is as follows;

$$y_t = \beta_0 + \beta_1\pi_t + \beta_2\pi_t^2 + \beta_3INV_t + \beta_4POP_t + \beta_5TOP_t + \beta_6M2_t + \varepsilon_t \dots\dots\dots(3)$$

In here all the other variables as define in Equation 2, only term  $\pi_t^2$  is added in this Equation (3). In here investment as a percentage of GDP, population growth, trade openness and M2 aggregate money supply are used as control variables. In this model, it is expected that  $\pi_t$  would have a positive sign which indicate the low inflation on output, whereas  $\pi_t^2$  is expected to have a negative sign and should have adverse impact with higher inflation. The combination of positive significance  $\pi_t$  and negative significant  $\pi_t^2$  implies as an inverted U-shape curve. This demonstrates that the spillover from positive effect to negative effect inflation exceeds a threshold level. The prime point of the quadratic function identifies the threshold level which the marginal effects of inflation become negative.

For finding the threshold level of inflation from the quadratic model shown in equation (3) following two conditions to be satisfied to get maximum level of GDP growth.

*The First Order Necessary Condition:*  $\frac{\delta y_t}{\delta \pi_t} = 0$  and

*The Second Order Sufficient Condition:*  $\frac{\delta^2 y_t}{\delta \pi_t^2} < 0$

In order to examine the non-linearity hypothesis, the Equation-3 will be estimated in both linear and squared term. If both coefficients are significantly different from zero then the critical point of the inflation threshold level can be written as from equation (3);

$$\frac{\delta y_t}{\delta \pi_t} = \beta_1 + 2 \beta_2 \pi_t = 0 \dots\dots\dots (4)$$

Solving the above equation for  $\pi_t$ , the critical point of inflation beyond the marginal impact becomes negative is obtained;

$$\pi_t^* = - \frac{\beta_1}{2\beta_2} \text{ (e.g. } < 0) \dots\dots\dots (5)$$

## **5. Data and empirical findings**

### **5.1 Data used**

The basic data used in this study include time series on GDP, Population, the CPI, Investment and Trade openness. The time period is 1980-2017. The data is collected from The World Bank data indicators, Bangladesh Bank (BB), The Bureau of Statistics (BBS), and Bangladesh Economic Review Publisher by Ministry of Finance.

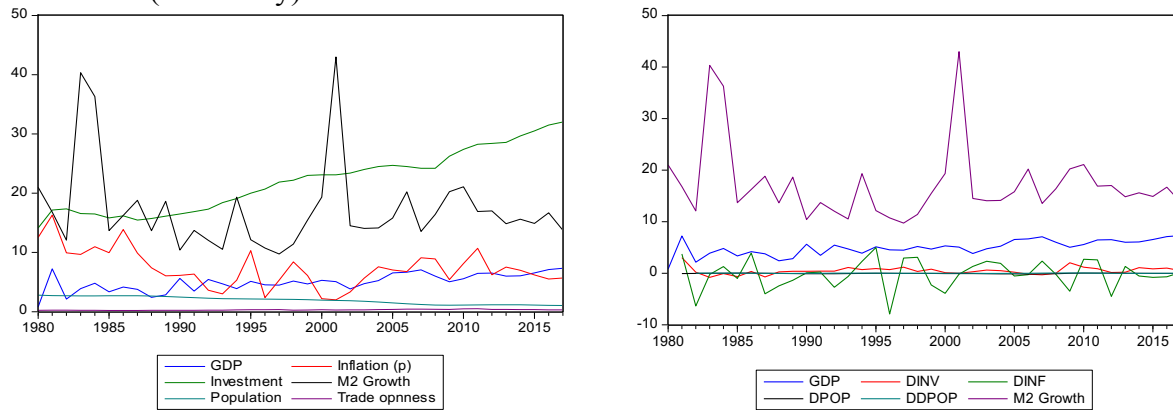
### **5.2 Empirical Findings**

As we have adopted the Ordinary Least Square (OLS) method for estimation, it has to be certain that all the variables included in the different models are stationary in order to get the reliable result and to avoid spurious regression. To do this we used the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test. It is important to recall that some variables are define as annual change or growth rate ( $y_t$ ,  $\pi_t$ , and  $POP_t$ ), while others are defined as the ratios (INV, TOP and M2).

### 5.3 Unit Root Test

In here the p value is calculated at 1%, 5% and 10% level of significance. I (O) indicate the series is stationary that means the null hypothesis of non-stationary is rejected while I (1) mean the variable is non-stationary in which we failed to reject the null hypothesis.

Figure 2a: Variables at the level (Non-Stationary)      Figure2b: variables after first or second difference (Stationary)



Source: Author’s own calculation by using Eviews software version 9.0

Figure 2(a), 2(b) shows the stationary and non-stationary respectively, while table-3 shows test result.

Table 3: Unit Root Test

Variables	Unit Root Test					
	ADF Test			PP Test		
	t-Statistic	Prob.*	Order of Integration/ Stationary	Adj. t-Statistic	Prob.*	Order of Integration/ Stationary
GDP	-8.842	0.0000	I(O)	-8.53773	0.0000	I(O)
$\Delta inv$	-6.68477	0.0000	I(O)	-6.45039	0.0000	I(O)
$\Delta \pi$	-7.24788	0.0000	I(O)	-11.8776	0.0000	I(O)
$\pi_2$	-4.71594	0.0029	I(O)	-4.6196	0.0038	I(O)
$\Delta(\Delta pop)$	-4.98368	0.0023	I(O)	-2.51271	0.3205	I(1)
$\Delta top$	-6.03813	0.0001	I(O)	-6.06962	0.0001	I(O)
M2	-4.75799	0.0026	I(O)	-4.69584	0.0030	I(O)

Source: Author’s own calculation.

**Note:** ‘ $\Delta$ ’ means the first difference and ‘ $\Delta (\Delta)$ ’ means the second difference. Variables are taken at trend and intercept term.

### 5.3 Granger Causality test

Professor Christopher Sims (1972) introduced the notion of Granger causality test into the debate over the real effects of money. The Granger causality test has been used to investigate the linear causation between inflation and economic growth. Khan and Senhadji (2001) used this test because they thought that inflation may not be an exogenous variable in the growth-inflation regressor and therefore the inflation coefficient may be biased. Though as suggested by Fisher (1993), the causality is more likely to run predominantly from inflation to economic growth. It is significant to indicate that causality does not inevitably mean exogeneity. However, Mubarik, (2005); Risso and Carrera, (2009); Hussain and Malik, (2011) demonstrate that the absence of a response causes from growth to inflation assists in the preference of dependent and independent variables for the model. It also offers a superior suggestion that inflation does an impact on growth indeed (Chimobi, 2010); (Hussain, S. and S. Malik. 2011; Risso, W. A. and E. J. Carrera. 2009; Chimobi, O.P. 2010).

Table 4: Granger Causality test

Pairwise Granger Causality Tests  
Sample: 1980 2017  
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
Inflation does not Granger Cause GDP	37	1.15731	0.2896
GDP does not Granger Cause Inflation		4.67235	0.0378

Source: Author's own calculation by using Eviews software version 9.0

Table-4 shows the test result. The test statistics shows that the null hypothesis that inflation does not Granger-Cause GDP is not rejected at the 1%, 5% and 10% level of significance, in where the p-value is 0.2896. That means inflation does not causes economic growth. On the contrary, the null hypothesis that GDP does not Granger-Cause Inflation is rejected at the 5-10% level of significance, as shown by the p-value of 0.0378. This is meaning that economic growth does cause inflation. Then it may be concluded from these results that there is no feedback from inflation to GDP growth to imply that there is a unidirectional causality running from GDP growth to inflation.

### 5.4 Quadratic Regression Model Results

A quadratic regression model has been estimated to determine the level of threshold inflation in here. This empirical estimation has been taken relatively small secondary sample size annual data from 1980 to 2017 of Bangladesh. The regression is estimated by means of Ordinary Least Square (OLS) method. Before that ADRL Model (General to Specific) is used because modifying an over parameterized model to a parsimonious model. According to Hendry's (1995) the variables which are statistically insignificant regressors have been successively eliminating to obtain the final parsimonious equation (David F. Hendry. 1995). In this process using Wald Test and saw that

some of coefficient was found statistically insignificant and therefore it was dropped. The redundant variable test (Likelihood Test) also gives the same result like Wald Test. In the estimation the number of lags was restricted to 2 (two) in order to preserve the degrees of freedom.

Table 5: Wald Test-Coefficient Restrictions and Redundant Variables Test (Likelihood Ratio Test)  
Wald Test:

Wald Test				Redundant Variables Test (Likelihood Test)			
Test Statistic	Value	df	Probability	F-statistic	Value	df	Probability
F-statistic	0.304916	(5, 15)	0.9024	F-statistic	0.304916	(5, 15)	0.9024
Chi-square	1.524581	5	0.9102				

Source: Author's own calculation by using Eviews software version 9.0

Table-5, shows the Wald Test-Coefficient Restrictions and Redundant Variables Test (Likelihood Ratio Test) and Table-6, shows the Quadratic Regression Model Results.

Table 6: Quadratic Regression Model Results

Dependent Variable: GDP

Method: Least Squares

Sample (adjusted): 1982 2017

Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\pi_{t-2}$	0.438083	0.112329	3.899987	0.0010
$\pi_{t-2}^2$	-0.027932	0.007180	-3.890054	0.0010
Inv <sub>t</sub>	-0.842239	0.211686	-3.978716	0.0008
Inv <sub>t-2</sub>	0.883355	0.182940	4.828660	0.0001
Top <sub>t-1</sub>	7.164616	2.908033	2.463732	0.0235
Pop <sub>t</sub>	43.91969	7.839227	5.602554	0.0000
Pop <sub>t-1</sub>	-89.49529	15.29171	-5.852535	0.0000
M2 <sub>t</sub>	-0.081817	0.016990	-4.815528	0.0001
Dummy	-0.581852	0.327878	-1.774598	0.0920
C	-10.66695	5.731461	-1.861123	0.0783
R-squared	0.945057	Mean dependent var	5.045071	
Adjusted R-squared	0.898789	S.D. dependent var	1.328552	
S.E. of regression	0.422661	Akaike info criterion	1.420873	
Sum squared resid	3.394209	Schwarz criterion	2.168646	
Log likelihood	-8.575721	Hannan-Quinn criter.	1.681866	
F-statistic	20.42575	Durbin-Watson stat	1.774473	
Prob(F-statistic)	0.000000			

Source: Author's own calculation by using Eviews software version 9.0

According to the result (Table-6) reported on table 5, the goodness of fit of the model revealed by the  $R^2$  is satisfactory. The model explains 94.51% of the variation of growth, and p-values indicate that the main explanatory variables are statistically significant. The estimated Durbin Watson (D-W) test result is greater than  $R^2$  value, which means that the model has no spurious problem and D-W test result also rejects the hypothesis of serially correlated. Moreover, the F-statistic shows that the explanatory variables are jointly significant at the 1% and 5% level of significance. According to theoretical prediction and empirical evidence the Investment (Inv) is found the statistically significant and has a negative impact but in lag 2 it has a positive impact on GDP growth ( $y_t$ ). After all the cumulative effect of Investment on GDP is positive which is a 1% increase in Investment will increase GDP growth by 0.04%. While the Trade Openness (Top) in lag-1 found the positive and 1% in Trade Openness increased GDP by 7.16%, while the monetary growth (M2) has found the negative impact on GDP growth by 0.08%. The dummy variable in the model is also significant at 10% level and have the expected sign (the negative sign) to the GDP growth implies that the destabilizing effect of the period of from 1995 to 2000. The Population growth impact on GDP growth in this model is both are positive and negative (in normal and Lag-1 period) and also significant as expected on the theoretical literature. But the cumulative effect of Population on GDP is negative, which is a 1% increase in Population will decrease GDP growth by 43.91%.

According to the literature assumption it has expected that the coefficient of the linear term, Inflation ( $\pi_t$ ) will be positive and in the estimation, it has found a positive sign (0.438083), while the coefficient of the squared term,  $\pi_t^2$  has found a negative sign (-0.027932) as expected both in Lag-2. Moreover, both coefficients are statistically significant whereas the both p-value is 0.0010 same. These results indicate that the lower inflation level is enhancing the GDP growth, while the higher level of inflation reduce the growth, which describe in this study is non-linear and inverted U-shape curve. In other words, these findings stated the hypothesis that there are exists a turning point or threshold level of inflation in Bangladesh. On the base of the estimation result the threshold level of inflation obtained in two steps. Step-1: The partial derivative of model (3) with respect to  $\pi_t$  and the outcome has shown in model (4); and Step-2: The partial derivative was set equal to zero and solve for  $\pi_t$  to find the turning point,  $\pi_t^*$ . Solving for  $\pi_t$ , the steady state value was used, whereby the current and lagged values of inflation and squared inflation are considering. The calculations are as follows;

$$\frac{\delta y_t}{\delta \pi_t} = 0.438083 + 2(-0.027932) \pi_t = 0 \dots\dots\dots (6)$$

$$\frac{\delta^2 y_t}{\delta \pi_t^2} = -0.055864 < 0 \dots\dots\dots (7)$$

Since the both conditions for maximization are satisfied, we can find the threshold level of Inflation by solving from equation (7) as follows:

$$0.438083 - 0.055864 \pi_t = 0$$

$$\Rightarrow \pi_t^* = \frac{0.438083}{0.055864} = 7.84 \dots\dots\dots (8)$$



The above result indicates that when the inflation level reaches the threshold level at 7.84 then the economic growth is in peak position. That means the GDP growth is in maximum to the corresponding threshold inflation level. In the context of Bangladesh, inflation is enhancing the GDP growth when the inflation level is below at 7.84, but if inflation exceeds this threshold level then it will negatively impact to the economic growth.

### 5.5 Residuals Diagnostic tests for quadratic equation

Diagnostic tests were done for the quadratic equation shown in equation (6) and the diagnostic results are depicted in table -7 and found that Residuals are normally distributed, No serial correlation, no heterosckdastic error.

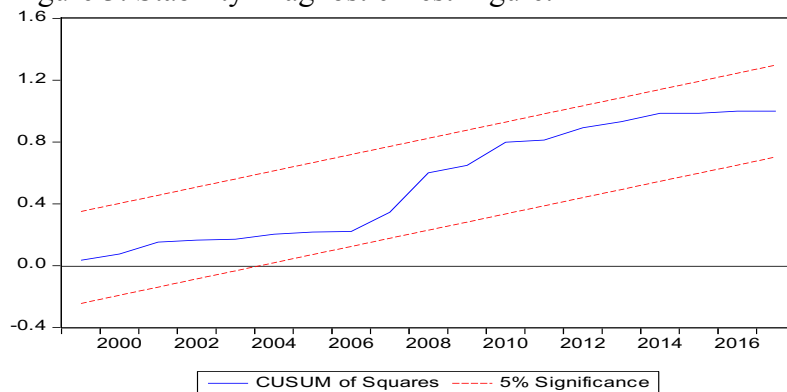
Table -7: Diagnostic tests.

Diagnostic tests for quadratic equation			
Name of the test	Obs*R-squared	Prob. Chi-Square(1)	Decision
Normality Test (JB Test)	2.932233	0.2308	Residuals are normally distributed
Serial Correlation (LM Test)	0.629413	0.4276	No serial correlation
Heteroskedasticity (ARCH Test)	2.322755	0.3131	No heterosckdastic error

Source: Author's own calculation by using Eviews software version 9.0

### 5.6 Stability Diagnostic Test

Figure 3: Stability Diagnostic Test Figure.



Source: Author's own calculation by using Eviews software version 9.0

The stability diagnostic test figure-3, shows that parameters of this model are stable, that's means in this model there is no structural break.

## 6. Conclusion

The main objective of this study was to empirically examine the relationship between inflation and economic growth in Bangladesh, and to investigate the ongoing possible threshold effect between these variables. The results demonstrate that the relationship between inflation and GDP growth is non-linear with a subsistence of a break point. Historical data (table-2) show that average economic growth marked its peak when inflation range is in between 5-7 percent in Bangladesh. Correlation matrices also validate this range because of the inflation-growth correlation is positive when the rate of inflation is smaller than 7.84 percent but its turns into negative when this inflation rate is greater than 7.84 percent. Moreover, the Granger Causality test implies that there is no feedback from inflation to GDP growth, meaning that there is a unidirectional causality running from GDP growth to inflation. This empirical estimation results are similar with empirical studies on Developing countries (Khan & Senhadji, 2001; Mubarik, 2005; Ahamed & Mortaza, 2005; Pollin & Zhu, 2005; Hossain, 2005; Sayera, 2013; Musoni J, 2015; Singh et al. 2010; Nicas Yabu et al. 2015; Siddique, 2016).

The deviation of the results in the present study from the previous one might be by reason of data coverage and methodological variation. This paper is the first attempt to address the multivariate regression analysis to estimate the threshold effect in Bangladesh. Therefore, it is a vital in this sense that it offers a baseline study in research of the optimal inflation for Bangladeshi economic growth. Besides this, in Bangladeshi perspective, acquiring a special measure of threshold inflation within the range of 7-8 percent in this study is fairly realistic.

In Fiscal Year (FY) 2016-2017 the inflation rate of Bangladesh is 5.89 percent, while the threshold level of inflation found in this study is 7.84 percent. In these circumstances the inflation level should be increased around 6.5-7.5 percent. But at the same time the higher inflation is politically unviable for the democratic government because the fear of losing people mandate. So, increased broad money supply or lower the interest rate is sometimes critical for the political government. Here the necessary point is that, the macroeconomic stability. Theory implies that, Low or moderate inflation indicates the macroeconomic soundness and creates a friendly atmosphere for doing business. However, only lower level of inflation cannot accomplish the enough provision for economic growth of Bangladesh. Data illustrates that higher inflation has a negative impact on private investment in manufacturing sector. That is why optimal growth can be achieved by controlling inflation and raising private investment side by side. In addition, the government has to manage budget deficits within sensible limits. Discouraging government allocation to the unproductive sector might be the solution also (Bishnu Pada Biswas et al. 2016).

These empirical results have a significant proposition for conducting monetary policy of Bangladesh. The study proposed that the Bangladesh Bank should maintain the precautionary and growth friendly monetary policy structure by keeping inflation targeting below 7.84 percent or else the growth may be held back.

Finally, although the objective of this research is achieved, some important issues have not been addressed, such as the channels through which inflation related exerts a negative impact on economic growth and the effect of inflation variability on output growth. So, I think there are scopes to investigate about these issues in future.

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