

Major Macroeconomic Determinants of Inflation in Bangladesh: An ARDL Bound Test Approach

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Abstract: Growth, sustainability and strength of an economy reflected through the variables which measure the macroeconomic performances e.g. output, unemployment rate, stability of price, balance of export and import and exchange rate stability. All of that stability of price which is pronounced in field of economics by inflation is more complicated and a fragile variable, measures the overall strength and welfare of an economy. Interactive augmentation among the variables is needed to be identified and defined for the policy making purpose which is comprehensive and pre-requisite to implement and design the policy prescriptions. In this paper we investigate the macroeconomic variables which determined the inflation of Bangladesh by using time series data from year 1981 to 2020. Using Autoregressive Distributed Lag (ARDL) model with bound test approach, it is found that gross domestic product (gdp), broad money supply (m2), export growth (xg), import growth (mg) and growth of population (pg) are the major determinants of inflation (inf) in Bangladesh. Though the interaction of those variables is different on inflation but there long-run and short-run penetrations are statistically impactful.

Keywords: Inflation, GDP, Export, Import, Money Supply, ARDL Bound Test

1. Introduction

One of the three major macroeconomic goals of an economy is to maintain sustainable inflation rate which is a burning issue for the policy makers in every year. Inflation reflects the continuous increase in overall price level of goods and services. Rise in inflation decreases the value of money. Moreover, inflation is mainly determined by the supply side and demand side factors in which output growth, capital formation, rise in tax and wage levels, exchange rate and fall in agricultural production are from supply side factors and rise in money growth, private consumption, government expenditure and change in interest rates etc represents demand side factors [27]. Monetarist like Friedman (1963) agreed that inflation is a monetary phenomenon which comes from the excess demand of goods and services resulting from an excess supply of money [30]. Growth in the quantity of money also increases inflation as mentioned in quantity theory of Money [21, 38]. On the other

hand, Structuralist summarized with the view of inflation as, if prices of food or export rises rapidly than prices in the rest of the economy then the rate of inflation will be affected not only the excess supply of money but also by the change of relative prices reflecting sectoral excess demand.

Inflation not only caused by aggregate demand and supply but also can be affected by the sociological, institutional, natural and socio-political factors in the short run and long run mostly for developing countries [16, 28]. Some noticeable factors such as lack of private savings, lack of adequate developed industries, political unrest, inadequate infrastructure and strong institutions are caused pressure on central bank to maintain a tolerable inflation rate [16].

Several works have already done to find out the determinants of inflation for different countries. Inflation in national level has been accelerated by income, money supply growth, GDP and oil price [27, 63]. In emerging market economics has experienced price hike due to the influence of output gap, money supply, wage level, exchange rate, import price and oil price [50]. Along with those factors, the inflation

of an economy also manipulated by the macroeconomic factors e.g. interest rate, tax revenue, unemployment rate, military expenditure and current account balance [8]. Oil price is considered as influential factors which determine inflation in India [7]. Price mechanism is distorted by higher inflation which causes fall in investments and saving, disrupts in earning of fixed income groups, creditors [62]. Using ARDL method on low and high inflation countries and came on a conclusion that inflation is affected by GDP growth and import of goods and services in long run for low inflation countries whereas high inflation countries has significant long run impacts on inflation for money supply, national expenditure and GDP growth [46]. However, this paper tries to focus on the influences of macroeconomic variables such as money supply, export import growth and population growth on inflation in Bangladesh.

The rate of inflation is experienced a subsequence fluctuation at period of time which is (Figure 1. INF) considered to be utilizing in this study. The country has observed a lowest

inflation rate which was 1.94 percent in year 2000, whereas the highest inflation rate was 16.29 percent in a particular year 1989. A downward trend has been observed from year 2011 to 2020. The inflation rate has been declined 10.92 percent in year 2011 to 4.08 percent in year 2020. In 2011, rise in inflation mostly came from broad money growth (16.92 percent), growth in export (29.34 percent) and growth in import (29.15 percent) and this leads to increase in GDP growth (6.46 percent) also. By adopting continuously contractionary monetary policies, central bank was able to reigning inflation rate that drops to 4.08 percent in 2020 from 4.45 percent in 2019 where GDP growth rate declined to 3.51 percent in 2020 from 8.15 percent in the corresponding previous year. Due to covid-19 pandemic crisis, economy has observed a rise in consumer price index to 189.91 in 2020 from 179.68 in 2019 where economy experienced a decline in growth of export and import by 18.24 and 10.44 percent respectively. Population growth is also showing a downward trend from 1981 with 2.64 percent which decline to 1 percent in 2020.

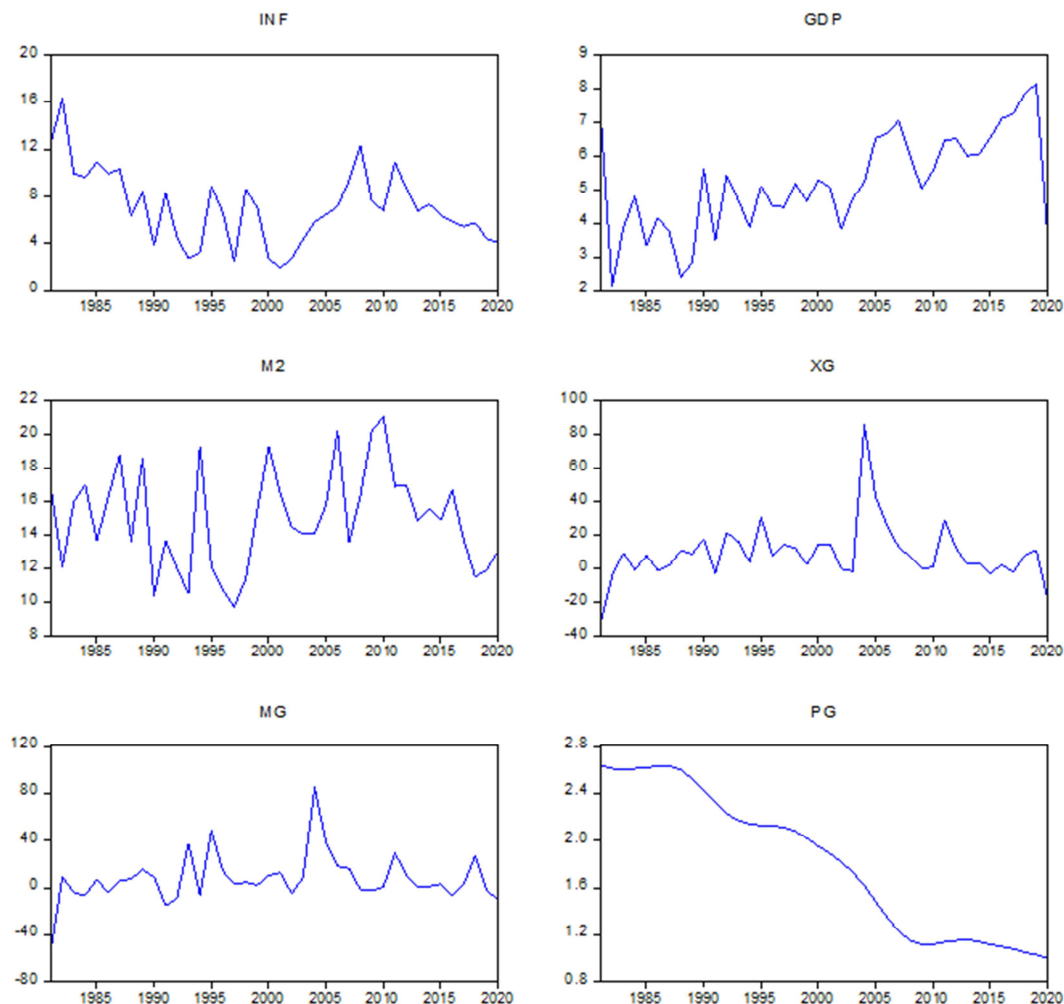


Figure 1. Growth of the Series from the year 1981-2020.

In Section 2, we discuss the previous studies which are relevant for this research work and at section 3 we develop the methodology and describe on data which we use to determine the determinants of inflation in the economy of

Bangladesh. At section 4, we explain the findings of this paper and explain some diagnostic analyses which support the findings of this research and conclusion follows in next section.

2. Study of Literature

Controlling inflation and achieving price stability is one of the main objectives of macroeconomics. An error correction co-integration method demonstrates a significant influence of real GDP on inflation of Bangladesh and another study also elicit inflation rate of Bangladesh is influenced not only by the real GDP but also influenced by broad money, import volume and government expenditure [4, 12, 34]. On the other hand, government revenue and export reduce the impact of inflation on the economy of Bangladesh [12]. There are some specific supply side factors which are liable to enhance cost push inflation in Bangladesh. Those factors are wage/labor cost, import cost, exchange rate, oil price, market syndication and supply shortage of agricultural commodities [51]. Monetary and exchange rate policies can explain the extent of inflationary pressure in Bangladesh [56]. By using an advance aggregate demand and supply model, it has been understood that, in Bangladesh agriculture, import bottlenecks, government expenditure, rate of interest, wage rate, bank credit and expected inflation are the determining factors of inflation [18].

In the economy of Nepal growth of real GDP, money supply and import are the trigger factors of inflation [23]. Though there is a close correlation between the inflation rate and consumer price index but one of the recent studies on Indonesia reveals that during the pandemic COVID-19 exhibits insignificant relation between consumer price index and inflation [53]. In contrast the economy of Iran has experienced long-run positive significant relationship between consumer price index and inflation rate, along with consumer price index other variables such as GDP, money supply and interest rate boost the country's inflationary presser whereas the influence of oil price on inflation regardless [61]. In Malaysia, consumer price index is influenced by GDP, export, money supply and consumption expenditure by households and which also enhances the inflation rate [67]. In Bangladesh both demand and supply side factors like as inward remittances, government debt, inflation inertia, non-competitive market behavior, food and oil prices affect inflation to a large extent [4]. In Nigeria, government expenditure is the main factor which is responsible for price instability and inflationary tendencies [2]. According to this study, it has been concluded that money supply, government expenditure and bank credit have a significant positive impact on the inflation but the impact of government revenue is still obscure.

Mallik and Chowdhury, have examined the short-run and long-run dynamics of the relationship between inflation and economic growth for four South Asian economies: Bangladesh,

India, Pakistan and Sri Lanka [47]. Applying co-integration and error correction models to the annual data retrieved from the International Monetary Fund (IMF) and International Financial Statistics (IFS). They found two motivating results. First, the relationship between inflation and economic growth is positive and statistically significant for all four countries. Second, the sensitivity of growth to changes in inflation rates is smaller than that of inflation to changes in growth rates. Taslim used regression models for explaining the inflationary process of Bangladesh [64]. He explored that one year lagged money supply had significant positive effect on inflation. However, the introduction of wage variable as an additional independent variable resulted in dramatic fall of statistical significance of coefficients of other variables in the regression model. Khanam and Rahman examined the causative factors of inflation in Bangladesh during the period from 1972-73 to 1991-92 using Ordinary Least Square (OLS) method [39]. Their results showed that growth rate of import prices and money wages, both considered as supply side variables, affect the inflation positively. They also found that all demand side variables have insignificant influence on the rate of growth of prices. Ahmed and Das found that world food price and fuel price triggered inflationary pressure in Bangladesh [3]. They also detected inflation inertia is another reason to sustain higher inflation. Several studies are conducted by different researchers on the economy of Pakistan to determine the factors which are enhanced the price level [17, 13] Basir et al. traced determinants of inflation in Pakistan for the period from 1972 to 2010 using Johansen Co-integration and Vector Error Correction approached. The study carries out long run as well as short run estimates of some factors influencing consumer price index (inflation) in Pakistan. The result of the analysis reveals that money supply, gross domestic product, government expenditures and imports are contributed in raising consumer price index while consumer price index is bound to decrease due to higher government revenues. In the long-run, the coefficient of error correction term is -0.03 suggest 3 percent annual adjustment towards long run equilibrium. Bonato, in his study on price level, money supply, output, rate of return on money and *EXR* in Iran observed a long-run and the short-run relationship between money growth and inflation. Bhattacharya and Lodh [19] observed a negative correlation between price change and real-output gap. Brahmananda argues that high growth rate is impossible without low inflation. He observed that inflation can be controlled by controlling the money supply.

The summery of relevant studies has given on *Table 1*.

Table 1. Previous Literature Outcomes.

Author (s)	Study Period	Study Zone	Model (s)	Empirical Findings
Uddin et al. [66]	1972-2012	Bangladesh	ARDL	GDP, money supply, exchange rate, interest rate influence the inflation of Bangladesh.
Arif and Ali [12]	1978-2010	Bangladesh	Cointegration, ECM	GDP, government expenditure and import have a positive impact on inflation whereas the impact of export is negative.
Al-Mukti [6]	1977-2014	Bangladesh	Co-integration, ECM	GDP, money supply, imports, remittances and exchange rate accelerate the inflation of Bangladesh.

Author (s)	Study Period	Study Zone	Model (s)	Empirical Findings
Ferdous and Sultana [29]	1981-2015	Bangladesh	VAR, ARDL	In long-run economic growth has increase the rate of inflation where as inflation does not cause economic growth.
Hossain [33]	1972-1999	Bangladesh	Co-integration, ECM	Currency devaluation impact on inflation is not significant.
Begum [18]	1959-1986	Bangladesh	Multiple OLS	Output, import, government expenditure, rate of interest, wage rate, bank credit and expected inflation are the major factors of inflation.
Muktadir-Al-Mukit et al. [52]	2000-2011	Bangladesh	Co-integration, VECM	Inflation is positively influenced by import.
Alawin and Oqaily [9]	1990-2014	Jordan	Co-integration, ECM	Current account deficit has been slugged the inflationary pressure.
Islam et al. [36]	1980-2014	Malaysia	OLS	Money supply enhance the inflation whereas appreciation of domestic currency and reduction on unemployment rate reduce the influence of inflation.
Bowdler and Nunziata [22]	1961-93	OECD	Boschen and Weise Model	Trade openness reduces inflation.
AL-Mutairi et al. [8]	1979-2015	Kuwait	OLS	Interest rate spread, money supply and import of goods are positively and significantly influence the inflation, on the contradictory tax revenue and the favorable current account balance reduce the level of inflation rate.
Al-Ezzee [5]	1980-2010	Bahrain	Co-integration, ECM	Monetary instruments such as money supply, nominal effective exchange rate, nominal interest rate have long run positive innovation on CPI as well as fiscal instruments such as government expenditure is also the source of inflation.
Ubide [65]	1990M1-1996M12	Mozambique	VAR	Seasonal impact due to agriculture production and policy augmentation are fundamental determinants of inflation.
Dragos et al. [26]	1987-2011	USA, China	Multiple Regression Analysis	Money supply, interest rate and exchange rate policy influence inflation for both nations.
Pourroy [60]	2004Q1-2006Q4	Emerging Economy	Diff-in-diffs	Exchange rate, GDP and real interest determinants of inflation.
Almounsor [10]	1995Q1-2007Q4	Yemen	OLS, VAR, VECM	In short run, external shocks and currency depreciation creates inflation whereas in medium term the intensity of impact depends on money supply and domestic demand.
Bhattacharya [20]	1999Q1-2012Q3	Vietnam, Emerging Asia	VAR	Instrument of monetary policy blows the whistle of inflationary presser.
Bandara [14]	1993-2008	Sri Lanka	VAR, Granger Causality	Money supply, exchange rate and GDP are the main determinants of inflation.
Domac & Elbirt [25]	1992:01-1997:07	Albania	Co-integration, ECM	Money supply and exchange rate promote inflation on the other way the cause of reduction of inflation is real income.
Jaradat et al. [37]	2000Q1-2010Q3	Jordan	Co-integration, ECM	The real GDP and money supply reduce the inflation whereas the export, remittance and external shock are the causes of high inflation.
Basher and Elsamadisy [15]	1980-2008	Gulf Arab	Panel Co-integration	Money Supply and exchange rate accelerate inflation rate both short run and long run.
Odusanya and Atanda [55]	1970-2007	Nigeria	Co-integration, ECM	GDP, money supply, lagged inflation, real import and interest rate determine the inflation rate.
Adu and Marbuah [1]	1965-2009	Ghana	ARDL	Real output, exchange rate, money supply, interest rate and fiscal deficit determine the inflation rate.
Kim [42, 44]	1990Q1-1999Q4	Poland	Co-integration, ECM	Appreciation of currency and increase of wage reduce the inflation rate and the impact of monetary policy instrument is passive on inflation.
Bashir et al. [15]	1972-2014	Pakistan	ARDL	In long run the inflation increased by government expenditure, import, government revenue and public debt where as it reduced due to increase of foreign direct investment, electricity generation and population growth.
Altowaijri [11]	1996Q1-2010Q4	Saudi Arabia	Cointegration, ECM	Oil price, domestic demand, fall the price of dollar are the main determinant of inflation in long run.
Bashir et al. [17]	1972-2010	Pakistan	Johansen Cointegration, VECM	Money supply, GDP, import and government expenditures have positive innovation on inflation whereas government revenue reduces inflation in long run.

Author (s)	Study Period	Study Zone	Model (s)	Empirical Findings
Khan and Gill [41]	1970-2007	Pakistan	OLS	Exchange rate, value of import increase CPI, WPI, SPI and GDP deflator whereas budget deficit has no role to trigger up the inflation.
Menji [49]	1998Q3-2008Q2	Ethiopia	Co-integration	growth of GDP, appreciation of currency have negative impact on inflation on the other hand money supply, lending rate, previous year inflation have positive innovation on inflation.
Greenidge and Dacosta [31]	1970-2006	Caribbean Countries	Co-integration, ECM	Both cost-push and demand-pull factors are potential to determine the inflation in Caribbean region.
Khan et al. [40]	1973-2006	Pakistan	OLS	Adaptive expectation, private sector credit and import price are triggered up the inflation.
Kia and Sotomayor [43]	1975Q1-2015Q4	Egypt, Mexico	Johansen-Juselius Maximum Likelihood estimation	Inflation of both nations has the consequence of fiscal and monetary policy instruments.
Inim et al. [35]	1999-2018	Nigeria	ARDL	Compare to the money supply fragile infrastructure, instable exchange rate and politics, corruption and double taxation stimulate the inflation rate.
Chaudhary and Xiumin [23]	1975-2016	Nepal	OLS	Money supply and real GDP are the focal determinant of Inflation.
Nadiva [53]	2016-2020	Indonesia	OLS	The paper investigated the effect of consumer Price Index (CPI) on inflation in Indonesia during the pandemic and showed that the CPI had no significant effect on inflation.
Venkadasalam [67]	1960-2013	Malaysia	VECM	This research paper identified that CPI is statistically significant and positively related to broad money, exports of goods and services, GDP and households' final consumption expenditure.
Yolanda [68]	1997-2016	Indonesia	MRA	Bank rate, money supply, gold price positively influence the inflation rate whereas the impact of exchange rate is insignificant.
Kulatunge [45]	2000Q1-2013Q4	Sri Lanka	Cointegration, ECM	Inflation determined by economic growth, exchange rate, government expenditure, money supply, oil price, interest rate.
Radnia [61]	1971-2010	Iran	Co-integration, FMOLS, VECM	Inflation is positively related with GDP, money supply, interest rate but negative with oil price which is also statistically insignificant.
Lim and Sek [46]	1970-2011	28 high and low inflation nations	Dynamic Panel ARDL	GDP growth, money supply, expenditure, imports of goods and service has significant role to determine the rate of inflation.

3. Data and Methodology

3.1. Data and Its Statistical Parameters

This study is embedded on an intensive time series data from 1981 to 2020 (40 years). In this research manuscript inflation (inf) considered as the regressand whereas growth of gross domestic product (gdp), broad money supply (m2), export growth (xg), import growth (mg) and growth of population (pg) are considered as regressors. The statistical

properties of those variables are demonstrated on table 2. The average value of series inf, gdp, m2, xg, mg and pg is 7.10, 5.20, 15.01, 9.31, 7.55 and 1.81 respectively. The maximum value of inf rate is 16.26 which follows the minimum value 1.94 and on the other hand the highest growth rate gdp is 8.15 and the lowest growth rate is 2.13 in the time frame 1981 to 2020. Most of the series are normally distributed except the variable of xg and mg because the p-value of Jarque-Bera statistic is less than the critical value 0.05 per cent (0.00 in here).

Table 2. Statistical Description.

Variables	Mean	Maximum value	Minimum Value	Std. Dev.	Jarque-Bera	Probability of Jarque-Bera
inf	7.10	16.29	1.94	3.15	2.01	0.36
gdp	5.20	8.15	2.13	1.47	0.68	0.71
m2	15.01	21.08	9.74	2.97	1.20	0.54
xg	9.31	85.61	-31.77	17.84	108.69	0.00
mg	7.55	84.75	-52.51	20.83	41.69	0.00
pg	1.81	2.64	1.00	0.60	4.08	0.12

3.2. Methodology

Unit Root

In time series and panel data analysis the most common and comprehensive question is, whereas the series is stationary or non-stationary. This concept in the field of time series econometrics is familiar as the unit root phenomenon. The unit root is concerned with the time varying mean and variance of the data. The order of integration which follows from the unit root test guide the research to use optimal model which is used to explain or reveal the causation among the variables. Unit root is a time series phenomenon which implies the secular change the mean value and variance over the time which make forecasting difficult and challenging. The increasing necessity of time series forecasting for policy making and to understand the change of economic parameters over the time the importance and popularity of unit root test is paramount [32]. Unit root test is used to perceive that any variable the consumer price index (as a dependent variable) and GIN, GDP, M2, XG, PG (as independent variables) are co-integrated or there is any causal relationship among these variables [54]. Considering a first order autoregressive [AR (1)] model [24]:

Assume n elements of series X is; $X_1, X_2, X_3, \dots, X_n$, which is used to construct AR: 1 model,

$$X_t = \phi X_{t-1} + \varepsilon_t \quad [-1 \leq \phi \leq 1] \quad (1)$$

Here,

ε_t = white noise error term. Assume that, $\varepsilon_t \sim N(0,1)$. Take first order difference on Eq: (1),

$$X_t - X_{t-1} = \phi X_{t-1} - X_{t-1} + \varepsilon_t$$

$$\Delta X_t = (\phi - 1)X_{t-1} + \varepsilon_t$$

$$\Delta X_t = \phi X_{t-1} + \varepsilon_t \quad [\phi = \phi - 1]$$

If, $\phi = 1$, then $\phi = 0$, implice the series is stigmatized by unit root which follows time varying mean and variance. So, the null and alternative hypothesis statements are:

$$H_0: \phi = 0$$

$$H_a: \phi \neq 0$$

There are three impressions of AR: 1, time series model considering the situation of series. Those impressions are potterry on Eq: (2), Eq: (3) and Eq: (4) respectively:

$$\Delta X_t = \phi X_{t-1} + \varepsilon_t \quad (2)$$

$$\Delta X_t = \alpha_1 + \phi X_{t-1} + \varepsilon_t \quad (3)$$

$$\Delta X_t = \alpha_1 + \alpha_2 t + \phi X_{t-1} + \varepsilon_t \quad (4)$$

In Eq (2), Eq (3), and Eq (4) are demonstrate the random walk, random walk with drift and random walk model with drift and deterministic trend respectively and in each model error terms (ε_t) is considered normally distributed and uncorrelated with lag value of error term. But in reality it is usual that error term is correlated, in these circumstances, Dickey and Fuller [24] develop Augmented Dickey-Fuller (ADF) test. It is called augmented because this test holds all three conditions afore mention in equations 2, 3 and 4. The basic ADF equation is follows,

$$\Delta X_t = \alpha_1 + \alpha_2 t + \delta Y_{t-1} + \sum_{i=1}^m \beta_i \Delta Y - (t-1) + \varepsilon_t \quad (5)$$

In Eq: (5), all three important factors like as random work, drift and trend are taking into accounts. In this research paper along with ADF unit root test we also use Phillips-Perron (PP) [57] unit root test. We do it because to avoid the one test dependence biased. This test is nonparametric test which is considered to estimate the unit root problems for the data which distributed heterogeneously as well as considering the serial correlation in disturbance term without adding the lag difference term [59]. The basic regression equation (Eq: (6)) for PP unit root test is given:

$$Y_t = \mu + \alpha Y_{t-1} + e_t \quad (6)$$

Autoregressive Distributed Lag (ARDL) Bound Test Technique

Autoregressive Distributed Lag (ARDL) bound test approach is one of the well-established models which is used to investigate the long-run co-integration between the variables. Most of the cases to establish long-run co-integration among the variables, the pre-requisite is the mean and variance of the time series data is time invariant (Emeka and Kelvin, 2016). But such type of assumption is very difficult to find in real world. For the co-integration analysis if the regressors are $I(1)$, then it is easy to pursue a long-run relationship among the variables. But for the ARDL approach it is regardless whether the regressors are $I(1)$ or $I(0)$. It always provides the consistence estimates of long-run coefficient [58]. In ARDL Bound test process a set of bound values is given for the purely $I(1)$ and $I(0)$ or the combination of both which will be used to identify the long-run relationship among the regressors and such process is more reliable than conventional F and t-statistics when the exact order of integration for the regressors is passive [57].

We can simple proceed the methodological process concerning a two variables model. In that particular model we assume a nexus between Y_t and X_t . Unrestricted error-correction [48] model for ARDL bound test approach is given:

$$\Delta Y_t = \beta_0 + \beta_1 t + \sum_{i=1}^m \beta_{2i} \Delta Y_{t-i} + \sum_{i=1}^n \beta_{3i} \Delta X_{t-i} + \beta_4 Y_{t-1} + \beta_5 X_{t-1} + e_{1t} \quad (7)$$

$$\Delta X_t = \phi_0 + \phi_1 t + \sum_{i=1}^m \phi_{2i} \Delta X_{t-i} + \sum_{i=1}^n \phi_{3i} \Delta Y_{t-i} + \phi_4 X_{t-1} + \phi_5 Y_{t-1} + e_{2t} \quad (8)$$

Both of the equations (Eq: (7) and Eq: (8)) represent the dependence of one variable to another or vice-versa or both.

The consequence of the equations depends on the lag values of dependent and independent variables. Equation has the

autoregressive (AR) components as well as distributed lag (DL) elements as a why it is called ARDL model. In those particular equations, Δ represents the first order difference and e is the white noise error term which is identically and normally distributed. All coefficients are non-zero where as β_4 and ϕ_4 are negative because those values represents the speed of adjustment. The coefficients β_2 and β_3 measures the short-run dynamic coefficient, on the other hand β_2 and β_2 are the long-run coefficient. In equation, β_0 and β_1 are represent the drift and trend factors.

If the co-integration between the equations Eq: (7) and Eq: (8) exist then an equivalent unrestricted ARDL model is used to estimate short-run and long-run models. The bound test hypothesis to examine the presence of co-integration is

$$H_0: \beta_0 = \beta_1 = \dots = \beta_n = 0$$

$$H_A: \beta_0 \neq \beta_1 \neq \dots \neq \beta_n \neq 0$$

To justify the test hypothesis, Pesaran [57] develop F-statistic critical value to consider five different circumstances.

4. Result and Discussion

In the time series analysis the mountainous challenge is that, the series is stationary or not implies the mean and variance of time series variables are constant or varying over the time horizon. This phenomenon is known as unit root. In this paper Augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP) is utilized to track down the time varying mean and variance of the variables. In this paper, both methods of unit root detection apply not only ensure robustness of the study but also to avoid the single test biased. At 0.01 per cent critical approach the Augmented Dickey-Fuller test revile the inflation rate (inf) is non-stationary at level and the Phillips-Perron test

also support the same finding (table 3). Accordingly taking the first order difference the series of inf is stationary (at 1% level of significance). The dependent variable (inf) in this model is integrated order one ($inf \sim I(1)$). Similarly the series gdp and m2 also integrated order one implies at level both variable have unit root and by taking the first difference first both variable have been release the stigma of non-stationary. The export growth (xg), import growth (mg) and population growth are stationary at level.

Table 3. Unit Root Diagnostic.

Name of Series	ADF		PP		Decision
	I (0)	I (1)	I (0)	I (1)	
inf	-1.56	-7.27***	-1.59	-9.38***	I(1)
gdp	-0.31	-9.09***	-1.19	-11.51***	I(1)
m2	-0.89	-9.74***	-0.70	-21.75***	I(1)
xg	-3.93	----	-3.99	----	I(0)
mg	-5.14	----	-5.20	----	I(0)
pg	-2.75	----	-3.11	----	I(0)

Note: '***' denote 1% significant level.

This research has the combination of stationary and non-stationary variables. According to the time series econometrics, in this circumstances the Autoregressive Distributed Lag model (ARDL) is ideal to find out the impact of independent variables on the dependent variable. The optimal ARDL model is ARDL (4, 3, 4, 2, 4, 4) which is selected on the criteria based on AIC, BIG, HQ and Adj. R-square (table 4). At model 01, on table 3 has the lowest value of AIC, BIC and HQ among the remaining nine (09) compatible models and the model 01 has the highest adjusted R-square (0.74%) than other models. So, the long-run model with short-run dynamics following an error correction term is:

Table 4. Model Selection Criteria.

Model	LogL	AIC*	BIC	HQ	Adj. R-sq	Specification
01	-36.86	3.54	4.73	3.96	0.74	ARDL (4, 3, 4, 2, 4, 4)
02	-36.34	3.57	4.80	4.00	0.72	ARDL (4, 4, 4, 2, 4, 4)
03	-36.77	3.59	4.83	4.02	0.71	ARDL (4, 3, 4, 3, 4, 4)
04	-39.10	3.61	4.76	4.01	0.73	ARDL (3, 3, 4, 2, 4, 4)
05	-36.16	3.62	4.89	4.06	0.68	ARDL (4, 4, 4, 3, 4, 4)
06	-37.36	3.63	4.86	4.06	0.70	ARDL (4, 3, 4, 4, 3, 4)
07	-36.48	3.63	4.91	4.08	0.67	ARDL (4, 4, 4, 4, 3, 4)
08	-38.55	3.64	4.82	4.05	0.71	ARDL (3, 4, 4, 2, 4, 4)
09	-36.69	3.64	4.92	4.09	0.67	ARDL (4, 3, 4, 4, 4, 4)
10	-38.82	3.65	4.84	4.07	0.71	ARDL (3, 3, 4, 3, 4, 4)

$$\Delta inf_t = \alpha_0 + \beta_1 gdp_t + \beta_2 m2_t + \beta_3 xg_t + \beta_4 mg_t + \beta_5 pg_t + \delta_{1i} \sum_{i=1}^3 \Delta gdp_t + \delta_{2i} \sum_{i=1}^4 \Delta m2_t + \delta_{3i} \sum_{i=1}^2 \Delta xg_t + \delta_{4i} \sum_{i=1}^4 \Delta mg_t + \delta_{5i} \sum_{i=1}^4 \Delta pg_t + \varepsilon_i Ect_{t-1} \quad (9)$$

Equation (9) shows the combination of long-run and short-run impact on the dependent variable with a error correction components. In this equation, β 's shows the long-run coefficient; δ 's show the short-run components and ε shows the error correction components for the ARDL model. In table 5, the long-run and short-run coefficient of ARDL model shows in closet A and B respectively.

In closet A, the gdp growth, money supply, import growth and population growth have positive impact on inflation in the economy of Bangladesh but export growth has negative impact on the inflation rate. On the other hand the growth rate of gdp will increase the inflation rate but this result is not significant statistically (t-value: 1.68).

Table 5. Long-run and Short-run Coefficient.

Closet A. Long-run Coefficient	
gdp_t	3.01 (1.68)
$m2_t$	1.68*** (4.11)
xg_t	-0.48* (-2.00)
mg_t	0.70* (2.04)
pg_t	9.39** (2.47)
Closet B. Short-run Coefficient with error correction	
Δgdp_t	1.07*** (4.44)
$\Delta m2_t$	0.67*** (6.86)
Δxg_t	-0.07*** (-2.83)
Δmg_t	0.10*** (3.77)
Δpg_t	6.32 (0.34)
Ect_{t-1}	-0.64*** (7.47)
<i>R-Square</i> : 0.93 (93 per cent)	
<i>Adj R-Square</i> : 0.84 (84 per cent)	
<i>Durbin-Watson</i> : 2.01	

Note: (), shows t-value and ***, **, and * shows 1%, 5% and 10% significance level respectively.

Table 6. Long-run Cointegration and Bound Test.

Estimates	Statistical Value	Significant Level	Bound		Decision
			Lower Bound	Upper Bound	
<i>F – Statistics</i>	5.98	10%	2.26	3.35	Cointegration
		5%	2.62	3.79	
		1%	3.41	4.68	
<i>t – Statistics</i>	-7.47	10%	-2.57	-3.86	Cointegration
		5%	-2.86	-4.19	
		1%	-3.43	-4.79	

Note: Finite Sample, n=40

F-statistics and t-statistics on table 6, demonstrate the evidence of long-run cointegration among the variables because the critical F and t value exceeded the upper-bound value of bound statistics. Specifically the Wald statistics on table 7, explained that both of long and short run coefficients are statistically co-integrated. The critical $\chi^2 - square$ values for long-run and short-run impact on dependent variable are 36.45 and 12.83 respectively and corresponding p-value for long-run Wald statistics is 0.00 and for short-run it is 0.025 which implies long-run and short-run variables are the consequence for the change of dependent variables.

Wald test on table 7, represent the long-run and short-run causations of independent variables on the dependent variables (inflation). The $\chi^2 - square$ value for the long-run variable on the dependent variable is 36.45 with the p-value less than 5 per cent, which statistically assure the long-run causation of independent variables on the dependent variable. In case of short-run causation this recitation finalize the evidence of causality because the $\chi^2 - square$

Money supply growth ($m2$) has a long-run positive impact on the inflation rate and which is significant statistically. At 1 percent increase in money supply will lead inflation by 1.67 percent (t-value: 4.11). Import growth (mg) and population growth (pg) will increase inflation rate by 0.70 and 9.39 percent respectively and which are statistically significant also. On the contradictory, the growth of export (xg) will reduce the inflationary pressure on the economy of Bangladesh by 0.48 (t-value: 2) percent in long-run.

In short-run, all explanatory variables except population growth (pg) have significant influence on the inflation (inf). All independent variables except export growth (negative) have positive impact on inflation of Bangladesh (closet B, table 5).

Table 7. Wald Test for the Long-run and Short-run Coefficient Causation on the Dependent Variable.

Long-run Variable			
Test Statistics	Value	P-value	Decision
$F - statistics$	7.29	00.00	Long-run Causation
$\chi^2 - square$	36.45	0.00	
Short-run Variable			
$F - statistics$	2.56	0.10	Short-run Causation
$\chi^2 - square$	12.83	0.03	

value (12.83) is significant (p-value: 0.03 per cent).

The validity and purity of any econometric analysis should be standardized by considering some standard diagnostics procedure otherwise the result of the model should not be allowed to utilize policy making purposes. In table 8, several comprehensive diagnostic tests e.g. residual normality, serial correlation LM, BPG test and Ramsey Reset test are used to examine the statistical stability of estimated aforementioned ARDL model.

Table 8. Diagnostic Tests.

Name of Diagnostics	Estimates	Statistical Value	Hypothesis and Decision
Residual Normality	<i>Jarque-Bera</i>	1.43 (0.48)	H_0 : Normally Distributed. H_a : Not Normally Distributed. (accept null)
Serial Correlation LM	$\chi - square$	1.68 (0.40)	H_0 : No serial correlation. H_a : Serial correlation. (accept null)

Name of Diagnostics	Estimates	Statistical Value	Hypothesis and Decision
Heteroskedasticity Brusch-Pagan-Goldfrey Test	χ – square	28.13 (0.32)	H_0 : Homoskedasticity. H_a : Heteroskedasticity. (accept null)
Ramsey Reset Test: Specification Errors	F – statistic	0.04 (0.83)	H_0 : No Specification Errors. H_a : Specification Errors. (accept null)

Note: (), shows the p-value.

Residual of estimated model is distributed normally which is reflected by the Jarque-Bera statistics with its estimated value 1.43 (p-value: 0.48). The disturbance term of the residual is serially uncorrelated, so that this model is buckshee from the stigma of serial correlation because the LM statistics is 1.68 with p-value 0.40 per cent. The variance of the error term is homoscedastic and Ramsey Reset test is established that model is specified correctly.

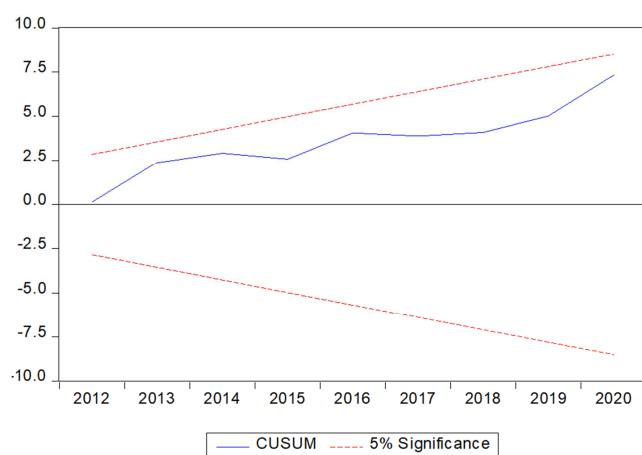


Figure 2. Stability Test (CUSUM).

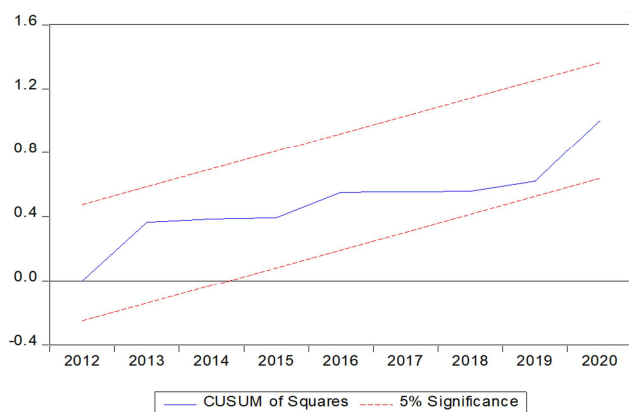


Figure 3. Stability Test (CUSUM Squares).

The cumulative sum chart (CUSUM) on Figure 2 illustrated the mean deviation adjustment consistence is stable over the time with 5 per cent level of significance and which is also stable cumulative sum chart square (CUSUM square) reflected by Figure 3.

5. Conclusion

Inflation is one of the major burning issues in the economy

regardless, what is the stage of development of particular economy (develop and developing). It is one of the core objectives of the macroeconomists to sable the price level over the time. It is unfortunate but truth that, many develop and developing countries face the difficulties to keep inflation in tolerance level. The aim of this paper is to identify the major macroeconomic determinants which are responsible to trigger the inflation of Bangladesh. To implement a comprehensive and effective policy instruments to control the pressure of inflation, it is necessary to detect and identify the source of inflation. By using Autoregressive Distributed Lag (ARDL) model on time series data which starts from year 1981 and ends 2020, has been revel that, growth of gross domestic product (gdp), broad money supply (m2), export growth (xg), import growth (mg) and the growth of population (pg) are major determinants which are the consequence of inflation in Bangladesh.

Those factors have long-run and short-run influence on inflation. Though, the influence and significance are differing but it is impactful. The growth of GDP has positive impact on the inflation in short-run as well as long-run. The long-run impact which percentage is 3.01 is not statistically significant because the t-value is 1.68 which is less than accepted level but in short-run GDP growth dominance inflation by 1.07% which is significant statistically. On the other hand, the growth of money supply (m2) statistically and positively influences inflation by 1.68% in long-run and short-run it is 0.67%. Import growth (mg) has similar impact on inflation. The repercussion of import growth (mg) in long-run is 0.70% which dominate the short-run impact which is 0.10%. Population growth has long-run positive and significant impact on the inflationary pressure, but in short-run impact is insignificant. It is only export growth (xg) which reduces the inflationary pressure due to its negative and significant impact in long and short-run. In long-run the negative penetration of export growth on inflation is -0.48% where as in short-run it is -0.07%.

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