2015

An Empirical Study of Inflation in Bangladesh

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University of Rajshahi

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A dissertation submitted to the University of Rajshahi
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in Economics

By

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Dedication

To

My Parents

and

My Maternal Uncle Late Lutfor Rahman

Declaration

I hereby declare that the whole of the work submitted here as a dissertation entitled, "**An Empirical Study of Inflation in Bangladesh"** for the degree of Doctor of Philosophy at the Institute of Bangladesh Studies**,** Rajshahi University is the result of my original research work and it has not been submitted in part or full for any diploma or degree in any other university or institute. My indebtedness to other works/publications has been duly acknowledged at the relevant places.

Muhammad Akhtaruzzaman

Certificate

This is to certify that the dissertation, **“An Empirical Study of Inflation in Bangladesh”** is an original research work done by Muhammad Akhtaruzzaman for the degree of Doctor of Philosophy in Economics at the Institute of Bangladesh Studies, Rajshahi University under my supervision. The thesis has not been submitted elsewhere for any other degree. The references cited in it have been duly acknowledged.

Professor Dr. K.B.M. Mahbubur Rahman
Supervisor

Acknowledgement

First and foremost, I would like to express my sincere appreciation to my honorable supervisor, Dr. K.B.M. Mahbubur Rahman, Professor, Department of Economics, University of Rajshahi, for his guidance and constructive criticism throughout the research process. He always shared his valuable time with me to discuss different issues and problems related to thesis. He has offered advice and suggestions whenever I needed them. I am very grateful to him.

I would like to express my gratitude and deepest appreciation to Dr. Tariq Saiful Islam, Professor, Department of Economics, University of Rajshahi, for his affection, bright insight, generous help, much appreciated suggestions and comments for the thesis.

It is with immense pleasure that I record my gratefulness to Director, Institute of Bangladesh Studies (IBS), University of Rajshahi, and all teachers of IBS, for their affection, support and advice during the period of my research work.

I am thankful to all my teachers at the Department of Economics, University of Rajshahi for their help and valuable suggestions.

My thanks also go to fellows of different batches of Institute of Bangladesh Studies (IBS) for their instant support and back-up.

Words cannot express my gratefulness to my mother, Fatima Begum, and to my father, Moinuddin Shaikh, for their care, endurance and support and their foremost role of enabling me in reaching this point in my life.

Finally, I would like to express my gratefulness to my wife for her precious and everlasting support, encouragement and patience, and my daughters for their sacrifice.

Muhammad Akhtaruzzaman

Abstract

This is an empirical study on inflation in Bangladesh. This study examines the relative importance of demand-pull, and cost-push factors explaining inflation in Bangladesh, investigates causal relationships among inflation and some of its determinants, and studies impact of inflation on GDP growth over the period 1976-2013 through empirical analysis. The results show that money supply, real income, inflation expectation, and real rate of interest are the key demand-pull determinants of inflation. The estimates of sub-periods demonstrate that money elasticity of inflation is higher during pre-liberalization period (1976-1990) than the post-liberalization period (1991-2013), but the fully reverse results are found in case of interest elasticity of inflation. The cost-push model gives evidence that the nominal wage and exchange rate are important determinants of inflation. The ARDL-VEC models show that in the long-run, inflation in Bangladesh is influenced by the money supply growth, real income growth, real interest rate, and import price growth, while in the short-run, it is mainly determined by the nominal wage, one year lag money supply, real income, and real rate of interest. The Granger causality test shows a unidirectional causality between money supply and inflation runs from money supply to inflation, while there is a bi-directional causality between wage and inflation that is the case of wage-price spiral in Bangladesh. The inflation is also found to affect GDP growth negatively in the long-run but not in the short-run. In addition, the Toda-Yamamoto causality test confirms a two-way causality between inflation and GDP growth in Bangladesh. The result of the IRF indicates that the responses of inflation to GDP growth are non-linear in nature. The CUSUM test suggests stability of the models in the study period for Bangladesh. To control inflation in Bangladesh, fiscal policy should be consistent with the targets of prudent monetary management.

List of Abbreviations

ADB	Asian Development Bank
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AR	Auto-Regression
ARDL	Auto-Regressive Distributed Lag Model
BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistics
BER	Bangladesh Economic Review
BLUE	Best Linear Unbiased Estimates
CE(s)	Cointegrating Equation (s)
CPI	Consumer Price Index
DF	Dickey-Fuller
DF-GLS	Dickey-Fuller Generalized Least Squares
DV	Dependent Variable
D-W	Durbin Watson
ECM	Error Correction Model
ECT	Error Correction Term
EPU	Economic Planning Unit
ER	Exchange Rate
FDI	Foreign Direct Investment
FP	Fiscal Policy
FPE	Final Prediction Error
GDP	Gross Domestic Product
HIES	Household Income Expenditure Survey
HQ	Hannan-Quinn Information Criterion
IFS	International Financial Statistics
IMF	International Monetary Fund

IRF	Impulse Response Function
MP	Monetary Policy
OBS	Observations
OLS	Ordinary Least Square
PN	Policy Note
PP	Philips-Perron
PPI	Producer’s Price Index
Prob.	Probability
PU	Policy Unit
RAW	Imported Raw Materials
RU	Rural
SC	Schwarz Information Criterion
TI	Transparency International
U	Urban
USD	United States Dollar
VAR	Vector Auto-Regression
VD	Variance Decomposition
VEC	Vector Error Correction
VECM	Vector Error Correction Model
VIF	Variance Inflation Factor
WDI	World Development Indicators
WEO	World Economic Outlook
WP	Working Paper
WPI	Wholesale Price Index

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Chapter 1
Introduction

One of the most important basic macroeconomic objectives for any country is to sustain high economic growth together with low inflation. But, the economy of Bangladesh has been suffering from high inflation since its inception and it has even crossed a double-digit in recent years. The rate of inflation has increased steadily since July 2009 and become around 12 percent in September 2011. The recent rise in inflation underscores the need for a better understating of inflation dynamics in Bangladesh. Moreover, to control inflation, it is important to know what factors are working behind this rising. There is a popular argument that cost-push factors are no less important than demand-pull factors in stimulating inflation in the Bangladesh economy. There is also historical and contemporary evidence in favor of this argument.

In this background, the objective of this thesis is to examine empirically various aspects of inflation in Bangladesh. Empirical research on inflation has three parts. First part deals with examining relative importance of different cost-push and demand-pull factors of inflation in Bangladesh in the long-run and short-run while the second part studies causal connection between inflation and its major sources. And the third part investigates the long- and short- run effect of inflation on GDP growth. Beside this, the study also examines the structural influence between the pre- and post-liberalization periods and the state of inflation during these two periods. All these aspects are dealt with in this thesis based on rigorous time series econometric analysis.

This study covers the period 1976-2013. It is divided into two parts the pre-liberalization period (1976-1990) and post-liberalization period (1991-2013). The first period is characterized by highly regimented interest rate policy while the second period is marked by greater interest rate flexibility.

1.1 Statement of Problem

Inflation is meant a persistent rise in the general price level in the economy over time. Like any other phenomenon, inflation has causes and effects and substantial debate is still going on among economists regarding the causes of inflation and concerning the appropriate policy to control inflation (Javed et. al., 2011). From surveys of the literature available elsewhere (Holzman, 1965, Shapiro, 1982, Samuelson and Nordhaus, 2004) it is sufficient here to note that most of the discussion of inflation centers on two schools of thought: "cost-push" and "demand-pull”. The cost-push advocates assert that the source of rising prices is not excess demand but rather market power that permits either wages to be raised by strong labor unions, which results in price increases as wage costs are passed on to the consumer (wage-push inflation), or prices to be increased directly by oligopolistic firms (profit-push inflation). Then, according to this view, the money supply is passively increased as the monetary authority validates the inflation to avoid unemployment. In contrast, the monetarists or demand-pull adherents assert that the cause of inflation is an increase in money demand or too much money chasing too few goods. Rather than responding passively, the monetary authority actively determines the rate of inflation by permitting an excessive rate of increase in the nominal stock of money (Friedman, 1993).

The widespread and intense interest in inflation also often focuses on the determinants of inflation and relationships among some important economic variables: the CPI indices P, the money supply M, the nominal wage indices W, and the economic (GDP) growth Y, among others.

Hossain (1996) postulated that the sustained higher rate of inflation in Bangladesh is the result of excess money supply in the real money market, where the excess money supply is caused mainly by an increase in bank-credit in excess of the increased demand for money balances.

On the other hand, according to an increasingly popular diagnosis, though inflation is normally caused by a combined effect of demand-pull and cost-push factors, the recent inflation problem in Bangladesh is relatively more a cost-push inflation than a demand-pull or monetary inflation.

Because higher cost of production from higher wage relative to its productivity, higher prices of imported raw-materials, energies, fuel, and intermediate goods (cost-push inflation), in combination with a demand-pull inflation from expansionary economic policies have caused persistent inflation in Bangladesh and altogether these have created a supply-side problem by decreasing productivity. The situation of Bangladesh also has been aggravated due to political problem.

If supply-side or cost-push factors are indeed what underlie Bangladesh's inflation, the scope for anti-inflationary monetary tightening, which works by dampening aggregate demand, would come at a steep cost in terms of forgone growth impacts. There is a very real risk that the cost-push diagnosis will influence monetary authorities and become an excuse for inaction against inflation.

From the brief discussion above, it is possible to state testable hypotheses that will provide an indication of whether inflation in Bangladesh has been primarily case of cost-push inflation about which monetary authority can do very little, or, are there other demand-pull, or a combination of both (hybrid) factors at play.

If the monetarists are correct and inflation is primarily demand-pull one should find a unidirectional causal link running from the stock of money to prices. Over the past decade economic growth in Bangladesh, was impressive. Is it also possible that Bangladesh's inflation may be of the demand-pull variety from economic growth, in which aggregate demand leads to rising prices?

Alternatively, if the cost-push thesis is valid, unidirectional causation should run from prices to money. Moreover, if labor union activity has caused the cost-push phenomenon, a unidirectional causal link running from wages to prices should be observed. The answer to these questions has enormous implication for monetary policy in Bangladesh.

The objective of this thesis is, therefore, to determine empirically the factors affecting inflation in Bangladesh from the cost-push and demand-pull point of view and causal relationships between money supply and inflation and between wages and inflation in the 1976-2013 periods, using a test of Granger causality. And the study also investigates causal impact of inflation on gross domestic product (GDP) growth. This approach differs substantively from earlier empirical studies of inflation in which the direction of causation was assumed rather than investigated in Bangladesh.

The monetary history of Bangladesh is divided into two parts, the pre-liberalization period from 1972 to 1990 and the post-liberalization period from 1991 onwards. This study examines structural influence between these two periods and the state of inflation during these two epochs. It is hoped that the findings provide useful insights into both in the process of inflation in Bangladesh and the policies to control it.

1.2 Research Questions

Given the various issues relating to the concept of empirical study of inflation in Bangladesh, a number of research questions arise as follows:

1. Whether inflation in Bangladesh is a case of demand-pull or cost-push or a combination of both (hybrid)?

2. Is there any structural influence between pre- and post-liberalization monetary inflation models?

3. Is there long-term or short-term relation between inflation and the factors affecting it?

4. What is the causal relationship between wages and inflation, and between money supply and inflation in Bangladesh?

5. What is the long-run and short-run impact of inflation on economic growth in Bangladesh?

1.3 Research Objectives

The present study is a modest attempt to answer these questions. The objective of this study is to make a thorough empirical examination of inflation in Bangladesh using long and latest time series data. To attain this, the following objectives are specified.

i) To examine the relative importance of the demand-pull and cost-push factors influencing inflation in Bangladesh using demand-pull, cost-push, and hybrid inflation models;

ii) To estimate a monetary model of inflation for the pre-and the post-liberalization period separately;

iii) To look at the long-run and short-run relationship of inflation with the variables after their identifications;

iv) To specifically investigate the causal relationship between wage and inflation;

v) To thoroughly study the causal connection between money supply growth and inflation;

vi) To ascertain the short-term and long-term impact of inflation on economic growth and the causal link.

1.4 Research Hypotheses

The following testable hypotheses which are implied in the research questions are considered appropriate for this study and are therefore subjected to empirical investigation. Some of these hypotheses are stated below.

i) Cost-push factors are important in explaining inflation in Bangladesh.

ii) Demand-pull factors are significant in influencing inflation in Bangladesh.

iii) Inflation in Bangladesh is a monetary phenomenon.

iv) There is a significant structural influence between the pre- and post-liberalization monetary inflation model.

v) Inflation and wage growth Granger cause each other.

vi) Money supply (broadly defined) growth Granger causes inflation but not the other way round.

vii) Inflation has a significant long- and short-run impact on GDP growth.

viii) Inflation and GDP growth cause each other in Bangladesh.

1.5 Rationale of the Study

Inflation can be singled out as the most critical challenge faced by the Bangladesh economy in recent years. As a matter of fact, it has been a major concern both for the economists, policymakers and the public at large and it has been subject to large amounts of scholarly research. There is no doubt that knowledge for the future level of inflation in Bangladesh, will greatly help to avoid some negative effects resulting from it. It is also necessary to know, especially for the implementation of macroeconomic stabilization policy, the causal factors of inflation from the economic point of view and the relative importance of these factors in explaining inflation in Bangladesh. And it would require an empirical analysis using appropriate econometric techniques that goes beyond speculative assumptions.

There is a good number of works on inflation in Bangladesh, but most of them investigate inflation from monetary (demand-pull) point of view with few exceptions (i.e. Taslim, 1982, Majumder, 2006). But, a careful analysis of inflation from the cost-push and demand-pull point of view has not been thoroughly done for Bangladesh. Although it is widely thought that Bangladesh's inflation is mostly cost-push which is due to wage-push, demand-pull factors are no less important, particularly when money supply is steadily growing (Majumder, 2006). Hence, to bridge all these gaps as far as possible, there is need for a thorough examination of the multidimensional aspects of inflation in Bangladesh using an empirical econometric approach.

1.6 Methodology

This is an empirical study that investigates empirically various aspects of inflation in Bangladesh using quantitative methods and specifically using time series econometric for the period 1976-2013.

The study employs different time series econometric techniques to achieve the empirical results. In the first stage, to test for the unit roots of relevant time series variables and to identity the order of integration of the variables, three popular techniques have been used: the augmented Dickey-Fuller (ADF, 1981) test and the Phillips-Perron (1988) test, and Dickey-Fuller generalized least square (DF-GLS) test.

In the second stage, to capture the inflation dynamics in the country different models explaining Bangladesh's inflation have been estimated by ordinary least squares (OLS) method. While estimating demand-pull or monetary equations, the whole sample period (1976-2013) are divided into two sub periods, pre- and post-liberalization period. Analysis with regression model gives further findings on inflation determinants. From general hybrid inflation model a specific inflation model has been also developed using Hendry's general to specific modeling techniques under ARDL approach. The long-run and short-run relationship between inflation and its determinants have been estimated from the specific inflation model using Pesaran (2001) ARDL and error correction techniques. An error correction model (ECM) is employed to see whether the economy is approaching equilibrium in the long-run or not and the short-run dynamics of the co-integrated time series variables.

In the third stage, Granger causality test has been used to determine the causal connection between money supply and inflation and between nominal wages and inflation.

Finally, the long-run and short-run impact of inflation on GDP growth has been estimated using cointegration, Granger causality based on error correction modeling, Toda-Yamamoto causality, impulse response function and variance decomposition.

The stability property of the different inflation equations is examined by using CUSUM test. Besides this, the estimates obtained have been also tested for robustness using different diagnostic tests. At the end, the main findings from the study are presented for policy implications.

1.7 Data for the Study and Sources

The study is basically based on secondary data. The data used in this study is aggregate annual time series data covering the period 1976-2013 of Bangladesh. The variables needed for the study are: consumer price index (CPI) as a measure of inflation; broad money (M2, which equals currency and demand deposits (M1 or narrow money) plus time deposit); Y, real income or real GDP; real interest rate (r); nominal wage index (W) as a measure of wage rate; exchange rate of taka per USD (ER); import price indices (Pm); price of imported raw materials (RAW) and world oil price (WPP). One period lag CPI (Pt-1) and real GDP are also used as a proxy for opportunity cost of holding money (or expectation factor) and economic growth respectively.

Data on these macroeconomic variables have been collected mainly from the *Statistical Yearbook of Bangladesh* published by the Bangladesh Bureau of Statistics (BBS), *Monthly Economic Trends* published by the Bangladesh Bank, *World Development Indicators* (WDI), World Table of World Bank and from many others relevant reports and papers.

1.8 Empirical Estimation

This is a time series analysis. For this reason, different standard time series econometric procedures are applied to obtain the empirical estimates. In the first step, unit root for stationarity is tested using ADF, PP, and DF-GLS unit root tests. In the second step, demand-pull, cost-push, and hybrid inflation models are estimated using the ordinary least squares (OLS) technique. After this, the empirical exercise focuses on identifying the general model and then moves towards a specific model for the country; this provide empirical analysis using Hendry's general to specific autoregressive distributed lags (ARDL) model and an error correction model (ECM) for determining both the long-run and short-run inflation equation for Bangladesh.

In the third step, causal relationship between nominal wage and inflation and between money supply and inflation are determined by the Granger causality test.

Next, the long-run and short-run causal impact of inflation on GDP growth is examined using vector error correction model (VECM) based Granger causality and Toda-Yamamoto causality. The impulse response function (IRF) and the variance decomposition of these two variables are used as a supplement of Granger causality test in VAR structure.

For attaining empirical estimations stated above, different econometric and statistical software like E-Views, Stata, Microfit, and R among others can be used. In this thesis, we have used much familiar and widely recognized econometric software E-Views 8.0 for convenience and availability.

1.9 Organization of the Thesis

This thesis is organized into seven chapters: (i) Introduction; (ii) Inflation in Bangladesh; (iii) Literature Review; (iv) Models of Analysis and Econometric Methodology; (v) Data for the Econometric Estimation; (vi) Empirical Results; and (vii) Summary and Conclusion.

Chapter 1 is the introductory chapter, which provides an introduction to the study. It introduces the objectives, hypotheses, rationale, methodology, estimation procedures, data used and their sources.

The background part of the thesis is presented in Chapter 2. This discusses historical experiences and trend of CPI inflation in Bangladesh. The chapter is broken down into three sections: description of the composition and structure of CPI inflation followed by historical perspectives of inflation and decomposition of inflation into various unobserved components like trend, cyclical, and random.

Chapter 3 reviews the literature of the major works done in the area of inflation. The review is divided into two parts. These are the general works, that is the major works done on inflation internationally and the works on inflation in Bangladesh. This chapter ends with some thoughts of the appropriate empirical models and methodology.

The empirical specification and estimation techniques used in this study are explained in Chapter 4. The demand-pull or monetary models with various alternatives, cost-push models, and hybrid models are described in this chapter. Different econometric methods that have been used for empirical estimations of chapter 6 are provided in this chapter. These include ADF, PP and DF-GLS unit root tests, OLS regression, ARDL cointegration approach, VECM, Granger causality test, Toda-Yamamoto causality test, IRF, and VDC.

Chapter 5 contains necessary data that have been used as inputs for empirical estimation of inflation in Bangladesh. Among other variables, these include long time series on inflation (CPI), money supply (M), GDP (Y), nominal wage (W), real deposit interest rate (R), exchange rate (ER), value of imported raw materials (RAW), world oil price (WPP), and import price index (Pm).

The empirical results of this study based on econometric estimates are presented and analyzed in Chapter 6. Firstly, the chapter gives the results of determinants of inflation from monetary, cost-push, and a combined angle and forms a general model then moving towards a specific one. This also analyzes the long-run and short-run relation of inflation with its determinants. Causality between wage and inflation, and money supply and inflation is also presented in this chapter. Finally, this chapter ends with thorough discussion of causal impact of inflation on GDP growth.

Chapter 7 summarizes all the findings of this thesis together with some major policy implications, and conclusion.

At the end of the thesis, a comprehensive bibliography is given.

Chapter 2
Inflation in Bangladesh

In this chapter attempts have been made to provide a historical overview and trends of inflation in Bangladesh. This chapter is divided into three sections. First section discusses the composition and structure of consumer price index (hereafter referred to as CPI); second sections shows trends of inflation from historical perspectives; and third section decompose inflation trends into different unobserved components. The data and materials used in this chapter have been taken mainly from various issues of *Bangladesh Economic Review*, published by the Ministry of Finance and data from the various issues of the *Statistical Yearbook of Bangladesh* published by the Bangladesh Bureau of Statistics, and *Monthly Economic Trends*, Bangladesh Bank.

2.1 Composition and Structure of CPI in Bangladesh

There are various indices which measure the price level, such as: CPI; wholesale price index (WPI); gross domestic product (hereafter GDP) deflator and so on. The CPI is considered the most common measure of general inflation. It measures changes in the cost of buying a representative fixed basket of goods and services and generally indicates inflation rate in the country.

The national (official) CPI is conceptually designed to provide a general measure of inflation for all Bangladeshi households. It is based on a composite of urban and rural price data compiled on monthly basis by the Bangladesh Bureau of

Statistics (BBS)[1] and reflects household expenditure patterns in the 1995/96 household income expenditure survey (HIES). For each of the CPI (national, rural and urban), three sub-categories are also distinguished as: food CPI, non-food CPI and general CPI.[2] BBS currently uses commodity-wise expenditure shares from 1995/96 HIES as base year weights for calculating the CPI.[3]

The components and weights of the CPI index basket are presented in Table 2.1. It is observed from the Table 2.1 that the foods, beverages and tobacco group dominate the CPI. This group includes 106 items and represents almost 63 percent of the consumption basket in rural areas with food alone representing more than 60 percent. In urban areas it includes 113 items and represents weight of nearly 49 percent, with food items alone covering around 45 percent.[4]

The non-food group has 109 items with a weight of 37 percent in rural areas compared with189 items having a combined weight of 51 percent in urban areas. In the non-food category, gross rent, fuel, and lighting group has the highest weight, nearly 15 percent and 22 percent in rural and urban areas respectively. The

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[1] BBS compiles CPIs for rural and urban areas separately using appropriate price data and relevant weights. The national CPI (CPI-N) is taken as the weighted average of the CPIs for rural and urban areas, with a weight of 70.9 percent for the rural CPI (CPI-R) and 29.1 percent for the urban CPI (CPI-U). These weights reflect the population shares in the respective areas.

[2] General CPI is the weighted average of food and non-food CPIs with respective expenditure shares adopted as weights.

[3] In Bangladesh, the CPI is calculated on the basis of Laspeyre’s formula with base year quantity (households’ commodity-wise expenditure shares) as fixed weight: CPI = $\sum \frac{p_1 w_0}{p_0 w_0} \times 100$. In the past, the weights used in estimating CPI inflation referred to different year such as 1969-70, 1973-74, and 1985-86.

[4] Of this, the weight of cereals is nearly 27 percent (rice 24 percent) in rural areas compared with 14 percent (rice 11 percent) in urban areas.

consumption basket and the weights underlying CPI rural and CPI-urban also differ significantly in Bangladesh (Table 2.1).

Table 2.1
Consumer Price Index Basket (Base: 1995-96=100)

Items	CPI-rural		CPI-urban	
	No. of Items	Weights (Percent)	No. of Items	Weights (Percent)
Food Beverage and Tobacco	106	62.96	113	48.80
Food	99	60.48	104	44.53
Beverage	3	0.96	3	2.40
Tobacco Products	4	1.52	6	1.87
Non-Food	109	37.04	189	51.20
Clothing and Footwear	33	6.88	48	6.79
Gross Rent, Fuel and Lighting	6	14.69	13	22.17
Furniture, Household Equipment	28	2.70	37	2.58
Medical and Health Expenses	5	2.79	16	2.97
Transport and Communication	11	2.98	22	7.07
Education, Recreation, Others	11	3.20	19	6.40
Miscellaneous Goods and Services	15	3.80	34	3.22
Total	215	100.00	302	100.00

Source: Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh,* various issues.

It appears from the Table 2.1 that, in general, the food inflation is higher in the urban area relative to the rural area while the situation is reverse in the case of non-food inflation.

2.2 Inflation in Bangladesh, 1976-2013

In the 1950s and 1960s Bangladesh experienced a low level of inflation. During the period (1950-70) the inflation rate was around three percent per annum (Ahmed 1984).[5] But, the rate of inflation increased persistently since Bangladesh's

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[5] For this section, inflation is calculated as the percentage change in the price level. In the rest of the study, it is calculated as difference of the natural logs. Both are equivalent in the limit; however the later is taken as standard and makes for easy interpretation (i.e. coefficient is taken as elasticity).

independence in 1971. During the period 1971-75 the inflation rate was exceptionally high, it was 49 percent, 54.8 percent and 21.9 percent in 1973, 1974 and 1975 respectively (Hossain, 1996, p. 270). During the period 1971-75, expansionary fiscal, credit, and monetary policies, coupled with domestic production shortfalls and a rapid rise in import prices, were the major causes of inflation (Hossain, 1995).

During the period 1975-80, after a pause of two consecutive years, inflation rates ranged between 10 to 15 percent and, on at least two or three occasions during the period 1975-80, potentially serious inflationary situations (due to droughts and floods) were averted by emergency imports and open market selling through distribution channel.

During the first half of the 1980s the country experienced a double-digit episode of inflation and even the inflation rate rose up to 15 percent in 1982 as illustrated in Figure 2.1. The inflation rate then gradually declined during the second half of 1980s and in 1983-90 the inflation rate was ranging between 10 to 12 percent. Higher import prices, lower food production, and increased money supply were the major reasons for the rise in prices (Hossain, 1995).

However, moderate rates of inflation were observed throughout the 1990s. Throughout the first half of the 1990s, inflation rate was, on average, 5.37 percent. In the second half of the 1990s, the inflation rate increased steadily and it was on an average 5.52 percent. The increasing trend of inflation rate during the latter half of 1990s had been corrected since the beginning of the new decade after 1990s.

During 2001 to 2005, the inflation rate was observed at 4.14 percent, on average. Bangladesh was worst-hit by inflation in 2007-08 and 2011-12. The yearly average inflation was estimated at 12.28 percent in 2007-08 and 10.89 percent in 2010-11 with food inflation at 16.69 percent and 14.09 percent respectively. During the period, rural households were observed to experience much higher inflation, mainly driven by food prices. The average food inflation was 17.7 percent in rural areas and 14.16 percent in urban areas in 2007-08.[6] After experiencing a high episode of inflation in 2007-08, Bangladesh experienced as somewhat lower inflation in the following two years, ranging between 7 and 8 percent, when relatively low prices of food, particularly rice price, played the key role to drive down inflation.

Again, inflation started soaring from 2010-11 with a new phenomenon of rising non-food inflation, and since then they were remaining between the range 7 to 9 percent. The study of CPD revealed that, among the South Asian countries, general inflation was the highest in Bangladesh reaching 11.6 percent in January 2012, much higher than the government's target of 7.0 percent. In fact, while Bangladesh's inflation rate rose drastically, its neighbors India, Pakistan, Sri Lanka and Nepal managed to bring down their inflation rates from 9.48 percent, 13.9 percent, 6.2 percent and 7.5 percent in January 2011 to 6.55 percent, 10.1 percent, 3.8 percent and 6.8 percent respectively in January 2012.

[6] Inflation scenario during the period 2008-14 is reported using 2005-06 as base year along with 1995-96 as base year, but using the 2005-06 as base year most of the previous data is unavailable in BBS.

The report cited food and the upward adjustment of administered petroleum and electricity prices, growth in money supply, increased cost of production including wage rate and exchange rate depreciation as major causes of inflation in Bangladesh. While the contribution of food inflation to overall inflation declined from 75.8 percent to 64 percent in 2012, non-food inflation exceeded food inflation in the first seven months of 2012 due to a fuel price hike and the domino effect it had on other sectors including transportation and housing.

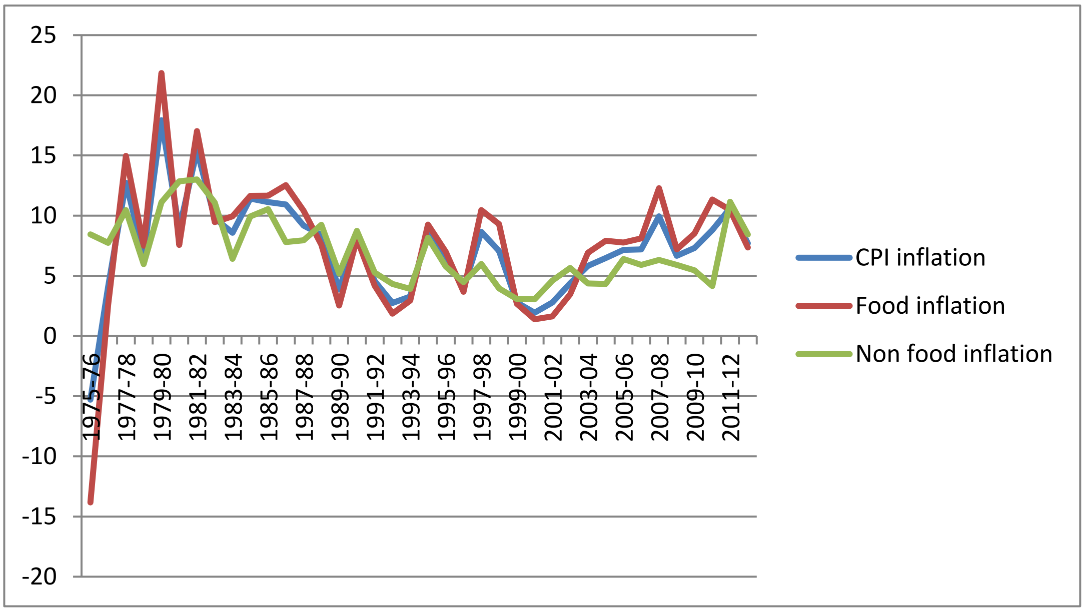
Table 2.2
Inflation in Bangladesh, 1976-2013

Period	CPI inflation	Food inflation	Non food inflation
1975-76	-5.29	-13.83	8.44
1976-77	4.08	2.58	7.74
1977-78	12.74	14.96	10.46
1978-79	6.77	7.50	5.97
1979-80	17.93	21.85	11.11
1980-81	8.89	7.57	12.85
1981-82	15.41	17.03	13.01
1982-83	9.78	9.47	11.09
1983-84	8.57	9.94	6.41
1984-85	11.42	11.64	9.93
1985-86	11.13	11.66	10.54
1986-87	10.93	12.53	7.81
1987-88	9.18	10.41	7.95
1988-89	8.41	7.58	9.24
1989-90	3.86	2.53	5.19
1990-91	8.31	8.08	8.73
1991-92	4.56	4.18	5.27
1992-93	2.74	1.86	4.32
1993-94	3.28	2.95	3.91
1994-95	8.87	9.25	8.16
1995-96	6.65	6.99	5.78
1996-97	3.96	3.67	4.47
1997-98	8.66	10.46	5.99
1998-99	7.06	9.30	3.95
1999-00	2.79	2.68	3.08
2000-01	1.94	1.39	3.05

Period	CPI inflation	Food inflation	Non food inflation
2001-02	2.79	1.63	4.61
2002-03	4.38	3.46	5.66
2003-04	5.83	6.92	4.37
2004-05	6.48	7.91	4.33
2005-06	7.16	7.76	6.40
2006-07	7.20	8.11	5.90
2007-08	9.94	12.28	6.32
2008-09	6.66	7.19	5.91
2009-10	7.31	8.53	5.45
2010-11	8.80	11.34	4.15
2011-12	10.62	10.47	11.15
2012-13	7.70	7.35	8.43

Source: Author's calculation based on BBS.

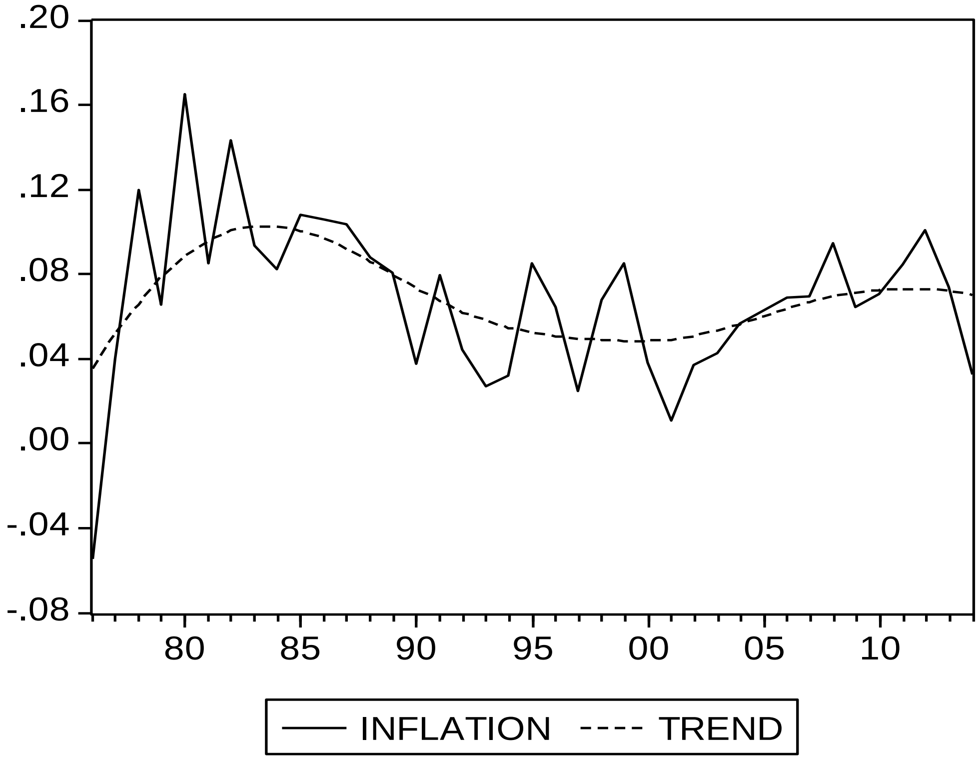
Figure 2.1
Inflation in Bangladesh, 1976-2013



The trends of inflation, computed by the Hodrick and Prescott (HP) filter can be shown graphically with the help of Figure 2.2 below.[7]

[7] The trend is computed by using the Hodrick and Prescott (HP) filter. The HP filter defines a trend τ for z as the solution to the problem: $\min \sum_{t=1}^{T}(Z_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1}[(\tau_{t=1} - \tau_t)(\tau_t - \tau_t)]^2$ where the parameter λ represents the choice between smoothness of the trend (λ=∞), that is, a linear trend versus perfect fit of the trend (λ=0), that is, the trend replicates the series. As suggested by Hodrick and Prescott, the benchmark value in the case of annual data for λ is 100.

Figure 2.2
Trend of Inflation in Bangladesh, 1976-2013



The Figure 2.2 suggests that inflation had started at the review period at around 4 percent and increased to double digit in the 1978 and it hiked to its peak around 16 percent in the 1980.[8] This high inflation period corrected itself with inflation decreasing to the lower level at which it had started during 2000-2003.

2.3 Decomposition of the CPI into its Unobserved Components: Trend, Cyclical and Random

In this section, the CPI inflation (P_t) has been decomposed into its basic sub components so that each component of inflation is detected separately into sub patterns.[9]

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[8] In 1976 inflation rate was -5.29 percent, not a normal case. For this reason, it is not reported in details.

[9] Inflation is computed as the change in the natural log of the CPI.

The decomposition of CPI series is a statistical method that deconstructs the series into notional components based on the rate of change or predictability.[10] Such decomposition shed more light on the behavior of the CPI inflation. Classical time series analysis starts with an assumption that every time series can be decomposed into four elementary components: (i) underlying *trend* (T), (ii) cyclical variations (C), (iii) seasonal variations (S) and, (iv) irregular or random variations (R) (Davis and Pecar, 2013, pp. 406-25).[11] The general mathematical representation of the decomposition approach can be written as:

$$P_t = f(T_t, C_t, S_t, R_t). \qquad (2.1)$$

The trend component in the classical time series analysis approach to forecasting that covers the general tendency of the non-recurring movement of the CPI series over a long period of time. The seasonal component consists of the long-term variations that happen over a period of several years that usually arises out of calendar effects[12], institutional influences, weather influences and expectations. If the time series is not long enough, sometimes we might not even be able to observe this component because the cycle is either longer than our time series or it is just not obvious. However the seasonal component applies to seasonal effects happening within one year. Therefore, as the CPI series consists of annual data, there is no need to worry about the seasonal component (Davis and Pecar, 2013).

[10] In this section decomposition is made based on rate of change.

[11] See, Glyn Davis and Branko Pecar (2013). Business Statistics Using Excel. Oxford University Press, 405-443.

[12] Calendar effects cover festivals, customs or holidays or other events within a year.

However, the cyclical component includes fluctuations over 3 to 11 years that are related with the short waves. The distinction between seasonality and cyclicality is that seasonality repeats itself at fixed interval (such as month or week) whereas cyclical factors have a longer duration that varies from cycle to cycle. And, finally, the irregular or random component is everything else that does not fit into any of the previous three components.

Following Ubide (1997), and Domac and Elbirt (1998), the multiplicative method based on autoregressive integrated moving average (ARIMA) model has applied to decompose the price series into various unobserved components and it is expressed as:

$$P_t = T_t \times C_t \times R_t. \qquad (2.2)$$

Here P_t presents the actual (observed) values of inflation.[13] The purpose of decomposition is to identify T_t, C_t and R_t by analyzing the original data P. More specifically this can be done by calculating moving averages (MA) and can be specified as:

$$MA = T_t \times C_t. \qquad (2.3)$$

Here MA is a moving average over a determined period and T_t is the trend. For this study, MA is taken to be two year moving averages while T_t is computed as earlier. Further, the ratio of P to MA will yield:

[13] Ubide (1997), Domac and Elbirt (1998) suggested that the multiplicative model had some more advantages over additive model and it was the most used model for annual time series data in developing country case.

$$\frac{P}{MA} = \frac{Tt \times Ct \times Rt}{Tt \times Ct} = Rt \qquad (2.4)$$

This contains only an error or randomness. These values have been calculated for Bangladesh with the trend as calculated earlier; the cyclical and random components are depicted below in Figure 2.3 and 2.4 respectively:

Figure 2.3
Cyclical Components of Inflation in Bangladesh, 1976-2013

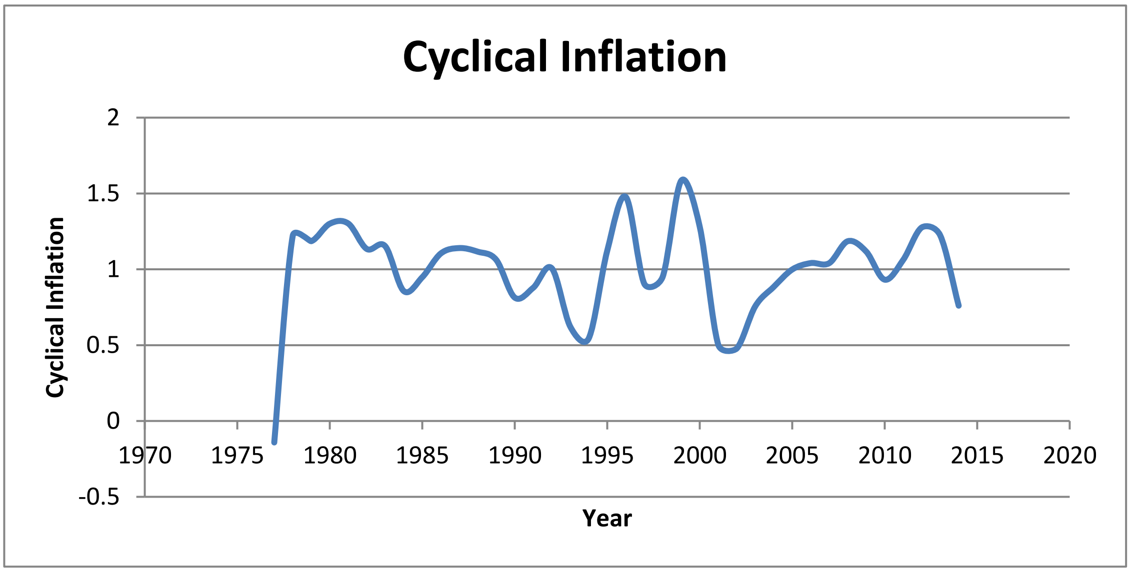
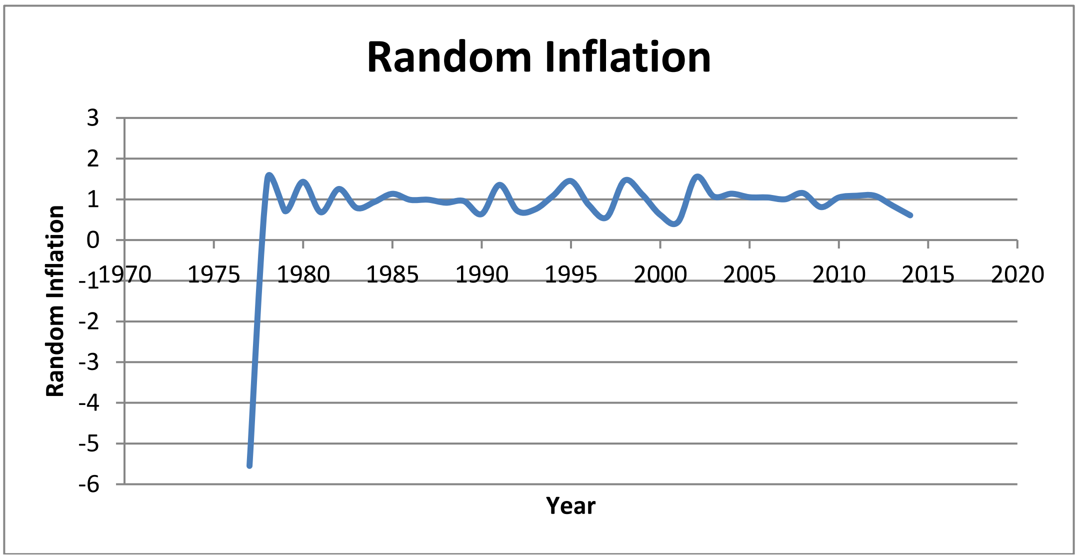


Figure 2.4
Random Components of Inflation in Bangladesh, 1976-2013



It is observed from the Figure 2.3 and 2.4 that in general, the contributions of cyclical and random components of inflation are stable over the period and it appears that inflation in Bangladesh is driven by the trend component of inflation.

2.4 Chapter Summary

The main objective of this chapter is to provide a background to the study. This chapter tries to explain the pattern and trends of inflation in Bangladesh during 1976-2013. The chapter is divided into three sections.

The first one explains composition and structure of consumer price index (CPI) in Bangladesh.

The second analyzes trends of Bangladesh's inflation experience. It is observed that the rate of inflation has increased persistently since Bangladesh's independence in 1971, it has gradually declined in the early years of new millennium, and it has rocketed to cross double digit in the years of 2007-08 and 2011-12.

The third one decomposes inflation into three components: a trend, a cyclical, and an irregular component. The results of the decomposition suggest that the rate of inflation in Bangladesh is driven by the trend component, and the contributions of cyclical and random components of inflation are stable over the period.

Depending on this background, different works on inflation have been reviewed for choosing the appropriate models and methodology, and for identifying the influencing factors of inflation for the next chapter.

Chapter 3
Literature Review

A good number of works on various aspects of inflation have been reviewed in this chapter to acquaint with the previous related research works and to identify the research gap in this field. It is also essential to update the analysis by utilizing current techniques as highlighted in the empirical literatures. The chapter is divided into two parts. The first part contains a general review of works on inflation, while the second part consists of the works that have been done on Bangladesh. This chapter ends with some thoughts of the appropriate empirical methodology for the study.

3.1 Review of Works in General

There are some studies which examine inflation processes in the region as a whole- the group of countries taken together. Although these are important for gaining general insights, these have been found to lose out information on country-specific experiences. Therefore, it is equally important to look at individual country-specific studies. Review of some works regarding these is given below.

Harberger's (1963) study of Chilean inflation was one of the first and the best known empirical analysis of the causes of inflation in any Latin American country, developing country. Harberger developed an econometric model of the causes of Chilean inflation for the period of 1939-1958 using annual data which can readily be generalized and estimated for all Latin American countries. In his model, he selected inflation rate as dependent variable and following a monetarist approach, he introduced the percentage change in the money supply during the current and preceding years and the percentage change in real income during the current year as independent variables. To allow for changes in velocity caused by changes in the expected costs of holding money, he introduced past changes in the rate of inflation as a proxy for these changes. To allow for the influence of structural factors, he also included a wage variable. In other regressions Harberger used the wholesale price index and various components of the wholesale and consumer indices as the dependent variable, and he used both quarterly and annual data. The results of the study reported that the sign, magnitude and significance of each coefficient agreed with Harberger's expectations, although changes in velocity caused by changes in the expected costs of holding money was significant only at the 5 percent level. But, when the wage variable was added, its coefficient was less than its standard error, and it did not appreciably affect the magnitudes or standard errors of the other coefficients, except that changes in velocity caused by changes in the expected costs of holding money. Moreover, it was no longer significant at the 5 percent level of confidence.

Until the mid of 1970s there was the conventional empirical wisdom about the effects of inflation on economic growth that inflation helps accelerating economic growth and some interpreted it as the Tobin (1965) effect. Mundel (1965) and Tobin (1965) predicted a positive relationship between the rate of inflation and the rate of capital formation, which in turn implies a positive relationship between the two variables. According to their logic inflation reduces people's wealth. Since the rate of return on individuals real money balances falls. To accumulate desired wealth, people save more by switching to assets, greater savings means greater capital accumulation and thus faster output growth.

Vogel (1974) developed a monetary model for explaining inflation in Latin America. Harberger study could not completely resolve the controversy between the monetarists and structuralists. Vogel extended Harberger's model to sixteen Latin American countries for the period 1950-1969 to investigate the impact of monetary factors on inflation, and in particular, the extent to which countries with widely varying inflationary and monetary experiences exhibited homogeneous behavior. The author's model considered the rate of inflation (P_t) as a dependent variable and the percentage change in money supply during current and previous years (M_t, and M_{t-1}), percentage change in real income during current period (Y_t) and change in inflation rate lagged by one year and two years (P_t and P_{t-1}) as explanatory variables. Vogel (1974) concluded that the coefficients of M_t and M_{t-1}1 were highly significant and thus indicated that an increase in the rate of growth of money supply caused a proportionate increase in the rate of inflation within two years. At the same time the rate of inflation was found to be inversely influenced by the growth rate of real income. The rate of inflation was not found to be so much influenced by (P_{t-1}– P_{t-2}); rather inflation rate lagged by one year, P_{t-1} had much influence on the current rate of inflation.

Darrat (1986) analyzed and tested empirically the monetary explanation of inflation in the case of the moderate inflationary experience of three major OPEC economies over the two decades, 1960:Q1-1980:Q2 using quarterly data. Darrat used the procedure proposed by Sargent (1976) to test the direction of causation between money and prices for Morocco, Tunisia and Libya. CPI inflation was used as dependent variable in the study. The estimated model took into account the underlying money demand relationship and paid careful attention to the model's lag specifications. The empirical results of the study showed a unidirectional causation running from money to prices without feedback for all the three countries concerned. Darrat concluded that the results support the monetarist view that money causes inflation and the monetary model of inflation also adequately explains the inflationary process in each of the countries studied.

Chhibber et al. (1989) developed a detailed econometric model, which took into account both monetary and structural factors in the course of inflation in Zimbabwe. Their investigation determined that monetary growth, foreign prices, exchange rate and interest rates, unit of labor cost and real income were the determinants of inflation in that country. A similar macroeconomic model of inflation was employed for Ghana by Chhibber and Shaffik (1990a) for the period from 1965-1988. This study suggested that the growth of money supply was one key variable explaining the Ghanaian inflationary process. Official exchange rates could not exert any significant influence on inflation.

Neupane (1992) had continued exploration of the appropriate model for Nepal and in this vein, had examined both monetarist (closed economy) and structuralist approaches to the inflation process in Nepal over the period 1965-

1988 by using OLS technique. The author has used percentage change in CPI as the dependent variable and percentage change in current money supply, money supply lagged by one and two years, percentage change in GDP, and the expected cost of holding money, percentage change in output in commodity producing sectors lagged by one year, percentage change in the import price index lagged by one year and percentage change in government budget deficit as the explanatory variables. The monetarist model includes the rate of growth (as indicated by a dot over the respective variables) of money supply (M), per capita income (Y), and expected cost of holding money (C) as explanatory variables of inflation. Similarly, the structuralist model of inflation is examined by using agricultural bottleneck, foreign exchange constraints, and fiscal constraints. The model consists of one year lagged percentage change in output (Y_{t-1}) and import price index (MP_t), percentage change in government expenditure (GOV_t) and expected cost of holding money (C_t). The findings of the study suggested that monetary policy is an important instrument to control inflation. An increase in money supply in line with the growth of per capita GDP could help to control inflation. However, the study could not empirically provide superiority of one approach to the other in explaining inflation; rather it exhibits the broader perspective of the complexities of the inflationary process.

Chhibber (1992) incorporated cost-push components into the monetarist model and applied this to a number of African economies. In his model, inflation was a weighted average of inflation in the prices of traded goods (P), non-traded goods (P_n) and controlled-price goods (P_c). Inflation in traded goods prices was determined according to the absolute purchasing power parity model, where as non-traded goods prices were determined according to a mark-up applied to unit wage cost (W) and the cost of imported inputs (M_c). The mark-up was not fixed but was modeled as a function of excess demand in the economy, and was used as proxy of the excess real money balances (EMB). Chhibber's final model identified the basic sources of inflation in an African context as (a) imported inflation, (b) inflation due to the cost-push effect of devaluation, wage-push inflation, demand-pull inflation, and (c) inflation stemming from the control and subsequent decontrol of prices. This model was then applied to four types of policy regimes in Africa that vary according to the type of exchange rate regime, openness of the capital account and the degree of price control. The author found a direct cost-push effect from exchange rates to prices. The degree of devaluation pass-through was found to vary widely, implying no evidence of a unique relationship between devaluation and inflation.

In pooled cross-section time series regressions for a large set of countries, Fischer (1993) and De Gregorio (1993) found evidence for a negative link between inflation and growth. This was also confirmed by Barro (1995, 1996). Fischer (1993) has investigated the link between inflation and growth in time-series, cross section and panel data sets for a large numbers of countries. The main result of these works is that there is a negative impact of inflation on growth. Fischer (1993) argued that inflation hampers the efficient allocation of resources due to harmful changes of relative prices. At the same time relative prices appear to be one of the most important channels in the process of efficient decision-making.

Similarly, McCandless and Weber (1995) looked at inflation in 110 countries based on the data 1960-1990, a 30-year period. For each country, they calculated the long-run (up to 30-year) geometric average rate of growth for the standard measure of production, gross domestic product adjusted for inflation (real GDP); a standard measure of the general price level, consumer prices; and three commonly used definitions of money (M_0, M_1, and M_2). They also looked for correlation over two specific sub samples of countries. One of the subsamples consisted of 21 OECD countries; the other consisted of 14 Latin American countries. The empirical results showed three principal long-run monetary facts. First, growth rates of the money supply and the general price level were highly correlated, with a correlation coefficient close to one, for three money definitions. Second, the growth rates of money and real output were not correlated. This fact is not robust, however. For a subsample of OECD countries, growth rates of money and real output were positively correlated. Third, the rate of inflation and the growth rate of real output were essentially uncorrelated. The study, furthermore, concluded that inflation and monetary aggregates are positively correlated in the long-run. However, as the time horizon shortens, the correlation falls.

Furthermore, Lim and Papi (1997) shed light on the possible causes of inflation in Turkey using an ad hoc general equilibrium model. In this study, they adopted time series data for 1970-1995. The authors applied Johansen cointegration technique to find out results. The theoretical approach adopted in this study incorporated both long and short-run dynamics within a macroeconomic model comprising the goods, money, labor and external sectors. They used domestic price level as dependent variable and nominal wage, exchange rate (defined as the price of domestic currency in foreign currency), money, the exogenous price of exports, exogenous imported input prices as explanatory variables in their long-run price equation. The inflation equation was estimated for two sub-periods (1970-80 and 1981-95) to allow for structural shifts. Because, Turkey moved from an import-substitution policy in the 1980's to an export-incentives policy. The analysis concluded that money, wages, prices of exports and prices of imports had positive influence on domestic price level where as exchange rate exerted inverse effect on the domestic price level in Turkey.

Ubide (1997) studied the determinants of inflation in Mozambique using monthly data for the period 1989:M1-1996:M12. This study tried to explain the behavior of inflation in Mozambique through three different approaches. The first one was to decompose inflation into three components: a trend that represents underlying inflation, a seasonal component that follows closely the agricultural season, and an irregular component. The second approach was to derive a theoretical model of inflation determination and to estimate an inflation equation. The third was to analyze the transmission mechanism embedded in the system by estimating a multivariate dynamic system. The model applied in the study was given as following log linear form:

$$\log P_t = c_t \log M_t + c_2 \log Y_t + c_3 \Delta \log P_{t-1} + c_4 \log E_t + c_5 \log P_{ft} \qquad (3.1)$$

where, P_t, M_t, Y_t, P_{t-1}, E_t and P_{ft} denote as inflation (CPI), money supply, real income, expected inflation, exchange rate and foreign prices. The empirical results showed that unpredictable factors in the agricultural sector, monetary expansion and the depreciation of the Metical/Rand exchange rate were the main drivers of inflation. Based on a co-integrated Vector Auto-Regression (VAR) including the Mozambican CPI (used as the normalizing variable), the South African CPI, money and the exchange rate, he reported a long-run exchange rate pass-through of 0.18, a long-run coefficient of 1.64 for the South African prices and 0.72 for money. Finally, this study also suggested that Mozambique's inflation pattern was a combination of a "fundamental" trend set by economic policies, seasonal behavior that followed closely that of agriculture and a collection of irregular events that corresponded mainly to agro-climatic conditions.

Domac and Elbirt (1998) employed three different approaches to examine the behavior and determinants of inflation in Albania. Firstly, the authors decomposed inflation into four components: seasonal, cyclical, trend, and random. Secondly, they used Granger causality test on both the consumer price index (CPI) and key economic variables, to investigate their information content. And, lastly, they apply cointegration and error-correction techniques to the process of inflation to a monetary model. The variables in the model were price, money supply and exchange rates. The authors conclude that (1) inflation exhibits strong seasonal patterns associated with agriculture seasonality with monetary aggregates matching inflation by lag of two-months and that the exchange rate also exhibits a stable seasonality pattern; (2) Granger causality test shows that M1 (currency in circulation plus demand deposits) and the exchange rate have predictive impact for most components of the CPI and that credit to government is a good predictor of medical care, transportation, and communication prices. The study finds that an increase in the fiscal deficit would undermine competitiveness by producing appreciation in the real exchange rate. (3) Lastly, the cointegration and error-correction model show that inflation is positively related to both money supply and the exchange rate and negatively related to real income in the long-run. The impact of the exchange rate on inflation occurs a month later, while the impact of real income and money take place two and four months later respectively.

Mathema (1998) moved away from focus on the monetary explanation of inflation in Nepal has used an expectation augmented Phillips Curve (PC) approach to examine whether the nominal wage increases are the most significant sources of cost push inflation. He used annual CPI inflation (P) as dependent variable, and real GDP growth (GDPR), change in money supply (narrowly defined; M), change in wages (W), change in imported price (PI) and change in price expectation (PE) as explanatory variables among others. The data for the study period is 1978-79 and 1995-96. OLS and unit root tests are performed for stationary test of the variables chosen. The author finds the importance of several wage variables for influencing domestic inflation but surprisingly does not find significant effect of imported prices. The author attributes this to "absorption of the effect of WPII (whole sale prices of India) by the money wages of laborers in the homeland" (Mathema, 1998, p.16). Granger Bi-variate Causality Test finds unilateral causation from the rate of inflation to wages of agricultural and masonry labor while industrial wages causes inflation in Nepal.

Liu and Adedeji (2000) studied the major determinants of inflation in the Islamic Republic of Iran for the period 1989-1999 by establishing a framework. They applied Johansen cointegration test and vector error correction model to conduct the study. While estimating the empirical model, disequilibria in markets for money, foreign exchange, and goods were taken into consideration and the impact of these disequilibria on dynamics of price, money, and exchange rate was also analyzed. The study found that lag value of money supply, monetary growth, four years previous expected rate of inflation were positively contributed towards inflation while two years previous value of exchange premium was negatively correlated with inflation. Their results were in line with the argument that ‘inflation is a monetary phenomenon’ in Iran.

Razzak (2001) discussed New Zealand experience of the relationship between inflation and money growths in the inflation-targeting regime from a monetary perspective. This study has provided evidence that the relationship between inflation and money growth has changed as the inflation-targeting regime has progressed. The study also showed that the time series correlation between inflation and monetary aggregates was high only during high-inflation periods and disappeared when inflation was low.

Laryea and Sumaila (2001) examined the major determinants of inflation in Tanzania, using the time series data over the period of 1992:1-1998:4 on quarterly basis. Ordinary least square method and Error Correction Model (ECM) were applied in their study. They used consumer price index (CPI) as the dependent variable and money supply (M_t), exchange rate (E_t) and GDP (Y_t) as the explanatory variables.

They developed following long-run price equation (in log linear form):

$$\log P_t = a_0 + a_1 \log Y_t + a_2 \log M_t + a_3 \log E_t + u_t \qquad (3.2).$$

The estimation results showed that money supply and exchange rate had positive impact on consumer price index while gross domestic product had negative impact on consumer price index in Tanzania and monetary factors was found to have a bigger impact (the long-run elasticity of money, 0.77) on the rate of inflation, compared to output effects (the long-run elasticity of output, 0.085) in the long-run. This finding supports the monetarist argument on the power of monetary factors in the long-run inflationary process.

Dlamini et al. (2001) estimated the relevant influencing factors of inflation in Swaziland using both open monetary and structural variables over the period 1974 - 2000. The CPI of Swaziland was taken as the dependent variable while the explanatory variables being the real income (Y), nominal money supply (M), nominal interest rate (R), nominal exchange rate (E), nominal wages (W) and South African consumer prices (SP). Due to limitations of real sector data, annual time series were used. They applied cointegration technique and error correction model (ECM) to estimate relationship between inflation and its determinants. The study found that money supply and interest rate had insignificant influence on inflation. The coefficient of real income growth was also insignificant, though it was positive. However, foreign price (i.e. South African inflation) and exchange rate were found to have a significant long-run influence in inflation. It was also found that a large interdependence between wages and inflation exist both in the short-and long-run. The study concluded that changes in the lagged exchange rate, South African inflation and nominal wages were major determinants of inflation in Swaziland.

Khan and Senhadji (2001) found out the threshold effect between inflation and economic growth using a data set which consists of 140 countries from a period of 1960-1998, using econometric techniques. They looked at the relation between inflation and growth for developed and developing countries separately. Their paper focused on whether there is a statistically significant threshold level of inflation above which inflation affects growth differently than at a lower rate. It also examined whether the threshold effect is similar across developing and industrial countries. The authors used growth rate in GDP recorded in local currencies and inflation measured by percentage change in CPI index. In order to test for the existence of a threshold effect, a log model of inflation was estimated. With the threshold level of inflation unknown, the authors estimated it using conditional least squares (CLS) along with the other regression parameters. Empirical results suggested that inflation levels below the threshold levels of inflation have no effect on growth, while inflation rates above the threshold have a significant negative effect on growth. The authors' results were that the threshold is lower for industrialized countries (1-3 percent) than it is for developing countries (7-11 percent). The thresholds were statistically significant at 1 percent or less, implying that the threshold estimates were very robust.

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

Maliszewski (2003) explained the behavior of inflation in Georgia and the relationship between prices, money and exchange rate over the period 1996:1 to 2003:2. A long-run equation linking prices to money and the exchange rate, as well as a short-run, dynamic equation for inflation were estimated. Error correction modeling (general to specific) approach was applied. The study found that exchange rate is the dominant determinant of inflation.

Akinboade et al. (2004) estimated the determinants of inflation in South Africa. Quarterly secondary data series, covering the period 1970.1-2000.2, on nominal as well as real gross domestic product in 1995 prices (Y), the broad definition of money stock (M_3), the nominal interest rate (commercial banks' lending rate), the consumer price index (CPI), unit labor costs (Wc), and the nominal effective exchange rate (E) were used among others. Johansen cointegration test and structural VAR have been applied to conduct the study. The study reported that a positive correlation was found between labor costs, broad money supply and domestic inflation in the short-run. An appreciation of the rand or an increase in the nominal effective exchange rate would lower domestic inflation in South Africa. In the long-run, rising labor costs contributed significantly to inflation. An increase in the nominal interest rate, the effect of which was insignificant in the short-run, would slightly reduce inflation in the long-run. On the other hand, an increase in the broad money supply would contribute to domestic inflation in the long-run.

Leheyda (2005) investigated empirically the determinants of inflation in a small open economy like Ukraine. The analysis was based upon three hypothesis of inflation determination: excess money supply, foreign inflation and cost-push inflation. She applied cointegration and error-correction modeling approach, which distinguishing the short-term and long-term effects and develop a general model that embeds with several hypotheses for inflation in Ukraine for the period 1997-2003. The exchange rate, inflation inertia and lagged money supply were found to be the most important determinants of inflationary process of Ukraine. The feedback from the short-run exchange rate movements to inflation was rather rapid. The statistically significant effect of the external sector disequilibrium in both specifications (of similar magnitude) was found. No evidence was found that the excess money supply affects inflation in the way implied by the monetarist's models. The unit labor cost contributed in the short term inflation, money demand, purchasing power parity, foreign prices and mark-up relationships were the factors for long-run upsurge in the price. The Granger causality between the wages and prices was found to be unidirectional that run from the wages to the prices. The study recommended channel of the exchange rate transmission mechanism instead of using the other channels like interest rate for the price stability.

Pandey (2005) studied the determinants of inflation in Nepal over the period 1973-2004. He employed an excess demand model of inflation and applied ordinary least square test, stationary test and cointegration technique, and also error correction modeling approach to study the inflation in Nepal. Pandey has selected money supply (both narrow and broad), real GDP, government expenditure, Indian inflation and exchange rate as explanatory variables influencing inflation. Although bi-variate regression between price and the average money revealed significant relationship, the low explanatory power of the equation suggested inclusion of more variables. The study could not find any change in the explanatory power of the model while including public expenditure as well as real GDP, a supply side variable. In an open economy monetarist model, Indian prices and exchange rate with Indian rupees and US dollar are included; however, the explanatory power of the model is limited to 47 percent only. The study had then used the ECM to avoid the problem of loosing long-run information on data to reveal both short-term relationship and adjustment toward long-run equilibrium. Pandey has found long-run relationship of inflation in Nepal with money supply (narrowly defined), Indian inflation and exchange rate with India (as explanatory variables) however the error-correction term was found not to be significant, suggesting that there is no short-run adjustment with regard to inflation in Nepal.

Khan and Shimmelpfinnig (2006) identified the relative importance of monetary and supply side factors for inflation in Pakistan over the period 1998:1-2005:6. The model consisted of money supply, credit to private sector and 6-month Treasury bill rate as monetary variables and nominal effective exchange rate, wheat prices guaranteed by the government as supply side factors. Both annual real and nominal GDP are interpolated to 12-month moving average as activity variable. The open economy generalized monetarist model included administered wheat prices to reach at hybrid monetarist – structuralist model. The variables used in the study were prices, money, real GDP, velocity of money, interest rate, exchange rate and wheat support price. The variables are taken in the natural logarithm form. The authors estimated the above relation in both the short term and the long term using a Vector-Error Correction Model (VECM). The authors appeared to a conclusion that in the long-run, monetary factors play dominant roles in inflation with a lag effect of one year, whereas administered prices influence inflation in the short-run only.

Cooray (2008) estimated a price equation for Sri Lanka in order to examine the factors influence general price in Sri Lanka. He used two models: an open economy model and a closed economy model over the period 1978-2006. He applied cointegration test to examine the existence of a long-run relationship between the variables. Cooray included Colombo Consumer Price Index (CCPI) as the dependent variable and money supply (M_2), real GNP (GNP_t), exchange rate (E_{rt}) and import prices (IMP_t) as the explanatory variables. The closed economy price equation included money supply, money supply lagged by one period (M_{t-1}), Colombo Consumer Price index lagged by one period (P_{t-1}) and real GNP as explanatory variables. The price equation was given as:

$$P_t = a_1+a_2M_t+a_3M_{t-1}+a_4P_{t-1}+a_5GNP_t+u_t \qquad (3.3).$$

The open economy price equation was developed incorporating two additional variables, the import price index and foreign exchange rate (Rupee/US Dollar) to the variables in the closed economy price equation, which was given as:

$$P_t = a_1+a_2M_t+a_3M_{t-1}+a_4P_{t-1}+a_5GNP_t+ a_6\, IMP_t+a_7ER_t+u_t \qquad (3.4).$$

The results of the study showed a long-run relationship between the price level, real GNP, the exchange rate and import prices. The results, furthermore, suggested the importance of supply side factors in determining the general price level and supported for the open economy model in explaining inflation in Sri Lanka.

Erbaykal and Okuyan (2008) analyzed the relationship between the inflation and the economic growth in Turkey over the period of 1987:1-2006:2. The existence of the long term relationship between these two variables was examined using Auto Regressive Distributed Lag (ARDL) model or Bound Test approach developed by Pesaran et al. (2001), and the existence of a cointegration relationship between the two series was detected following the test result. Whereas no statistically significant long term relationship was found with the formed ARDL models, a negative and statistically significant short term relationship has been found. The causality relationship between the two series was examined in the framework of the causality test developed by Toda and Yamamoto (1995). Whereas, no causality relationship was found from economic growth to inflation, a causality relationship was found from inflation to economic growth.

Kandil and Morsy (2009) studied determinants of inflation in GCC, using an empirical model that includes domestic and external factors for the period of 1970-2007. They used P, the domestic price level, measured by the consumer price index (CPI), as the dependent variable in their study. The explanatory variables included nominal effective exchange rate (NEER), weighted average of price in major trading partners (P*), broad money (M), and government spending (G).They found both the foreign and domestic factors explained inflation in GCC countries. Among foreign factors, inflation in major trading partners appeared to be the most relevant to domestic inflation in GCC. Among domestic factors, oil prices were the main source of inflation in the GCC countries. They stated that oil price affected World prices which in turn increased the price of imports. Also the rise in the oil price caused an increase in government's revenues and spending which tend to push domestic demand resulting in inflation.

Ratnasiri (2009) observed the main determinants of inflation in Sri Lanka over the period 1980-2005 using Vector Autoregressive Analysis (VAR). Variables in the study were Colombo Consumers Price Index (CCPI), GDP, money supply, exchange rate, rice price, and interest rate. The results indicated that money supply growth and rice price increases were the main determinants of inflation in Sri Lanka in the short-run and long-run. He also found that exchange rate depreciation and output gap have no statistically significant effect on inflation. He made a conclusion that inflation in Sri Lanka was influenced by both the demand and supply side factors in the long-run and short-run.

Javed et al. (2010) tested the validity of both cost-push and monetary diagnosis of inflation through empirical analysis. The empirical analysis was conducted by using the technique of ordinary least square using the annual data for the periods1971-1972 and 2006 -2007. It appeared from the regression analysis that cost-push factors were not less important than demand-pull factors in generating inflation in Pakistan. The monetary variables were also found to have significant impact on CPI (consumer price index), WPI (whole price index) and GDP as well.

Bashir et al. (2011) examined the determinants of inflation in Pakistan by applying Johansen cointegration and vector error correction method using time series data for the period of 1972-2010. The CPI of Pakistan was taken as the dependent variable with the explanatory variables being the broad money, gross domestic product, imports of goods and services, exports of goods and services, government expenditure and government revenue. They employed log – log model to find out the elasticity of price with respect to the explanatory variables. The results of the study suggested that consumer price index was found to be positively related with money supply, gross domestic product, imports, and government expenditures and government revenue was negatively related with consumer price index (CPI) in the long-run in Pakistan. Long-run elasticity of CPI with respect to money supply, gross domestic product, government expenditures, government revenue and imports were 0.61, 0.73, 0.32, -1.37 and 0.41 respectively. In the short-run, CPI lagged by one year and government revenue lagged by two year were found to be directly associated with increasing consumer price index of current year in Pakistan.

Bandara (2011) investigated the determinants of inflation in Sri Lanka during 1993–2008, a period which was characterized by upward and downward trends in the economy of Sri Lanka. Vector auto-regressive (VAR) models were used to find out appropriate explanations for inflation with accompanied application of Granger Causality Tests. The overall findings of estimated VAR models imply that the money supply, exchange rate and the GDP have information which helps in exploring the behavior of the inflation in Sri Lanka.

Altowaijri (2011) focused to identify the external and domestic factors that affect inflation in Saudi Arabia during the period 1996-2010. He utilized an inflation model which incorporated both domestic and foreign factors affecting the rate of inflation. The model included real GDP, money supply, real exchange rate, foreign (world) prices, and interest rate as explanatory variables while price level (CPI) as dependent variable. The researcher applied cointegration and error correction estimation to examine the short-run and long-run relationships between inflation and its determinants. Results of the study showed that the increase in world prices and the decrease in the value of Dollar were found to be important determinants of the inflation rate, both in the short and long-run and the increase in domestic demand resulted from the increase in oil prices raised the inflation rate. The study concluded that the external factors were more important to explain inflation in Saudi Arabia.

Datta and Mukhopadhyay (2011) showed the relationship between inflation and economic growth in the economy of Malaysia for the period of 1971-2007. The methodologies applied in the study were ADF, PP Unit Root Test, Vector Error Correction, Vector Auto Regression, Impulse response function and Variance Decomposition among other techniques. The two variables were GDP growth (GRH) and inflation (INF) in this study. The GDP data were deflated by GDP deflator (base 1995=100) to convert to real GDP. Then 1st difference of log real GDP was considered as GDP Growth. On the other hand the CPI data were converted to common base (1995=100) and then 1st difference of log CPI was considered as inflation. According to this study, in the short-run inflation was found to play the vital role for affecting economic growth negatively on the other hand in the long-run economic growth was found to cause inflation.

Durevall and Sjo (2012) provided an assessment of the main drivers of inflation in Ethiopia and Kenya. They applied a general-to-specific error correction modeling approach starting from the pragmatic view that inflation might arise from a combination of excess money supply, increases in world prices and domestic supply shocks. They found that the inflation rates in both Ethiopia and Kenya were driven by similar factors; world food prices and exchange rates had a long-run impact, while money growth and agricultural supply shocks had short-to-medium run effects. There was also evidence of substantial inflation inertia in both countries.

Patra and Sahu (2012) analyzed the consumer price inflation in South Asian Countries during 2000-2008. The annual percentage change in CPI and Average Annual Growth Rate in Consumer Price Indices were analyzed to examine the trend of inflation in South Asian Countries like Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. There was found positive co-relation between the rate of inflation and rate of changed in GDP at constant prices in Bangladesh, India, Pakistan, and Sri Lanka but negative co-relation in Nepal. But the negative co-relation between rate of inflation and changes in money supply in Bangladesh, Nepal and Pakistan was found to be positive co-relation in Nepal and Sri Lanka. In Pakistan the consumer price inflation was mainly due to oil price hike and food inflation.

Sahadudhen (2012) investigated the major determinants of inflation in India extracting 54 time series quarterly observations over the period 1996:1-2009:2. The study employed the econometric technique of cointegration and error correction model (ECM) in order to estimate a more specific relationship between inflation and its determinants. He selected inflation rate (wholesale price index was used as the measure of inflation) as the dependent variable and real GDP, prime lending rate, broad money and exchange rate as the explanatory variables among others for the estimation purpose. The results of the study found that GDP and broad money had positive effect on inflation while exchange rate and interest rates had negative association with inflation.

Qurbanalieva (2013) examined the factors affecting inflation in Republic of Tajikistan during 2005-2012, by applying Auto Regressive Distributed Lags (ARDL) model on the basis of cost-push and demand-pull inflation theory. In his study, he included both the demand and supply side factors of inflation as variables, based on theoretical explanation. The variables comprised consumer price index (as the dependent variable), world oil price, broad money supply, exchange rate, remittance-inflow, real wage, gross domestic product gap (GDP gap), world wheat price, government expenditure and economically active population. The findings of this study revealed that exchange rate, world wheat prices, world oil prices and labor supply Granger caused the price level in the long-run. Nevertheless, in the short-run, only world wheat price and labor supply were found to have significant impact. In case of demand pull inflation, GDP gap, remittances inflow, and real wages were endogenously determined in the system as they significantly affected the price level in the long-run. But in the short-run, GDP gap, remittances inflow, broad money, government expenditure and real wages Granger caused the price level. Furthermore, there was a bi-directional Granger causality between GDP gap and remittances inflow, and real wage also Granger caused the government expenditures. The GDP gap Granger caused the real wage, implying the scenario that a major cause of under production was the low level of employment. Finally, the price level Granger cause the real wage was a reflection of negative relationship between the two.

Lim and Sek (2014) investigated the factors affecting inflation in 28 countries using annual data for the period 1970-2011. The 28 countries were categorized into two groups as high inflation group and low inflation group. They used the annual data on inflation, money supply, national expenditure, imports of goods and services and gross domestic product growth. And, they applied an Error Correction Model (ECM) based on the Autoregressive Distributed Lag (ARDL) modeling to explain the short-run and long-run impacts of each variable on inflation. The results showed that money supply and national expenditure were found to have significant long-run effect on inflation in high income countries. The impact of national expenditure on inflation was negative and the impact of money supply on inflation was negative in low inflation group. GDP growth had negative impact on inflation and imports of goods and services had positive impact on inflation in low inflation countries.

Some generalizations can be made from the above studies of inflation: they utilized monetary models of open economy basis. They discussed to include cost-push factors. Regarding estimation methodologies, the earlier studies used simple regressions (e.g. OLS) however its limitations are apparent: in levels there is the problem of spurious results while simply taking first differences loose out long-term information. To address this shortcoming, some of the above studies applied cointegration, error correction mechanism (ECM); these techniques look at the long term for the prior and for the later combine short and long term analysis.

3.2 Review of Works on Bangladesh

Several studies made an effort to understand the causes of inflation in Bangladesh. Three early studies in Bangladesh were conducted by Bose (1973), Rahim (1973), and Chowdhury (1976). All these studies provided some preliminary analysis of the inflation problem in Bangladesh following its independence in 1971. Importantly, these studies pointed out the inflationary consequences of rapid economic growth in a war ravaged country and also provided suggestions for slowing down both the monetization of budget deficits and growth of bank-credit to nationalized industries. Due to data limitations, these studies were mainly descriptive and tentative in nature. It was only since the early 1980s that academics begun to study the inflation problem in Bangladesh using statistical techniques with time series data.

Bose (1973) analyzed first the inflationary situation in post liberation Bangladesh. He used data for four years, 1969 through 1972. He aimed at showing the extent of price rise of essential commodities and identifying the major causes underlying the price rise. He observed that wholesale price indices for agricultural and industrial products jumped to 161and 272 respectively in 1972 from 100 in 1969. His analysis also showed that two major factors contributed to rise in the prices in Bangladesh during the post-liberalization period were a substantial decrease in output and availability of goods, and a very high growth in money supply. Bose study did not attempt any quantitative analysis and it covered a period of one year only after the independence of Bangladesh.

Chowdhury (1976) studied cost inflation in Bangladesh tea industry for the period of 1967-75. He analyzed collective data collected from forty eight tea gardens in Bangladesh. And he reached the conclusion that there was annual cost inflation in Bangladesh tea industry since 1971, and this inflation originated mainly from a sharp rise in the unskilled labor and other primary materials.

Taslim (1982) was the first author who used the regression models for explaining the inflationary process in Bangladesh. He analyzed the factors contributing to inflation in Bangladesh in light of the structuralist-monetarist controversy, using data over the period 1960-1980. He tested both views separately and a hybrid model which stayed in the middle of the two views. Estimating monetarist models he showed 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. He concluded that the hybrid model performed best and suggested that both the monetary and structural factors were relevant in explaining inflation in Bangladesh. But during the period of this study, Bangladesh had fixed exchange rate regime[14] and the study could not consider the effect of liberalization on inflation.

Jones and Sattar (1988) examined causal relationship between money growth, inflation, and output growth in Bangladesh. They implemented Granger test for the period of June 1974 through December 1985. Money growth, inflation and output growth were used as independent variables. The study investigated two important issues: (1) price movements in Bangladesh might be better explained by changes in real phenomena rather than by changes in the nominal money supply and (2) changes in the nominal supply of money might have significant real effects in the long-run. The results of the test revealed the causal relationship between money supply growth and inflation but the rate of inflation was not equal to the rate of growth of money supply in the long-run, meaning that inflation in the long-run was not monetary phenomenon in Bangladesh. This implies that non-monetary factors had also significant impact on inflation. Finally, money supply growth also influenced long-run economic growth and there was a causal relationship between them in Bangladesh.

Parikh and Starmer (1988) studied the relationship between the money supply and prices in Bangladesh using monthly data for the period 1973-1986.

[14] From1972-1999 the exchange rate was pegged to the pound sterling and then to a basket of currencies, 2000-2002 crawling band and from May 2003 floating exchange rate regime.

They applied the Granger and Geweke approaches to analyze the relationship between money supply and prices. They found an interesting and uncommon causal relationship between money supply and prices in Bangladesh. The results indicated that there was a significant unidirectional feedback running from prices to money but not from money supply to prices. The main conclusion was that strict exogeneity of the money supply was rejected. These results were not consistent with monetarist view and with the earlier empirical studies, but with a structuralist view of the Bangladesh economy.

Hoque (1990) examined the determining factors of inflation to assess the relative importance of domestic and overseas influences on inflation in Bangladesh using data for the period 1969-70 to 1986-87. Hoque used the expectation augmented version of Philips curve model to explain the determinants of inflation. According to the study, the inflation in Bangladesh was found to be determined by the foreign price inflation to some extent. The results also showed that domestic factors like excess demand, cost-push influence from wage formation process and price expectation had influence on inflation in Bangladesh.

Begum (1991) formulated the inflation model in Bangladesh's context considering both demand and supply side factors and identified significant contributing factors of inflation including agriculture and import bottlenecks, fiscal expenditure, interest rate, bank-loans and expected inflation. The significance of factors, such as import bottlenecks, fiscal expenditure and expected inflation demonstrated the importance of the demand side on inflation in Bangladesh.

However these analyses were based on data when the Bangladesh economy was not liberalized and the exchange rate was the nominal anchor for monetary policy.

Hossain (1995) developed an integrated macroeconomic model of inflation, economic growth and the Balance of payments for Bangladesh for the period 1974 -85. He basically tested two major hypotheses: (1) is inflation in Bangladesh a monetary phenomenon? And (2) is inflation in Bangladesh consistent with the trade deficits and real inflow of foreign resources. While developing a model, he carefully combined the elements of both structuralist and monetarist theories. The model was then applied to policy analysis. The empirical results of the model support the twin hypotheses that inflation in Bangladesh was a monetary phenomenon and that the persistent trade deficits were ‘‘inherent in both its foreign aid based development strategy and its overvalued exchange rate policy. The policy experience reinforced a prior expectation that restrictive monetary and fiscal policy might lower inflation and prevent a price spiral originating from the sup-ply shock’’.

Khanam and Rahman (1995) looked into the causes of inflation in Bangladesh and found out their relative strength and significance by estimating an appropriate inflation function, through model specification process for the period of 1972-73 to 1991-92. They took a few representative variables from both supply side and demand side of the economy. The supply side variables were the growth rate of unit price indices of import, the growth rate of indices of nominal wage rate and the growth rate of output levels while the demand side variables were the growth rate of aggregate supply of money, the growth rate of government development expenditures, the growth rate of domestic savings, the growth rate of remittances and the growth rate of population. The ordinary least squares (OLS) method was used to examine the causative factors of inflation. The growth rate of import prices and money wages found to be significant to influence of Bangladesh during 1972-73 to 1991-92 periods and the growth rate of money wages found to be more powerful than that of import prices. But the demand side variables were insignificant to had influence on the rate of growth of prices.

Hossain (1996) also examined the relationship between money supply growth and inflation in Bangladesh for the period of 1972-1989. In this study, narrow money (M_1) and broad money (M_2) were used as independent variables and wholesale price index as dependent variable. The study also tested a co integral relationship between the stock of money supply and the price level and Granger causality test. According to this study, the possibility of co integral relationship between the stock of money supply and the wholesale price index was observed. And Granger causality test suggested that there was unidirectional causality running from money supply growth to inflation for the broad money supply, but not for the narrow money supply. However, the null hypothesis of no causality running from inflation to money supply growth was accepted for both the broad money supply and narrow money supply, meaning that there was no causal relationship between money supply growth and inflation running from inflation to money supply growth.

Akhtaruzzaman (2005) investigated the underlying factors responsible for inflation during the 1973-2002 periods in Bangladesh. Using cointegration and vector error correction modeling technique, he found that the rate of depreciation of the exchange rate, growth of the money supply and deposit interest rate played statistically significant roles in explaining the long-run inflationary process in Bangladesh. He observed that inflation was negatively correlated with real income in Bangladesh economy. He also found that, the increase in GDP, especially the high growth in agricultural output significantly reduced the upward pressure on general price level of the economy. For industrialized countries, the relation between inflation and output gap is expected to be positive following expectation augmented Phillips curve but the relation is expected to be reversed in the case of Bangladesh, a predominantly agricultural economy. An increase in agricultural output due to favorable weather reduced agricultural prices in Bangladesh, the study added.

Ahmed and Mortaza (2005) studied the relationship between inflation and economic growth in the context of Bangladesh using annual data set on real GDP and CPI for the period of 1980-2005. They employed the cointegration and error correction models to study the short-run and long-run relationship between the variables. They also estimated the threshold level or structural break point of inflation in Bangladesh. The results demonstrated that there exists a statistically significant long-run negative relationship between inflation and economic growth and threshold level of inflation is six percent for Bangladesh.

Mortaza (2006) examined empirically the sources of inflation in Bangladesh during 1990-2006. In this study, he used money supply (M_2), deposit rate of interest by scheduled banks, real GDP and exchange rate as the independent variables. He employed the unrestricted vector auto-regressions (VARs) system. He found that money supply and exchange rates had a significant positive influence on inflation in Bangladesh during fiscal year 1990-2006. The study also identified a significant negative relationship between deposit rate of interest and inflation.

Majumder (2006) attempted to examine the impact of cost push or supply side factors on inflation in Bangladesh. He constructed Pearson correlation matrix to find out the relationship between cost variables and inflation in Bangladesh. From the analysis of inflationary trend, he suggested of significance mutual relationship between consumer price inflation and supply side variables such as import cost, oil price hike, and exchange rate and production shocks. But, wage inflation was found to be weakly related to price inflation.

The IMF selected issues paper (2007) on Bangladesh showed the most important factors for Bangladesh inflation were money creation and inflation inertia rather than supply side shocks, such as shortages of domestic food production or rise in international oil price that some other studies emphasized. Among the supply side factors this study found only exchange rate had some significance on the inflation process in Bangladesh.

Osmani (2007) studied the underlying factors using various hypotheses based on economic growth, growth in remittances, global inflation in food prices and the exchange rate policy of Bangladesh. He observed that rising world prices and exchange rate depreciation of Taka against Dollar and Indian Rupee (INR) contributed significantly to inflation in Bangladesh. He was also of the view that economic growth and increased flow of remittances did not contribute to the inflation in Bangladesh in the studied period. Osmani also added that the pressure of growing remittances from the demand side was matched by the extra availability of goods imported using the newly acquired foreign exchange. But the proposition, Osmani observed, was not supported by any empirical evidence.

Afrin (2013) examined the fiscal deficit-CPI inflation relationship in Bangladesh for the period 1974 - 2010. Annual data were used in this study. Afrin used the Autoregressive Distributed Lag (ARDL) cointegration approach suggested by Pesaran and Shin (1995). In her model, the explanatory variables, among others were fiscal deficits, real GDP, inflation expectations and the current floating exchange rate. The study found that fiscal deficits had inflationary effects in the long-run and together with this factor, real GDP, inflation expectations and the current floating exchange rate regime had also impact on the inflation dynamics of Bangladesh. The findings of the study favored more to the fiscal-based inflation theory than previous inflation studies in Bangladesh. The overall findings emphasized on the importance of both the demand and supply side management policies to control inflation in the long-run in Bangladesh.

Ahmed et al. (2013) studied wage price spiral in Bangladesh employing ARDL bound testing approach suggested by Pesaran et al. (2001). They tested five models and found only two functions which showed the sign of cointegration between the variables.

Younus (2014) examined the determinants of the CPI inflation in Bangladesh particularly the impact of the exchange rate through import prices and some macroeconomic variables on the price level using data during 2003-2011, the post floating exchange rate regime. The empirical results showed that the price elasticity of the exchange rate was 0.23 implying that one percent increase in the exchange rate (i.e., depreciation) would increase the price level by 0.23 percent. The price elasticity with respect to broad money supply (M_2), appeared to be 0.32, while the spread between the lending rate and deposits rate had significant and negative influence on the price level in Bangladesh. The study concluded a continuously rising money growth and exchange rate depreciation can provoke a price spiral in the long-run.

In another study, Younus (2014) found that the relationship between inflation and growth was non-linear with an existence of a threshold level of inflation within the range of 7-8 percent. This implied that targeting too low an inflation level (relative to the threshold) would be hurtful for growth in terms of potential cost of forgone output and, at the same time, too high level of inflation would also impede economic growth.

Uddin et al. (2014) examined the causative factors of inflation in Bangladesh by estimating an appropriate inflation function for 1972 to 2012. This study employed Autoregressive Distributed Lagged Model (ARDL) to identify the factors that may influence the consumer price index of Bangladesh. The results of the study showed that the gross domestic product (GDP_t), money supply (M_{2t}), and interest rate (IR_t) of current year of Bangladesh as well as previous year's real exchange rate (RER_{t-1}) and interest rate (IR_{t-1}) have contributed to increase inflation in Bangladesh. It has also been found that current year's real exchange rate (RER_t) in Dollar and previous year's money supply (M_{2t}) have contributed to decrease the inflation rate. In their study, authors gave emphasis on the only significant variables on the basis of data availability and some important determinants like nominal wage rate (W_t), import price (IMP_t) and oil price (PP_t) among others were ignored in main model.

This survey shows that most of the earlier studies in Bangladesh emphasized on demand-pull (monetary) inflation, adequate importance was not given on cost-push inflation. Moreover, proper stress was not on ARDL cointegration, vector error correction modeling approach rather on simple regressions and correlations as mentioned above, with the notable exception of Akhtaruzzaman (2005), Afrin (2013), Younus (2014), Uddin et al. (2014) among other recent studies. Because of this, it is essential to update the analysis by utilizing current techniques as highlighted in the international studies, of cointegration and error correction mechanism, to give a clearer picture of inflation dynamics in Bangladesh.

3.3 Chapter Summary

This chapter reviews empirical works on different aspects of inflation. The first section of this chapter contains a general survey of works on various aspects of inflation, while the second section reviews some works on Bangladesh.

The general works, that is, works other than on Bangladesh, shed light on large number of issues, and reported a large number of results. These works represent the fascinating development of research on inflation. From this review the determinants of inflation are identified and how these variables cause inflation and is caused by the inflation are also identified.

The growing number of works on inflation in Bangladesh, though still few in number, also shed light on the both demand-pull and cost-push inflation, the two mainstream inflation analyses. In addition, less importance was given on the cost-push inflation analysis and on the ARDL- error correction modeling approach with few exceptions.

In this thesis, adequate emphasis is placed on the cost-push inflation as well, and ARDL cointegration and error correction modeling approach have been also employed. These may give a clearer picture of the aspects of inflation dynamics in Bangladesh.

Chapter 4
Models of Analysis and Econometric Methodology

In the previous chapters, an analysis of inflation in Bangladesh is given and a review of some of the works on inflation is also provided. The current chapter focuses on utilizing the previous experiences to undergo empirical specifications of models and econometric methodology for attaining the objectives of the study.

In the first place, to quantitatively determine the major factors explaining inflation in Bangladesh this chapter presents and explains three basic models of inflation such as monetary model, cost-push model, and the hybrid model in empirical mathematical and econometric form.

Second, different econometric tests and models, such as the unit root tests; cointegration tests, regression analysis using both OLS and the auto regressive distributed lags (ARDL) modeling, and vector error correction modeling (VECM) approach are stated and discussed. Importance is given on the ARDL-VEC modeling for determining both the long-run and short-run equation and relationship between the variables of interest.

Finally, the causality analysis based on Granger causality concept is demonstrated. And the empirical estimates and the analysis are reported in the next chapter based on this modeling.

4.1 Monetarist (Demand-Pull) Model of Inflation

The first model is the well-known monetarist hypothesis popularized by Nobel Laureate Milton Friedman where inflation is determined by the excessive growth rate of nominal money supply over that of real money demand. In this model inflation is purely a monetary phenomenon.

Following Saini (1982, 1984), and Darrat (1986) a monetarist model of inflation has been chosen for the less developed countries and especially for Bangladesh. The model can be explained as the result of excessive growth rate of nominal money supply over that of real money demand. Given a reasonably stable real money demand function, high inflation would then be the outcome of high money supply growth. Therefore, inflation can be defined as:

$$\dot{P} = \dot{M}^s - \left(\frac{M}{P}\right)d \qquad (4.1).$$

Where, $\dot{P}$= rate of inflation, $\dot{M}^s$=rate of change in nominal money supply; and

$$\left(\frac{M}{P}\right)^d = \text{real money demand} = f\,(Y^e\ ,\dot{P}^e, r^e) \qquad (4.2).$$

Here, Y^e = expected real income; $\dot{P}^e$= expected rate of inflation to measure the yield foregone on real assets; r^e= expected rate of interest to measure the yield foregone on financial assets.

Replacing expected real income by current real income, expected rate of inflation by lagged inflation and expected rate of interest by current real rate of interest, we get the following reduced form inflation function from equation 4.1 and 4.2:

$$\dot{P}_t = f(\dot{M}^s, \dot{Y}, \dot{P}_{t-1}, r) \quad (4.3)$$

Based on the above mentioned theoretical background of the monetarist approach to inflation and utilizing the common adaptive expectation scheme to approximate the expectation variables, a simple monetary inflation can be expressed as follows:

$$\dot{P}_t = \beta_0 + \sum \beta_{1i} \dot{M}^s_{t-i} + \sum \beta_{2i} Y_{t-i} + \sum \beta_{3i} \dot{P}_{t-1-i} + \sum \beta_{4i} r_{t-i} + e_t \quad (4.4)$$

Where, $\dot{P}$, $\dot{M}$, $\dot{Y}$ and r denote inflation, growth rate of nominal money supply, growth rate of real income and real interest rates respectively.

For econometric estimation, equation can be written as following log-linear form:

$$\ln P_t = \beta_0 + \beta_1 \ln M_t + \beta_2 \ln Y_t + \beta_3 \ln P_{t-1} + \beta_4 r_t + e_t \quad (4.5).$$

As Bangladesh's financial market is highly underdeveloped, like other underdeveloped and developing countries' financial markets in the world, the effects of changes in money supply are not instantaneously reflected in prices. Therefore M_{t-1} is designed to capture the lagged response of prices to money supply and the common practice is to incorporate one or more lagged values of money supply into the equation (4.6)[15]:

$$\ln P_t = \beta_0 + \beta_1 \ln M_t + \beta_2 \ln Y_t + \beta_3 \ln P_{t-1} + \beta_4 r_t + \beta_5 \ln M_{t-1} + \beta_6 \ln M_{t-2} + e_t \quad (4.6)$$

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[15] Theoretical justification for the inclusion of lagged variables of money supply can be found in the works of Harberger (1963), Saini (1982, 1984), and Masih and Masih (1998).

The monetarist approach to inflation predicts that the current rate of inflation varies, ceteris paribus, positively in relation to the rate of change of money supply and expected rate of inflation while negatively with respect to the growth of the real income. Symbolically, the hypotheses can be written as:

$\partial P_t/\partial M_t$, $\partial P_t/\partial M_{t-1}$, $\partial P_t/\partial M_{t-2}$, $\partial P_t/\partial\ (P_{t-1}/P_{t-1})>0$, and $\partial P_t/\partial Y_t<0$.

The sign of β_4, the coefficient of real interest rate (r) cannot be determined a priori. Because monetarists predict the positive relationship between real interest rate and inflation while Mundel (1963) and Tobin (1965), Darby (1975) and Feldstein (1976), and Stulz (1986) argued negative relationship between the real interest rate and the inflation (Kandel et al., 1996, p. 208).

Equation (4.6) has been estimated with various alternatives to evaluate the monetarist model of inflation in Bangladesh. The equation (4.6) is a demand-pull inflation model.

4.2 Cost-Push Model of Inflation

The second model which appeals most to populists and is well understood in Bangladesh is the cost-push model of inflation where the rate of inflation is determined by cost-push factors such as nominal wage and international fuel prices, and other sources of imported inflation reflected by the import costs, nominal exchange rate changes.

Cost-push inflation was initiated in its various versions by a wage-push from small unions facing an inelastic demand curve for labor, rivalry among groups of unions, profit-push generated through administered pricing, or, more generally, a supply shock (Gordon, 1976, Shapiro, 1987).

The study of inflation from the cost-push point of view is a relatively new analytical development. Fundamental omissions from the monetarist models are structural or cost push elements that cause inflation (Akinboade et.al, 2004). But, it is popularly argued that cost-push factors are no less contributory than demand-pull factors in stimulating inflation in Bangladesh.

An analysis of the inflation trend of recent years is suggestive of significant mutual relationship between inflation and cost-push factors such as import cost, oil price hike, and exchange rate and production shocks (Majumder, 2006).

Several studies also paid considerable attention to the nominal wages and exchange rate impacts, as the major supply-side drivers, on inflation in the papers by Lim and Papi (1997); Mathema (1998); Dlamini et al. (2001); Khan and Schimmelpfennig (2006); Cerisola and Gelos (2009) analyzing inflation dynamics respectively for Mozambique, Turkey, Nepal, Swaziland, Bangladesh, Armenia, Pakistan and Brazil.

Beside, other supply side bottlenecks such as international oil price is also known as the common factors of inflation in developing economies, as discussed by Montiel (1989); Ball and Mankiew (1995); Ubide (1997); and Khan and Schimmelpfennig (2006).[16]

[16] Center for Policy Dialogue (CPD) and Bangladesh Institute of Development Studies (BIDS) have made the argument that the recent increases in inflation in Bangladesh significantly originated from the increase in global price of oil and other imported commodities (See, CPD, 2006 and BIDS, 2006).

Following Javed et al. (2010)[17] and others, the estimating equation in log-linear form can be written as:

$$\ln P_t = \beta_0 + \beta_1 \ln ER_t + \beta_2 \ln W_t + \beta_3 \ln RAW_t + \beta_4 \ln WPP_t + \beta_6 D_t + e_t \quad (4.7)$$

In natural logarithmic form, (4.7) can be written as:

$$\ln P_t = \beta_0 + \beta_1 \ln ER_t + \beta_2 \ln W_t + \beta_3 \ln RAW_t + \beta_4 \ln WPP_t + \beta_5 D_t + e_t \quad (4.8).$$

Where, P, ER, W, RAW, and WPP are consumer price index (CPI), exchange rate, nominal wage index, value of imported raw materials and world oil price respectively. A dummy variable (D) (assume the value of 1 when the natural disaster occurs and otherwise 0), has been used to find out impact of disaster or supply shocks on inflation.

The explanatory variables are expected to have a positive impact on inflation and positive values of β_1, β_2, β_3, β_4, and β_5 are expected, though these cannot be determined a priori.

4.3 Hybrid (Demand-Pull plus Cost-Push) Model of Inflation

The third and more widely accepted model is hybrid model that combines both monetary and cost-push factors.

Following Bruno (1993), Bruno and Melnick (1994), Lim and Papi (1997), and Malesvic-Perovic (2008), a long-run hybrid model for analyzing inflation

[17] Wheat support price (WSP), real GDP is eliminated from the model because of insignificance in the context of Bangladesh.

determinants in Bangladesh has been used. One of the appealing features of the model that it incorporates both the demand-pull and cost-push factors of inflation.

The model starts from the balance between aggregate demand and aggregate supply[18]:

$$Y^d (M/p, P_x/PER; €d) = Y^s (W/p, P_m/PER; €s) \quad (4.9)$$

Where, P denotes the domestic price level, W nominal wages, E the exchange rate (defined as the price of domestic currency in foreign currency), M money supply, P_x the exogenous price of exports, P_m exogenous imported input prices, and €d, €s are random demand and supply shock respectively.

Solving for the price level and taking the natural logs of both sides the following long-run price equation can be yielded[19]:

$$lnP_t = c + \alpha_1 lnM_t + \alpha_2 lnER_t + \alpha_3 lnW_t + \alpha_4 lnP_x + \alpha_5 lnP_{mt} + e_t \quad (4.10)$$

This hybrid model offers a simple representation of an economy in which there are four sectors –goods, money, labor, and external.

In modeling an aggregate inflation function for developing country, several researchers (e.g. Domac and Elbirt, 1998, Dlamini, 2001, Pandey, 2005, Khan and Schimmelpfennig, 2006) incorporated real GDP and interest rate as the

[18] As in Bruno and Melnick (1994), standard aggregate demand (AD) and supply (AS) functions are assumed to determine long-run equilibrium level for domestic prices. The AD schedule is derived from the standard open economy IS-LM framework, where interest rates have been substituted from the model. The AS schedule is obtained from a three factors production function.

[19] There are however, generally three functional forms dominating the literature: linear-additive, log-linear and linear-no additive. There is general consensus that the log linear version is the most appropriate functional form (Sahadudhhen, 2012).

explanatory variables in their models among other variables. So, adding the variables in the equation (4.10), the following estimable inflation equation can be written as[20]:

$$lnP_t = c + \delta_1 lnM_t + \delta_2 lnER_t + \delta_3 lnY_t + \delta_4 lnW_t + \delta_5 lnPm_t + \delta_6 r_t + \in_t \quad (4.11)$$

This is the general model used in this study. Here, all the coefficients and variables are as defined, c is a constant parameter, and $\in_t$ is the white noise error term.

The sign of the elasticity coefficients δ_1, δ_2, δ_4, δ_5, are expected to be positive (i.e. δ_1, δ_2, δ_4, and $\delta_5 > 0$), while the sign of δ_3 is expected to be negative (i.e. $\delta_3 < 0$). The sign of the coefficient δ_6 cannot be determined a priori.

Equation (4.11) represents only the long-run equilibrium relationship and may form a cointegration set provided all the variables are integrated of order 1, i.e. I (1).

Today's rate of inflation should also depend on rates of inflation that existed in the recent past, when the rate of inflation is for a year or more, people develop inflationary expectation, which in turn have an inflationary impact on current and future inflation (Pindyck and Rubinfeld, 1981). Incorporating one year lagged inflation into equation 4.11, it can be expressed as:

$$lnP_t = c + \delta_1 lnM_t + \delta_2 lnER_t + \delta_3 lnY_t + \delta_4 lnW_t + \delta_5 lnPm_t + \delta_6 r_t + \delta_7 lnP_{t-1} + \in_t \quad (4.11\ A)$$

[20] Export price has been dropped from the model, because many researchers did not include the variable in case of developing country like Bangladesh.

The short-run dynamic parameters can be obtained by estimating an Error Correction Model (ECM) associated with the long-run estimates. This is written as follows:

$$\Delta \ln P_t = \beta_0 + \sum_{i=1}^{n} \left(\beta_{1i} \Delta \ln P_{t-i}\right) + \sum_{i=0}^{n} \left(\beta_{2i} \Delta \ln M_{t-i} + \beta_{3i} \Delta \ln ER_{t-i} + \beta_{4i} \Delta \ln Y_{t-i} + \beta_{5i} \Delta \ln W_{t-i} + \beta_{6i} \Delta \ln Pm_{t-i} + \beta_{7i} \Delta \ln RDEP_{t-i}\right) + \beta_8 ECM_{t-1} + \in_t \quad (4.12)$$

Here β_1, β_2... β_3 are the short-run dynamic coefficients of the model's convergence to equilibrium, and β_8, the coefficient of error correction term is the speed of adjustment.

4.4 The GDP Growth Model

A simple model for GDP growth has been also estimated that allows for feedback from inflation to GDP growth using VECM. A neoclassical production function of the Cobb-Douglas form can be written in modified form as follows:

$$Y_t = A_t (P_t) L_t^a K_t^{1-a} E_t \quad (4.13)$$

where Y_t is the production of the economy which is GDP at time t. A_t is the total factor productivity (TPF). L_t and K_t are the stock of labor and capital respectively. E_t is exogenous component of growth. P_t is inflation at time t. The impact of inflation and other relevant variables can be captured through A_t component of the production function.

Following Ghosh et al. (1998), and Erbaykal and Okuyan (2008) and taking the natural logs of both sides of the equation (4.13), an estimable long-run growth function can be written as follows: [21]

$$\ln Y_t = \delta_0 + \delta_1 \ln P_t + e_t \qquad (4.14).$$

Equation (4.14) shows only the long-run equilibrium relationship and may form a cointegration set provided all the variables are integrated of order 1, i.e. I (1).

The short-run dynamic parameters can be obtained by estimating an Error Correction Model (ECM) associated with the long-run estimates. This is specified as follows:

$$\Delta \ln Y_t = \alpha_0 + \Sigma^n_{i=1}(\alpha_{1i}\,\Delta \ln Y_{t-i}) + \Sigma^n_{i=0}(\alpha_{2i}\,\Delta \ln P_{t-i}) + \alpha_3 ECM_{t-1} + u_t \qquad (4.15).$$

Here α_1 and α_2 are the short-run dynamic coefficients of the model's convergence to equilibrium or long-run relationship. ECM_{t-1} is lag value of error term that obtained from long-run relationship and α_3 is the speed of adjustment. The details description and source of the variables mentioned above are provided in the data trend chapter.

4.5 Econometric Methodology (Modeling)

Econometric modeling of the study contains unit root tests, OLS regression, cointegration, ARDL cointegration, Granger causality, Toda-Yamamoto causality, Impulse Response Function (IRF), and Variable Decomposition (VDC). These are detailed below.

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[21] Ghosh et al. (1998) argued that inflation growth findings might not be robust once 'conditioning 'variables are included in the regression analysis. Besides conditional variables may themselves be function of the inflation rate. Inclusion of these variables in growth equation may reduce apparent effect of inflation.

4.5.1 The Time Series Econometrics and Tests of Stationarity

In econometric analysis, when time series data are used, the preliminary statistical step is to test the stationary properties of each individual series (Datta and Mukhopadhyay, 2011). To have a meaningful understanding and predictions of the relationship between two or more economic variables using regression technique, it needs that the time series (TS) satisfy some stationary properties.

A time series or a stochastic process is said to be stationary if its mean, variance and auto co-variances (at various lags) are constant over time (i.e., they are time invariant). If Y_t is a stochastic time series, the properties can be written as follows:

$E(Y_t) = \mu$	(constant mean)	(4.16)
$Var(Y_t) = E(Y_t - \mu)^2 = \delta^2$	(constant variance)	(4.17)
$\gamma_k = E[(Y_t - \mu)(Y_{t+k} - \mu)]$	(covariance)	(4.18).

Where, $\gamma_{k,}$ the covariance (or auto covariance) at lag k, is the covariance between the values of Y_t and Y_{t+k}, that is between two Y values k periods apart. If k=0, γ_0 is obtained, which is simply the variance of Y(=δ^2); if k=1, γ_1 is the covariance between two adjacent values of Y. These are the time series properties for stationarity.

Non-stationarity in TS generally arises due to the presence of trends in the data which is stochastic in nature (random walk process) and it confirms that the data has a unit root process. Stochastic behavior of TS is sometimes characterized by what is called drifts (first upward and then downward). Any regression result with non-stationary TS provide spurious relationships between variables and therefore, provide misleading implication of the relationship.

In this case stationarity can be achieved through differencing the variables. The number of differencing required to make the variables stationary is called order of integration.

However, the presence of a deterministic trend indicates that the series has no unit root process and it is a required condition to provide valid economic implication of the empirical results generated from statistical estimation techniques. Therefore, the variables in the economic model are required to be tested for its stationarity property (or unit root) and the order of its long-run integration prior to estimating a statistical relationship among them.

4.5.1.1 Unit Root

A test of stationrity (or nonstationarity) that has become widely popular over the past several years is the unit root test. To explain unit root test, the starting point is

$$Y_t = \rho\, Y_{t-1}+u_t \qquad -1\leq\rho\leq 1 \qquad (4.19).$$

Here u_t is a white noise error term.

If ρ=1, is the case of unit root, (4.19) becomes a random walk with drift, which is known as a non-stationary stochastic process.[22] For theoretical reasons, subtracting Y_{t-1} from both sides of (4.19), (4.19) is manipulated as follows to obtain:

$$Y_t - Y_{t-1} = \rho Y_{t-1} - Y_{t-1} + u_t \qquad (4.20)$$

$$= (\rho - 1) Y_{t-1} + u_t$$

$$\Delta Y_t = \delta Y_{t-1} + u_t \qquad (4.21)$$

Here $\delta = (\rho - 1)$, and Δ is the first difference operator. In practice, instead of (4.20), (4.21) is estimated and tested the (null) hypothesis that $\delta = 0$. If $\delta = 0$, then $\rho = 1$, that is there exists a unit root, meaning that the time series under consideration is non-stationary. But if δ is negative, the Y_t is stationary.[23]

4.5.1.2 Unit Root Tests

To test stationarity (or unit root) of a variable (or a series), the Dickey-Fuller (DF) test is widely applied. The DF test is estimated in the following three different forms.

Y_t is a random walk: $\Delta Y_t = \delta Y_{t-1} + u_t$ (4.22)

Y_t is a random walk with drift: $\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$ (4.23)

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[22] A technical point: if $\rho = 1$, (4.20) can be written as $Y_t - Y_{t-1} = u_t$. Now using the lag operator L, so that $LY_t = Y_{t-1}$, $L^2Y_t = Y_{t-2}$, and so on, (4.21) can be expressed as $(1-L)Y_t = u_t$. The term unit root refers to the root of the polynomial in the lag operator, if (1-L) = 0 is set, then L = 1 is obtained, hence the name unit root.

[23] Since $\delta = (\rho-1)$, for stationarity ρ must be less than one. For this to happen δ must be negative.

Y_t is a random walk with drift around a stochastic trend:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t \qquad (4.24)$$

Here t is the time or trend variable. In each case, the null hypothesis is that $\delta=0$; that is, there is a unit root, meaning that the time series is non-stationary. The alternative hypothesis is that δ is less than zero; that is the time series is stationary (Dickey and Fuller, 1979, pp. 427-431).

However, this test assumes that error terms are uncorrelated. If the error terms are correlated, as quite frequently is the case, then the DF test is not appropriate.

Another popular test, also advanced by Dickey-Fuller, is known as the Augmented Dickey-Fuller (ADF) test. This test takes into consideration the possible relationship between the error terms, that is, the problem of autocorrelation. The ADF test is conducted by "augmenting" the preceding three equations (4.22, 4.23 and 4.24) by adding the lagged values of the dependent variable ΔY_t and the test requires estimation of equations like the following regressions:

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Yt - i + \varepsilon_t \qquad \text{(intercept only)} \qquad (4.25)$$

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Yt - i + \varepsilon_t \quad \text{(trend and intercept)} \quad (4.26)$$

$$\Delta Y_t = \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Yt - i + \varepsilon_t \qquad \text{(no trend, no intercept)} \qquad (4.27).$$

Here Δ is the first difference operator, β_1 is the intercept (constant), t denotes a linear time trend (optional exogenous or deterministic variables), and β_2, δ and α are the coefficients where $\delta = \rho-1$. The random variable ε_t is a normally distributed white noise error term, that follows some classical assumptions as follows:

E $(\varepsilon_t) = 0$, Var $(\varepsilon_t) = \sigma_2$ and Cov $(\varepsilon_t, \varepsilon_{t-1}) = 0$ (that is the residual series ε_t is free of any significant autocorrelation and is normally distributed with zero mean and constant variance).

The lag length m is set so as to ensure that any autocorrelation in ΔY_t is absorbed, and the error term is distributed as white noise. In equations (4.25, 26, 27) we test the null hypothesis that the series Y_t have unit roots that is H0: $\delta= 0$ $(\rho=1)$ against the alternative H1: $\delta \neq 0$ by comparing the calculated tau (τ)-ratio (severer the than conventional t-ratio) of δ with critical values based on the simulations response surface in Mackinnon (1991 and 1996) which are essentially adjusted t-values. If the absolute value of the calculated τ-ratio is greater than the critical value, then the H0 of a unit root (non-stationarity) is rejected and the time series Y_t can be defined as integrated of order zero, I (0) in levels and hence, treated as stationary.

However, with a high degree of autoregression, the ADF tests are unable to discriminate well between non-stationary and stationary series. It is therefore possible that Y_t, which is likely to be highly autocorrelated, is in fact stationary although the ADF tests show that it is non-stationary. The ADF tests may also incorrectly indicate that the Y_t series contain a unit root when there is a structural break in the series.

In consequence, the Phillips-Perron (PP) test (Phillips and Perron, 1988) is applied. The PP test has an advantage over the ADF test as it gives robust estimates when the series has serial correlation and time-dependent heteroscedasticity, and there is a structural break. The test detects the presence of a unit root in Y_t series by estimating the following regression:

$$\Delta Y_t = \alpha + \rho Y_{t-1} + u_t \quad (4.28)$$

$$\Delta Y_t = \alpha + \beta t + \rho Y_{t-1} + u_t \quad (4.29)$$

Here the second equation includes a trend variable. The PP test is verified by the t value associated with the estimated coefficient of ρ. The series will be stationary if ρ is negative and significant.

Monte Carlo simulations show that the power of the various DF tests can be very low (Enders, 2010, p. 234). Maddala and Kim (1998, p. 107) comment that the DF test does not have serious size distortions, but it is less powerful than the PP test. Choi and Chung (1995) assert that for low frequency data like mine the PP test appears to be more powerful than the ADF test. Accordingly, we adopt the PP methodology to test unit roots in the variables and also to see whether the same conclusions can be achieved. If the results will be conflicted, PP test will be preferred due to the limitation of ADF test.

We have also applied a more efficient univariate DF-GLS test for autoregressive unit root recommended by Elliot, Rothenberg, and Stock (ERS, 1996). The test is a simple modification of the conventional augmented Dickey-Fuller (ADF) *t*-test as it applies generalized least squares (GLS) de-trending prior to running the ADF test regression.

Compared with the ADF tests, the DF-GLS test has the best overall performance in terms of sample size and power. It "has substantially improved power when an unknown mean or trend is present" (ERS, p.813). The test regression included both a constant and trend for the log-levels and a constant with no trend for the first differences of the variables.)

4.5.2 Ordinary Least Square (OLS) Estimation of the Regression Models

If y is dependent variable and x_1, x_2, x_3…, x_n are independent variables, then a population regression model is as follows:

$$Y = B_0+B_1 x_1+B_2 x_2+B_3 x_3 +\ldots+ B_n x_n +u, \quad (4.30)$$

while sample regression model of the population regression model is

$$Y = b_0+ b_1 x_1+ b_2 x_2+ b_3 x_3 +\ldots+b_n x_n +e \quad (4.31).$$

Here, sample regression line is an estimator of population regression line. Population regression line (which is almost impossible or time and money consuming to estimate) will be estimated from sample regression line. For example, b_1, b_2, b_3,… b_n, are estimators of B_1, B_2, B_3,…, B_n. Here, u is the residual for population regression line while e is the residual for sample regression line, e is the estimator of u. We want to know the nature of u from e.

4.5.3 Testing Cointegration

The concept of cointegration was developed by Engle and Granger in 1987. Cointegration means that despite being individually non-stationary a linear combination of two or more time series can be stationary. It tells us about the presence of long-run relation among two or more variables. When cointegration is run, it is assumed that all variables are non-stationary and they are all integrated in the same order.

There are two important tools to identify whether there exists a long-run relationship or cointegration among variables. They are: Engle-Granger's residual based test and Johansen –Juselius (JJ) test. Since Engle-Granger's test suffers from some shortcomings, Johansen –Juselius (JJ) test is preferred for cointegration analysis.

The Johansen and Juselius (1990, 1992) test determine empirically the number of r (maximum k-1) co-integrating vectors from a vector of k endogenous variables in the model along with coefficients of the variables and the adjustment parameters (the elements of α). Johansen's method follows VAR-based cointegration test, considering the following VAR of order p:

$$Y_t = A_1 Y_{t-1} + ... + A_p Y_{t-p} + BX_t + \mu_t \qquad (4.32).$$

Here Y_t is a k-vector of non-stationary I (1) variables, X_t is a d-vector of deterministic variables (such as a constant, or a constant and time trend and so on) and μt is a vector of residuals or innovations. Equation (4.32) can also be rewritten this VAR as (after taking first difference):

$$\Delta Y_t = \Pi\ Yt\text{-}1 + \sum_{i=0}^{p-1} \Gamma i\ \Delta Yt\text{-}i + Bxt + \mu t \qquad (4.33)$$

where $\Pi = \sum_{i=0}^{p} Ai - I$; and $\Gamma i = \sum_{j=i+1}^{p} Aj$

Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank r< k, then there exist k x r matrices α and β each with rank r such that $\Pi = \alpha\ \beta'$ and $\beta' Y_t$ is I(0). r is the number of co-integrating relations (the co-integrating rank) and each column of β is the co-integrating vector. Here, the elements of α are known as the adjustment parameters in the VEC model. Johansen's method is to estimate the Π matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of Π.

Johansen (1988) suggested two tests, trace and maximum Eigen value for estimating the number of co-integrating vector(s) as follows:

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{n} \ln(1 - \lambda i) \qquad (4.34)$$

and $\lambda_{max}(r, r+1) = -T \ln(1- \lambda_{r+1})$ (4.35).

Here T is sample size and λ is Eigen values. If the estimated statistic (Trace and/ or Max- Eigen value statistic) is greater than the critical value then the relevant null hypothesis is rejected and alternative hypothesis is accepted, meaning that there is a long-run relationship between dependent variable and independent variable (s).

4.5.4 Vector Error Correction (VEC) Models

Once the variables included in the vector autoregressive (VAR) model found to be co-integrated, vector error correction model is used, not VAR model. Indeed vector error correction model is a special type of restricted VAR, is introduced to correct a disequilibrium that may shock the whole system.

In VEC model, the dynamics of both short-run and long-run adjustment is made. VEC model also allows finding out the causal factors that affect our variables.

The basis of VECM is the Granger representation theorem. This theorem states that if the variables are co-integrated, then there must be either a unidirectional or bi-directional long-run relationship between them or the relationship can be represented as vector error correction model and vice versa (Engle and Granger, 1987).

Engle and Granger (1987) proposed a two-stage procedure for estimating VECM. In the first stage, the static long-run cointegration regression is estimated to test cointegration between the variables. If cointegration exists, then the lagged residuals from the static cointegration regression are used as the error correction term in the vector error correction model to estimate the short-run equilibrium relationship between the variables in the second stage.

To take the simplest possible example, we consider a two variable system with one co-integrating equation and no lagged difference terms. The co-integrating equation is

$$Y_t = \beta X_t \qquad (4.36)$$

and the VEC model is

$$\Delta Y_t = \alpha_1 (Y_{t-1} - \beta X_{t-1}) + \varepsilon_{1,t} \qquad (4.37)$$

$$\Delta X_t = \alpha_2 (X_{t-1} - \beta Y_{t-1}) + \varepsilon_{2,t}$$

Let's suppose that there are three variables that we're interested in modeling: a dependent variable, y, and two other explanatory variables, x_1 and x_2. More generally, there will be (k + 1) variables - a dependent variable, and k other variables. A *conventional* VECM for cointegrated data would be of the following form:

$$\Delta y_t = \alpha_0 + \sum \alpha_1 \Delta y_{t-i} + \sum \beta_j \Delta x_{1t-j} + \sum \delta_k \Delta x_{2t-k} + \phi z_{t-1} + \varepsilon_t \qquad (4.38)$$

In this simple model, the only right-hand side variable is the error correction term. Here, z, the "error-correction term", is the OLS residuals series from the long-run "cointegrating regression". In long-run equilibrium, this term is zero. However, if y and x deviate from the long-run equilibrium, the error correction term will be nonzero and each variable adjusts to partially restore the equilibrium relation. The coefficient ϕ_i measures the speed of adjustment of the ith endogenous variable towards the equilibrium and its negative sign indicates that the adjustment is in the direction (Hallam and Zanoli, 1993).

If we now replace the error-correction term, z_{t-1} with the terms y_{t-1}, x_{1t-1}, and x_{2t-1} into equation (4.38), following *unrestricted* ECM or *unconstrained* ECM is formulated.

$$\Delta y_t = \alpha_0 + \sum \alpha_1 \Delta y_{t-i} + \sum \beta_j \Delta x_{1t-j} + \sum \delta_k \Delta x_{2t-k} + \theta_0\, y_{t-1} + \theta_1\, x_{1t-1} + \theta_2\, x_{2t-1} + \varepsilon_t \qquad (4.39)$$

Pesaran et al. (2001) call this a "conditional ECM".

The major advantage of VECM is that all variables are stationary in the model. It ensures that no information on the levels of variables is ignored by the inclusion of the disequilibrium terms because; the VECM is developed to measure any dynamic adjustments between the first differences of the variables. It eliminates trends from the variables and resolved the problem of spurious results.

4.5.5 Auto Regressive Distributed Lags (ARDL) Model: Bounds Tests

In more recent times ARDL regression models have been shown to provide a very valuable vehicle for testing for the presence of long-run relationships between economic time-series. To model the relationship between time-series variables, taking into account any unit roots and/or cointegration associated with the data. There are three straightforward situations that we're going to put to one side, because they can be dealt with in standard ways:

Firstly, if all of the series are I(0), and hence stationary. In this case, we can simply model the data in their levels, using OLS estimation.

Secondly, if all of the series are integrated of the same order (e.g., I (1)), but they are not cointegrated. In this case, we can just (appropriately) difference each series, and estimate a standard regression model using OLS.

Thirdly, if all of the series are integrated of the same order, and are cointegrated. In this case, we can estimate two types of models: (i) An OLS regression model using the levels of the data. This will provide the long-run equilibrating relationship between the variables. (ii) An error-correction model (ECM), estimated by OLS. This model will represent the short-run dynamics of the relationship between the variables.

But, if some of the variables in question may be stationary, some may be I (1) or even fractionally integrated, and there is also the possibility of cointegration among some of the I (1) variables. In other words, things just aren't as clear cut as in the three situations noted above. In such cases if we want to model the data appropriately and extract both long-run and short-run relationships, we need the ARDL modeling approach.

4.5.5.1 ARDL Model Specification

Since in our models, some of the variables in question are stationary, some are I (1) or even fractionally integrated, and there is also the possibility of cointegration among some of the I (1) variables. So, to empirically analyze the long-run relationships and dynamic interactions among the variables of interest, the model has been estimated by using the bounds testing or ARDL cointegration procedure, developed by Pesaran et al. (2001).

The procedure is adopted for the following three reasons. Firstly, the bounds test procedure is simple. As opposed to other multivariate cointegration techniques such as Johansen and Juselius (1990), it allows the cointegration relationship to be estimated by OLS once the lag order of the model is identified. Secondly, the bounds testing procedure does not require the pre-testing of the variables included in the model for unit roots unlike other techniques such as the Johansen approach. It is applicable irrespective of whether the regressors in the model are purely I (0), purely I (1) or mutually cointegrated. Thirdly, the test is relatively more efficient in small or finite sample data sizes as is the case in this study. The procedure will however crash in the presence of I (2) series.

Following Pesaran et al. (2001) as summarized in Choong et al. (2005), we apply the bounds test procedure by modeling the long-run equation (4.39) as a general vector autoregressive (VAR) model of order p, in z_t :

$$z_t = c_0 + \beta_t + \sum_{i=1}^{p} \phi_i \, z_{t-i} + \epsilon_{t,} t = 1, 2,3 \dots, T \qquad (4.40).$$

Here c_0 representing a (k+1)-vector of intercepts (drift), and β denoting a (k+1)-vector of trend coefficients.

Pesaran et al. (2001) have derived further the following vector equilibrium correction model (VECM) corresponding to (4.40):

$$\Delta z_t = c_0 + \beta_t + \Pi z_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta \, z_{t-i} + \epsilon_{t,} t = 1, 2 \dots, T \qquad (4.41).$$

Here the $(k+1)$x$(k+1)$-matrices $\Pi = I_{k+1} + \sum_{i=1}^{p} \Psi_{\mathrm{i}}$ and $\Gamma_{\mathrm{i}} = -\sum_{j=i+1}^{p} \Psi_{\mathrm{j}}, \mathrm{i} = 1, 2, \ldots, \mathrm{p} - 1$ contain the long-run multipliers and short-run dynamic coefficients of the VECM. z_t is the vector of variables y_t and x_t respectively. y_t is an I(1) dependent variable defined as $\ln y_t$ and x_t =[M, W, Y, ER, Pm, R] is a vector matrix of 'forcing' I(0) and I(1) regressors as already defined with a multivariate identically and independently distributed (i.i.d) zero mean error vector $\epsilon_t = (\epsilon_{1t}, \epsilon_{2t}{}')$, and a homoskedastic process.

Further assuming that a unique long-run relationship exists among the variables, the conditional VECM (4.41) now becomes:

$$\Delta \mathrm{y_t} = c_{y0} + \beta_t + \delta_{\mathrm{yy}} y_{\mathrm{t-1}} + \sum_{i=1}^{p-1} \lambda_{\mathrm{i}} \Delta\, y_{\mathrm{t-i}} + \sum_{i=0}^{p-1} \xi_{\mathrm{i}} \Delta\, x_{\mathrm{t-1}} + \epsilon_{\mathrm{yt},} \mathrm{t} = 1, 2, \ldots, \mathrm{T} \qquad (4.42)$$

On the basis of equation (4.42), the conditional VECM of interest can be specified as:

$$\Delta \mathrm{lnP_t} = c_0 + \delta_1 \mathrm{ln} P_{\mathrm{t-1}} + \delta_2 \mathrm{ln} M_{\mathrm{t-1}} + \delta_3 \mathrm{ln} ER_{\mathrm{t-1}} + \delta_4 \mathrm{ln} Y_{\mathrm{t-1}} + \delta_5 \mathrm{ln} W_{\mathrm{t-1}} + \delta_6 \mathrm{ln} Pm_{\mathrm{t-1}} + \delta_7 RDEP_{\mathrm{t-1}} + \sum_{i=1}^{n} \left(\beta_{1i} \Delta \mathrm{lnP}_{t-i}\right) + \sum_{i=0}^{n} \left(\beta_{2i} \Delta \mathrm{lnM}_{t-i} + \beta_{3i} \Delta \mathrm{lnER}_{t-i} + \beta_{4i} \Delta \mathrm{lnY}_{t-i} + \beta_{5i} \Delta \mathrm{lnW}_{t-i} + \beta_{6i} \Delta \mathrm{lnPm}_{t-i} + \beta_{7i} \Delta \mathrm{lnRDEP}_{t-i}\right) + \epsilon_{\mathrm{t},} \qquad (4.43).$$

Here δ_i is the long-run multipliers, c_0 is the drift, and ϵ_t, is white noise errors.

4.5.5.2 Bounds Testing Procedure

The first step in the ARDL bounds testing approach is to estimate equation (4.43) by ordinary least squares (OLS) in order to test for the existence of a long-run relationship among the variables by conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables, i.e., H_N: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$ against the alternative H_A: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7 \neq 0$.

We denote the test which normalizes on P by F_P (P\M, W, Y, ER, Pm, R). Two asymptotic critical values bounds provide a test for cointegration when the independent variables are I (d) (where $0 \leq d \leq 1$): a lower value assuming the regressors are I (0), and an upper value assuming purely I (1) regressors.

If the F-statistic is above the upper critical value, the null hypothesis of no long-run relationship can be rejected irrespective of the orders of integration for the time series. Conversely, if the test statistic falls below the lower critical value the null hypothesis cannot be rejected.

Finally, if the statistic falls between the lower and upper critical values, the result is inconclusive. The approximate critical values for the F-test were obtained from Pesaran and Pesaran (1997, p. 478).

In the second step, once cointegration is established the conditional ARDL long-run model for P_t can be estimated as:

$$\ln P_t = c_0 + \sum_{i=1}^{n}(\delta_{1i}\ln P_{t-i}) + \sum_{i=0}^{n}(\delta_{2i}\ln M_{t-i} + \delta_{3i}\ln ER_{t-i} + \delta_{4i}\ln Y_{t-i} + \delta_{5i}\ln W_{t-i} + \delta_{6i}\ln Pm_{t-i} + \delta_{7i}\ln RDEP_{t-i}) + \epsilon_t \quad (4.44)$$

Where, all variables are as previously defined. This involves selecting the orders of the ARDL model in the seven variables using Akaike information criteria (AIC).

In the third and final step, we obtain the short-run dynamic parameters by estimating an error correction model associated with the long-run estimates. This is specified as follows:

$$\Delta\ln P_t = \beta_0 + \sum_{i=1}^{n}(\beta_{1i}\Delta\ln P_{t-i}) + \sum_{i=0}^{n}(\beta_{2i}\Delta\ln M_{t-i} + \beta_{3i}\Delta\ln ER_{t-i} + \beta_{4i}\Delta\ln Y_{t-i} + \beta_{5i}\Delta\ln W_{t-i} + \beta_{6i}\Delta\ln Pm_{t-i} + \beta_{7i}\Delta\ln RDEP_{t-i}) + \beta_8 ECM_{t-1} + \epsilon_t \quad (4.45).$$

Here β_1, β_2... β_7 are the short-run dynamic coefficients of the model's convergence to equilibrium, and β_8, the coefficient of error correction term is the speed of adjustment.

4.5.6 Causality Test

After testing for a unit root, cointegration, and applying a vector error correction model, the Granger causality test can be adopted to further detect the nature of relationships between money supply growth and inflation, wage growth and inflation, and inflation and GDP growth. Granger causality test provides important information of the causal direction between the variables.

The Granger causality approach measures the precedence and information provided by a variable (X) in explaining the current value of another variable(Y) (Gujarati, 2003, p. 696, Konya and Singh, 2006, p. 8).[24] It says that Y is said to be granger-caused by X if X helps in predicting the value of Y. In other words, the lagged values of X are statistically significant. Even if a variable (X) "Granger-causes" another variable (Y), it does not mean that X is exogenous. The null hypothesis (H_0) test is that X does not granger-cause Y and Y does not granger-cause X.

For inflation (P) and money supply (M) causality, the test involves estimating the following pair of regressions:

$$P_t = \sum_{i=1}^{n} \alpha_i M_{t-i} + \sum_{j=1}^{n} \beta_j P_{t-j} + u_{1t} \quad (4.46)$$

$$M_t = \sum_{i=1}^{n} \lambda_i M_{t-i} + \sum_{j=1}^{n} \delta_j P_{t-j} + u_{2t} \quad (4.47)$$

Similarly for inflation (P) and nominal wage (W) causality, the pair of regressions

$$P_t = \sum_{i=1}^{n} \alpha_i W_{t-i} + \sum_{j=1}^{n} \beta_j P_{t-j} + u_{1t} \quad (4.48)$$

$$W_t = \sum_{i=1}^{n} \lambda_i W_{t-i} + \sum_{j=1}^{n} \delta_j P_{t-j} + u_{2t} \quad (4.49)$$

For inflation and GDP causality, we have

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[24] "The concept of Granger causality, more precisely precedence, is based on the idea that a cause cannot come after its effect. More precisely, variable X is said to Granger- cause another variable, Y, if the future value of Y (y_{t+1}) is conditional on the past values of X (x_{t-1}, x_{t-2} ... x_0) and thus the history of X is likely to help predict Y" (Konya and Singh, 2006, p. 8).

$$P_t = \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{j=1}^{n} \beta_j P_{t-j} + u_{1t} \quad (4.50)$$

$$Y_t = \sum_{i=1}^{n} \lambda_i Y_{t-i} + \sum_{j=1}^{n} \delta_j P_{t-j} + u_{2t} \quad (4.51).$$

Gujarati (2003) has described following cases:

i) Unidirectional causality: if, the coefficient, $\sum\alpha_i \neq 0$ statistically, but the coefficient, $\sum\delta_j = 0$, conversely, $\sum\alpha_i = 0$ statistically, but $\sum\delta_j \neq 0$.

ii) Feedback or bilateral causality: if both the coefficients, $\sum\alpha_i \neq 0$ and $\sum\delta_j \neq 0$ are statistically significantly different from zero in both the regressions.

iii) Finally, independence: if both the coefficients are not statistically significant (i.e., $\sum\alpha_i = \sum\delta_j = 0$) in both the regressions.

4.5.7 The Toda-Yamamoto Approach to Granger Causality Test

Many of the time series studies have attempted to conduct cointegration and causality test between inflation and GDP growth have two basic limitations. In the first place, the methodology used to test long-run cointegration relationship requires that both the series to be integrated of order one or I(1) and any inference that can be made about the inflation and GDP growth nexus is conditional on the assumption that both the series are I(1). If the series are not I(1), or are integrated of different orders, no test for a long-run relationship is usually carried out. Moreover as demonstrated by Toda and Yamamoto (1995), the conventional F-statistic used to test for Granger causality may not be valid as the test does not have a standard distribution when the time series data are integrated or cointegrated (Giles and Williams, 1999; Toda and Yamamoto, 1995).

For the causality test a modified Wald test (MWALD) is used as propose by Toda and Yamamoto (1995) that avoids the problems associated with the ordinary Granger causality test outlined above by ignoring any possible non-stationary and guarantees the asymptotic distribution of the Wald statistic (an asymptotic $\chi 2$-distribution), since the testing procedure is robust to the integration and cointegration properties of the process.

The Toda and Yamamoto (1995) approach fits a standard vector autoregressive model in the levels of the variables (rather than first differences, as the case with Granger causality test) thereby minimizing the risks associated with the possibility of wrongly identifying the order of integration of the series (Mavrotas and Kelly, 2001). The basic idea of this approach is to artificially augment the correct VAR order, k, by the maximal order of integration, say d_{max}. Once this is done a $(k+d_{max})$th order of VAR is estimated and the coefficient of last lagged d_{max} vector are ignored (see Caporale and Pittis, 1999; Rambaldi and Doran, 1996). The application of the Toda and Yamamoto (1995) procedure ensures that the usual test statistic for Granger causality has the standard asymptotic distribution where valid inference can be made.

To undertake the Toda and Yamamoto (1995) version of the Granger non-causality test, we represent the inflation (P_t) and real GDP (Y_t) in the following VAR system:

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1,i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2,j} Y_{t-j} + \sum_{i=1}^{k} \lambda_{1,i} P_{t-i} + \sum_{j=k+1}^{d_{max}} \lambda_{2,j} P_{t-j} + v_1 \qquad (4.51.1)$$

$$P_t = \delta_0 + \sum_{i=1}^{k} \delta_{1,i} P_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{2,i} P_{t-j} + \sum_{i=1}^{k} \theta_{1,i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \theta_{2,j} Y_{t-j} + \nu_2 \quad (4.51.2)$$

Where α, δ, λ and θ are parameters of the model. d_{max} is the maximum order of integration suspected to occur in the system; $\nu_1 \sim N(0, \Sigma v_1)$ and $\nu_2 \sim N(0, \Sigma v_2)$ are the residuals of the model and Σv_1 and Σv_2 the covariance matrices of ν_1, and ν_2, respectively. The null of non-causality from inflation to GDP can be expressed as H0: μ_i, $\lambda_{1i} = 0$, $_i = 1, 2... m$. From Eq. (4.51.1), Granger causality from inflation to GDP, implies $\lambda_{1i} \neq 0$; similarly in Eq. (4.51.2), GDP Granger causes inflation, if $\theta_{1i} \neq 0$. The model is estimated using seemingly unrelated regression (SUR) (see, Rambaldi and Doran, 1996).

4.5.8 Impulse Response Function

A shock to the ith variable not only directly affects the ith variable but is also transmitted to all of the other endogenous variables through the dynamic (lag) structure of the VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables.

If the innovations u_t are contemporaneously uncorrelated, interpretation of the impulse response is straightforward. The ith innovation $u_{i,t}$ is simply a shock to the ith endogenous variable $y_{i,t}$. Innovations, however, are usually correlated, and may be viewed as having a common component which cannot be associated with a specific variable. In order to interpret the impulses, it is common to apply a transformation P to the innovations so that they become uncorrelated

$v_t = Pu_t \sim(0, D)$ (4.52)

where D is a diagonal covariance matrix.

4.5.9 Variance Decomposition

While impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VAR, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR.

4.6 Chapter Summary

This chapter is divided into two sections. First section deals with describing different inflation models to determine the macroeconomic determinants of inflation in Bangladesh while the second section presents the econometric models and methodology related to the study.

i) The monetary (demand-pull) model of inflation which is used in this study is described first. It has different versions. The first model shows that the inflation is a function of money supply, real GDP, one period lagged inflation (expectation factor) and real deposit interest rate. The second includes one period lagged money supply into previous equation and the third incorporates two periods lagged money supply into previous equation.

ii) The cost-push inflation model is presented after this, which shows that the inflation is a function of cost-push factors like nominal wage, exchange rate, value of imported raw materials, and world oil price. Besides this, a dummy variable accounts for natural disaster (supply shock) is also included in the cost-push model.

iii) The hybrid inflation model which is a combination of both the demand-pull and cost-push factors, is presented next where inflation is shown as a function of money supply, exchange rate, wage, real GDP, import price, real (deposit) interest rate in the first version, and in the second version previous year inflation (as an expectation factor) is incorporated into first version as a function of inflation.

iv) The modeling strategy adopted in this study also involves different steps. First, the Augmented Dickey-Fuller (ADF), Dickey-Fuller Generalized Least Squares (DF-GLS), and Phillips-Perron (1988) unit-root tests are described which are needed to determine the order of integration of the variables.

v) Second, the cointegration test is presented and illustrated. If the variables are integrated of same order, the Johansen –Juselius (1990, 1992, 1994) maximum likelihood method can be used to obtain the number of cointegrating vector(s).

vi) Third, the ARDL/Bounds testing cointegration approach of Pesaran and Shin (1999) and Pesaran et al. (2001) is discussed. If the variables are not integrated of the same order rather a mixture of I (0) and I (1) but not I (2), the ARDL bounds testing cointegration approach is applied to determine the long-run determinants of inflation.

vii) Fourth, the vector error correction model (VECM) with and without conditional framework is also discussed. If the variables are cointegrated, a VEC model is applied and incase of ARDL cointegration conditional VECM is employed to obtain relationship.

viii) Finally, pair-wise Granger causality, Toda-Yamamoto causality, IRF and VDC are presented and analyzed in brief.

Chapter 5
Data for the Econometric Estimation

This chapter describes the data that have been used for empirical estimation of the various types of inflation equations, for the examination of the causal connection between wage rise and inflation, and money supply growth and inflation, and also for the analysis of impact of inflation on economic growth. Along with a description of the data, analyses of these data are made. This will give a clear picture of their trends in Bangladesh, whose econometric analysis is conducted in the following chapter.

It should be pointed out that the time period of these variables are in terms of a fiscal year as identified by the government of Bangladesh. A fiscal year is the period from mid-July of a year to mid-July of the next year. The variables description along with their sources is provided below.

5.1 Consumer Price Index (CPI) of Bangladesh, 1976-2013

The national consumer price index (NCPI) gives a general measure of price level (P) or inflation in Bangladesh. Using 1995-96 as the base year, Bangladesh Bureau of Statistics (BBS) has computed the CPI. As reported in chapter 2, the index basket used includes a large number of food and non-food commodities and services utilized by the consumers in their daily life. To construct the price index of the base year 1995-96, the commodity and weight of the index basket have been obtained from Household Income Expenditure Survey (HIES), 1995-96.

The consumer price index for the period of 1976-2013 has been presented in Table 5.1. Data on this variable has been collected from various issues of *Statistical Yearbook of Bangladesh* published by the Bangladesh Bureau of Statistics and from various issues of *Monthly Economic Trends* published by the Statistics Department of Bangladesh Bank. Table 5.1contains two columns: first column year and second column CPI.

Table 5.1 reports that there has been an increasing trend of NCPI during the study period. It was 19.18 in 1976, increased to 28.34 in 1980. In fact, it increased gradually during the whole study period and the trend continued even after the end of the period. The consumer price index leveled 100 in 1996, and it rose 124.12 in 2000. It was 153.24 in 2005 and increased continuously to reach the amount 287.14 by the year 2013.

Table 5.1
Consumer Price Index (CPI) of Bangladesh, 1976-2013

Year	CPI (National)
1976	19.18
1977	19.96
1978	22.51
1979	24.03
1980	28.34
1981	30.86
1982	35.61
1983	39.10
1984	42.45
1985	47.29
1986	52.56
1987	58.30
1988	63.65
1989	69.01
1990	71.67
1991	77.63
1992	81.17
1993	83.39
1994	86.12
1995	93.76
1996	100.00
1997	102.52
1998	109.69
1999	119.46
2000	124.12
2001	125.48
2002	130.26
2003	135.97
2004	143.90
2005	153.24
2006	164.21
2007	176.04
2008	193.54
2009	206.43
2010	221.53
2011	241.02
2012	266.61
2013	287.14

Sources: *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics, various issues; *Monthly Economic Trends*, Statistics Department, Bangladesh Bank, various issues.
*Base: 1996=100

5.2 Money Supply of Bangladesh in Current Term, 1976-2013

The trend of broad money and its components for the period 1976 - 2013, have been described in the following pages with the help of table. The money supply (M) is measured by the both narrow money (M_1) and broad money (M_2). Data of these variables have been collected from various issues of *Monthly Economic Trends* published by the Statistics Department of Bangladesh Bank.

The components of broad money (M_2) are the narrow money and time deposits while the components of the narrow money (M_1) are the money outside bank and currency or demand deposits. Table 5.2 reports that during the period of 1976-2013 both the current narrow money and broad money have gone through a steady growth. The current broad money was 1,396.80 crore taka in 1976, then it gradually increased to 12,338.10 in 1986. The trend continued even after the post - liberalization period. In 1996 and 2006, the current broad money rose to 45,690.50 crore taka and 1,80,674.20 crore taka respectively. The growth was continuous and by the year 2013, the amount reached 6,03,505.4 crore taka.

Table 5.2
Money Supply of Bangladesh in Current Term, 1976-2013

Year	Narrow Money (in Crore Taka)	Time Deposit (in Crore Taka)	Broad Money (in Crore Taka)	M_2 Growth (in Percent)
1976	882.10	514.70	1396.80	10.89
1977	972.80	767.00	1739.80	24.56
1978	1224.10	916.90	2141.00	23.06
1979	1524.80	1235.20	2760.00	28.91
1980	1731.80	1513.10	3244.90	17.57
1981	1986.30	2149.70	4136.00	27.46
1982	2012.10	2536.60	4548.70	9.98
1983	2635.30	3263.90	5899.20	29.69
1984	3549.90	4835.90	8385.80	42.15
1985	4231.80	6302.40	10534.20	25.62
1986	4927.90	7410.20	12338.10	17.12
1987	5262.80	9090.30	14353.10	16.33
1988	5047.70	11360.30	16408.00	14.32
1989	5460.70	13617.40	19078.10	16.27
1990	6368.70	15928.90	22297.60	16.88
1991	7203.70	17800.70	25004.40	12.14
1992	8257.20	20268.70	28526.00	14.08
1993	9062.60	22473.00	31535.60	10.55
1994	11167.10	25235.90	36403.00	15.43
1995	13179.40	29032.90	42212.30	15.96
1996	14459.40	31231.10	45690.50	8.24
1997	15167.00	35460.30	50627.50	10.81
1998	15888.50	39980.50	55869.10	10.35
1999	17249.40	45777.30	63027.10	12.81
2000	19881.30	54881.10	74762.40	18.62
2001	22347.40	64826.80	87174.20	16.60
2002	24161.10	74454.90	98616.00	13.13
2003	26743.20	87251.10	113994.50	15.59
2004	30448.00	99273.70	129721.20	13.80
2005	35404.10	116042.30	151446.40	16.75
2006	42652.30	138021.90	180674.20	19.30
2007	50168.00	161336.20	211504.40	17.06
2008	59314.40	189480.50	248794.90	17.63
2009	66426.90	230073.00	296499.70	19.17
2010	87988.30	275042.80	363031.20	22.44
2011	103101.10	337418.90	440519.90	21.34
2012	109721.40	407388.10	517109.50	17.39
2013	123603.10	479902.30	603505.40	16.71

Source: *Monthly Economic Trends*, Statistics Department, Bangladesh Bank, various issues.

The fifth column of the Table 5.2 shows the growth of the current broad money. It was around 11 percent in 1976 and it was quite high, above 23 percent during 1977 -1985 except the year 1980 and 1982. In 1980 and 1982 it was 17.57 and 9.98 respectively. During the period 1986-2013 the growth rate of broad money ranged between 10 to 20 percent except 1996, 2010 and 2011. In 1996 it was the lowest, 8.24 percent. In 2010 and 2011, it was 22.44 percent and 21.34 percent respectively, it crossed 20 percent level. The highest growth was observed in 1984, 42.15 percent.

5.3 GDP Deflator Series

The GDP deflator enables us to scale down inflationary effect by dividing a series by it. The series is then expressed in real terms instead of nominal terms. The GDP deflator, which is used for different computation is given below.

Table 5.3 reports the data for GDP deflator series for the period 1976-2013. Data of the series has been collected from various issues of *Statistical Yearbook of Bangladesh* and *Monthly Economic Trends*. The base year for the study is 1996.

Table 5.3
GDP Deflator Series

Year	GDP Deflator
1976	19.61
1977	18.98
1978	23.85
1979	26.84
1980	31.56
1981	34.88
1982	38.26
1983	45.51
1984	47.35
1985	52.63
1986	56.84
1987	63.02
1988	67.81
1989	73.57
1990	78.24
1991	83.4
1992	85.88
1993	86.12
1994	89.37
1995	95.94
1996	100
1997	103.09
1998	108.53
1999	113.58
2000	115.69
2001	117.53
2002	121.28
2003	126.77
2004	132.15
2005	138.86
2006	146.04
2007	155.95
2008	169.65
2009	180.72
2010	192.42
2011	206.91
2012	223.46
2013	239.32

Sources: *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics various issues; *Bangladesh Economic Review*, Government of Bangladesh, various issues; *Monthly Economic Trends*, Statistics Department, Bangladesh Bank, various issues.
*Base: 1996=100

The GDP deflator series shows that in 1976 it was 34.88. It was 56.84 in 1986. It levelled 100 in 1996, which is the base year of the study. After another ten years, the GDP deflator increased to 146.04 in the year 2006. Finally, in 2013, the end year of our study, it reached 239.32.

5.4 Money Supply of Bangladesh in Real Term

Data on real money supply has been derived by deflating the current money supply by the GDP deflator. The data given below in Table 5.4 shows the trend of narrow money, time deposit and broad money in real term. Data in nominal term of these variables have been deflated by the GDP deflator series to have these in real term.

Table 5.4 reports the real narrow money and broad money supply. Both the money supply followed a quite steady increase during the study period with some early fluctuations. The real broad money supply was 7,122.89 crore taka in 1976, then gradually increased to 21,706.72 crore taka in 1986 and 45,690.50 crore taka in 1996. In another ten years it rose rapidly and was 1,23,749.50 crore taka in 2006, almost three times than that of in 1996. After that, it continued to rocket and get to 2,52,512.70 crore taka in 2013.

Table 5.4
Money Supply of Bangladesh in Real Crore Taka

Year	Narrow Money (in Real Crore Taka)	Time Deposit (in Real Crore Taka)	Broad Money (in Real Crore Taka)
1976	4498.21	2624.68	7122.89
1977	5125.39	4041.09	9166.49
1978	5132.49	3844.44	8976.93
1979	5681.07	4602.08	10283.16
1980	5487.32	4794.36	10281.69
1981	5694.66	6163.13	11857.80
1982	5259.01	6629.90	11888.92
1983	5790.59	7171.83	12962.43
1984	7497.14	10213.09	17710.24
1985	8040.66	11974.92	20015.58
1986	8669.77	13036.95	21706.72
1987	8351.00	14424.47	22775.47
1988	7443.88	16753.13	24197.02
1989	7422.45	18509.45	25931.90
1990	8139.95	20359.02	28498.98
1991	8637.53	21343.76	29981.29
1992	9614.81	23601.19	33216.12
1993	10523.22	26094.98	36618.21
1994	12495.36	28237.55	40732.91
1995	13737.13	30261.52	43998.64
1996	14459.40	31231.10	45690.50
1997	14725.24	34427.48	49152.91
1998	14576.61	36679.36	51256.06
1999	15131.05	40155.53	55286.93
2000	17139.05	47311.29	64450.34
2001	18938.47	54937.97	73876.44
2002	19967.85	61532.98	81500.83
2003	21057.64	68701.65	89759.45
2004	23066.67	75207.35	98273.64
2005	25470.58	83483.67	108954.20
2006	29213.90	94535.55	123749.50
2007	32158.97	103420.60	135579.70
2008	34890.82	111459.10	146349.90
2009	36699.94	127112.20	163812.00
2010	45827.24	143251.50	189078.80
2011	49807.29	163004.30	212811.50
2012	48765.07	181061.40	229826.40
2013	51716.78	200795.90	252512.70

Source: *Monthly Economic Trends*, Statistics Department, Bangladesh Bank, various issues.

5.5 Nominal and Real GDP of Bangladesh, 1976 -2013

The trend of nominal GDP and real GDP during 1976-2013 has been shown in the Table 5.5. The real GDP (Y) series has been calculated from nominal GDP series and deflated by the GDP deflator series. The data of this variable has been collected mainly from various issues of *Bangladesh Economic Review* and *Economic Trends.*

Table 5.5 contains three columns, year, nominal GDP and real GDP. Second column of the Table reports that nominal GDP of Bangladesh has gone up through a steady increase during 1976-2013 except the year 1977. It was 15,023.90 crore taka in 1976, and from the year of 1978 it gradually increased to 1,66,324 crore taka in 1996. The nominal GDP has grown sharply in Bangladesh from 1997 to 2013 and it has increased to 10,37,987 crore taka at the end of the year 2013.

The third column of the Table 5.5 gives information on real GDP of Bangladesh from 1976-2013. Table 5.5 shows that real GDP has also gone up steadily during the study period. In 1976, real GDP was taka 76,797.55 crore taka and then gradually increased to 110184.8 crore taka in 1986. It has increased at quite similar rate during 1987-2013. As it can also be seen from the Table, the real GDP reached to a peak 4,33,720 crore taka at the end of the year 2013.

Table 5.5
Nominal and Real GDP of Bangladesh, 1976-2013

Year	Nominal GDP (in Crore Taka)	Real GDP (in Crore Taka)
1976	15023.90	76797.55
1977	14930.30	77811.59
1978	20082.00	82728.97
1979	23690.70	86808.60
1980	28077.70	87932.89
1981	32213.60	93908.73
1982	36174.00	94634.72
1983	40830.80	98065.97
1984	48978.70	102194.50
1985	56194.40	105638.30
1986	63269.10	110184.80
1987	72771.10	114850.00
1988	79992.90	118130.90
1989	89059.80	121138.50
1990	100329.00	129193.60
1991	110518.00	133645.40
1992	119542.00	139245.70
1993	125369.00	145575.90
1994	135412.00	151518.40
1995	152518.00	158972.30
1996	166324.00	166324.00
1997	180701.00	175284.70
1998	200177.00	184443.90
1999	219697.00	193429.30
2000	237086.00	204932.10
2001	253546.00	215728.80
2002	273201.00	225264.70
2003	300580.00	237106.60
2004	332973.00	251965.90
2005	370707.00	266964.60
2006	415728.00	284667.20
2007	472477.00	302967.00
2008	545822.00	321726.00
2009	614795.00	340197.00
2010	694324.00	360845.00
2011	796704.00	385050.00
2012	914784.00	409053.00
2013	1037987.00	433720.00

Sources: *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics, various issues; *Bangladesh Economic Review*, Government of Bangladesh, various issues; *Monthly Economic Trends*, Statistics Department, Bangladesh Bank, various issues (1972-2013-3).

5.6 Nominal and Real (Deposit) Interest Rate of Bangladesh, 1976-2013

The trend of real interest rate for the period of 1976-2013 has been presented with the help of Table 5.6. The real (deposit) interest rate is the difference between the nominal (deposit) interest rate and the inflation rate in this study. Data on nominal interest rate has been collected from various issues of *World Development Indicators*.

Interest rate of Bangladesh can be divided into two phases. The first phase is the pre-liberalization when the interest rate was kept fixed and changed by the central bank while the second phase is the post-liberalization period when the interest rate became flexible to some extent and attempts was made to limit the central bank's influence.

It can be seen from the second column of the Table 5.6 that the nominal interest rate was 6.75 percent in 1976 and it was 7.00 percent in the following three years. In 1980, it was 8.25 percent, and then it was fixed around at 12 percent from 1981 to 1991. In 1996, it was 7.28 percent, after that it increased steadily with exception couples of years, and finally it arrived at 11.19 percent in 2013.

Fourth column of the Table 5.6 shows the trend of real interest rate in Bangladesh. Since the real interest rate is the difference between the nominal interest rate and the inflation rate, it did not follow any unique pattern of trend rather it fluctuated with the varying rate of inflation.

It is supposed to be a positive relationship between the inflation rate and the nominal interest rate according to theoretical expectation. There seemed to be a cyclical movement of the inflation rate whilst the interest rate was stable during 1976-1989 at 7.00 percent and 1981-1991 at 12.00 percent. However, during 1989-1982, in 1998, 2008, and 2010 nominal deposit interest rate remained higher than the inflation rate prevailing in the same period and this development cannot be explained by theory. In fact, there generated a gap as the inflation rate was falling whilst the deposit interest rate was rising.

Table 5.6
Nominal and Real (Deposit) Interest Rate of Bangladesh, 1976 -2013

Year	Nominal (Deposit) Interest Rate (in Percent)	Inflation Rate (in Percent)	Real (Deposit) Interest Rate (in Percent)
1976	6.75	2.30	4.45
1977	7.00	4.80	2.20
1978	7.00	5.30	1.70
1979	7.00	14.70	-7.70
1980	8.25	13.40	-5.15
1981	12.00	12.50	-0.50
1982	12.00	16.30	-4.30
1983	12.00	9.90	2.10
1984	12.00	9.70	2.30
1985	12.00	10.90	1.10
1986	12.00	10.00	2.00
1987	12.00	10.40	1.60
1988	12.00	11.40	0.60
1989	12.00	8.00	4.00
1990	12.04	9.30	2.74
1991	12.05	8.90	3.15
1992	10.47	5.10	5.37
1993	8.18	1.30	6.88
1994	6.40	1.80	4.60
1995	6.04	5.20	0.84
1996	7.28	4.10	3.18
1997	8.11	4.00	4.11
1998	8.42	8.70	-0.28

Year	Nominal (Deposit) Interest Rate (in Percent)	Inflation Rate (in Percent)	Real (Deposit) Interest Rate (in Percent)
1999	8.74	7.10	1.64
2000	8.56	2.80	5.76
2001	8.50	1.90	6.60
2002	8.17	2.80	5.37
2003	7.82	4.40	3.42
2004	7.11	5.80	1.31
2005	8.09	6.50	1.59
2006	9.11	7.20	1.91
2007	9.18	7.20	1.98
2008	9.65	9.90	-0.25
2009	8.21	6.70	1.51
2010	7.14	7.30	-0.16
2011	10.02	8.80	1.22
2012	11.69	10.60	1.09
2013	11.19	7.97	3.22

Source: *World Development Indicators*, World Bank, various issues.

5.7 Nominal Exchange Rate of Bangladesh, 1976 - 2013

Nominal exchange rate is the official exchange rate of Bangladesh. Table 5.7 reports data on the nominal exchange rate of Bangladesh taka against the US dollar for the periods of 1976-2013.

The annual time series data on nominal exchange rate has been collected from the various issues of *Statistical Year Book* published by Bangladesh Bureau of Statistics. Nominal exchange rate is measured by the Bangladesh taka, which is the local currency of Bangladesh for 12 months average against one US dollar.

It can be seen from Table 5.7 that the nominal exchange rate has gradually increased and the rate of increasing has been observed sometimes to accentuate. It was taka 15.05 against one US dollar in 1976. A negative growth was observed in 1978, when the nominal exchange rate decreased to 15.12 taka from 15.43 taka in

1977 against per US dollar. In 1980 and 1990 it went up gradually to arrive at 15.49 and 32.92 respectively against per US dollar. During the period of late 1990s to 2007 the nominal exchange rate increased at relatively higher rate. It is evident from the Table 5.7 that the highest growth in exchange rate was observed in 2006, when it rose to 67.08 taka from 61.39 taka per US dollar. In 2013, it gained 79.92 from 15.05 in 1976 against an average of one US dollar.

In 38 years of the study period, nominal exchange rate in Bangladesh increased more than 5.31 times. This picture indicates that the external value of money has gone down by 5.31 times and more and more money is needed in exchange of 1 US dollar with gradual increasing in nominal exchange rate in Bangladesh.

Table 5.7
Nominal Exchange Rate of Bangladesh, 1976-2013

Year	Nominal exchange rate (LCU per US$, period average)
1976	15.05
1977	15.43
1978	15.12
1979	15.22
1980	15.49
1981	16.26
1982	20.07
1983	23.8
1984	24.94
1985	25.96
1986	29.89
1987	30.63
1988	31.24
1989	32.14
1990	32.92
1991	35.67
1992	38.15
1993	39.14
1994	40.00
1995	40.20
1996	40.84
1997	42.70
1998	45.46
1999	48.06
2000	50.31
2001	53.96
2002	57.43
2003	57.90
2004	58.94
2005	61.39
2006	67.08
2007	69.03
2008	68.60
2009	68.80
2010	69.18
2011	71.17
2012	79.10
2013	79.92

Source: *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics, various issues.

5.8 Nominal Wage Index of Bangladesh, 1976-2013

Economic theory postulates a large degree of interdependence between wages and prices. Hence, wage is considered as an important cost push determinant of inflation. Table 5.8 reports the data on nominal wage indices during 1976-2013. The nominal wage rate series has been measured by the nominal wage indices taken from the various issues of the *Statistical Year Book of Bangladesh* and *Statistical Pocket Book of Bangladesh* published by the Bangladesh Bureau of Statistics.

Second column of the Table 5.8 shows that nominal wage index has gone up gradually throughout the 1976-2013 periods. It was 244 in 1976 and rose 433 in 1980. It increased to 1426 in 1990 from 724 in 1985. In 1995, the index of nominal wage get higher to 1786 and it gained 2390 in 2000. It was 3293 in 2005 and by the year 2013, the amount reached 7116. In 38 years, the nominal wage index increased from 244 in 1976 to 7116 in 2013, more than 29 times.

Table 5.8
Nominal Wage Indices of Bangladesh, 1976-2013 (Base: 1970 = 100)

Year	Nominal Wage Indices
1976	244
1977	252
1978	280
1979	346
1980	433
1981	492
1982	566
1983	598
1984	685
1985	734
1986	895
1987	1085
1988	1201
1989	1288
1990	1426
1991	1482
1992	1553
1993	1639
1994	1709
1995	1786
1996	1900
1997	1990
1998	2141
1999	2259
2000	2390
2001	2489
2002	2637
2003	2926
2004	3111
2005	3293
2006	3507
2007	3779
2008	4227
2009	5026
2010	5441
2011	5782
2012	6469
2013	7116

Sources: *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics various issues; *Statistical Pocket Book of Bangladesh,* Bangladesh Bureau of Statistics, various issues.

5.9 Export and Import Prices in Bangladesh, 1976-2013

Since this study deals with aggregate export and aggregate import, it can only have an index of prices of these items. Data of these variables are available in various issues of *Bangladesh Economic Review*; *Statistical Yearbook of Bangladesh* published by the Bangladesh Bureau of Statistics and is described below in terms of unit prices.

The unit price of export and import for the period of 1976-2013 are presented with the help of Table 5.9. It exhibits that both the indices have increased in Bangladesh during the study period. The price index of export has been displayed in the second column of Table 5.9. Although there was some fluctuation in some years the price index of export increased during the period of the study. It was 115.37 in 1976, increased to 240.45 in 1985. But, in 1990 the unit price of export decreased to 211.28. After that, it increased gradually and the trend continued even after the end of the period of the study. Finally, it reached a peak 740.36 in 2013.

The third column of Table 5.9 reports the price index of import. It was 201.57 in 1976. It climbed to 332.40 in 1985 and then it oscillated couples of years during 1986-1989. The price index of import dropped to 291.60 in 1989 from 332.40 in 1985. After the year of 1989 it continued to rocket to the end of the period of the study, with only an exception in 1992. Finally, it became 1502.32 in 1976, more than 7 times of that in 1976.

Table 5.9
Export and Import Prices in Bangladesh, 1976 - 2013

Year	Export Price Index	Import Price Index
1976	115.37	201.57
1977	130.42	197.82
1978	165.12	207.47
1979	210.96	234.65
1980	221.00	300.00
1981	191.83	340.50
1982	165.09	356.10
1983	168.18	337.50
1984	198.46	332.70
1985	240.45	332.40
1986	174.37	295.50
1987	180.78	269.70
1988	211.50	274.20
1989	204.65	291.60
1990	211.28	309.00
1991	225.20	322.20
1992	221.88	313.20
1993	237.13	323.40
1994	250.39	332.40
1995	266.97	362.10
1996	304.89	434.78
1997	313.53	441.86
1998	343.81	475.28
1999	365.29	520.51
2000	365.13	525.08
2001	373.91	564.60
2002	382.72	607.05
2003	392.30	654.09
2004	401.63	693.13
2005	434.04	768.11
2006	455.07	795.94
2007	505.05	1010.68
2008	522.12	1048.50
2009	543.15	1079.36
2010	575.77	1140.65
2011	635.51	1280.63
2012	687.63	1395.39
2013	740.36	1502.32

Sources: *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics, various issues; *Bangladesh Economic Review*, Government of Bangladesh, various issues; *Monthly Economic Trends*, Statistics Department, Bangladesh Bank, various issues.
*Export and Import prices, 1973=100.

5.10 Value of Imported Raw Materials in Bangladesh, 1976-2013

Table 5.10 reports data on the value of imported raw materials both in current term and real term during the 1976-2013. The Table contains three columns, year, value of imported raw materials in current term and value of imported raw materials in real term.

Second column of the Table shows that during this period the current value of imported raw materials increased from 71.22 crore taka in 1976 to 2525.13 in 2013. It went up from 71.22 crore taka during the period 1976-1986 to 217.08 crore taka. The value of imported raw materials was taka 456.90 in 1996 and taka 1237.18 in 2006. It increased steadily through the study period and finally in 2013, it reached taka 2525.13 crore.

The third column of the Table 5.10 also gives data for value of imported raw materials in real terms. It can be seen from the Table that it did not follow any uniform pattern rather it has fluctuated during the study period.

Table 5.10
Value of Imported Raw Materials in Current and Real Term in Bangladesh, 1976 - 2013

Year	Value (in Current Crore Taka)	Value (in Real Crore Taka)
1976	71.22	363.18
1977	91.65	482.88
1978	89.78	376.44
1979	102.81	383.07
1980	102.83	325.83
1981	117.55	337.01
1982	118.89	310.76
1983	142.07	312.18
1984	177.11	374.05
1985	200.17	380.34
1986	217.08	381.91
1987	227.75	361.40
1988	241.97	356.83
1989	259.30	352.46
1990	285.00	364.27
1991	299.82	359.50
1992	332.16	386.78
1993	366.16	425.17
1994	407.31	455.76
1995	439.99	458.61
1996	456.90	456.90
1997	491.09	476.37
1998	514.79	474.33
1999	554.91	488.56
2000	646.21	558.57
2001	741.74	631.10
2002	813.11	670.44
2003	899.20	709.31
2004	981.62	742.81
2005	1090.67	785.45
2006	1237.17	847.15
2007	1356.24	869.66
2008	1466.48	864.41
2009	1640.68	907.85
2010	1886.69	980.50
2011	2129.05	1028.97
2012	2298.26	1028.49
2013	2525.12	1055.13

Sources: *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics, various issues; *Bangladesh Economic Review*, Government of Bangladesh, various issues; *Monthly Economic Trends*, Statistics Department, Bangladesh Bank, various issues.

5.11 Oil (Petroleum) Price in World Market, 1976-2013

Table 5.11 shows the data for petroleum price in nominal term and real term for the period 1976-2013. It exhibits that the price of the petroleum fluctuated for the period of 1976-2013. This means oil price in world market went up for some years and went down the next year.

The second column of the Table 5.11 reports that oil price in current term increased during 1978-1984 but decreased the next year in 1985. But ultimately, it went up steadily during the study period from taka 186.39 croe in 1976 to taka 8562.63 crore in 2013.

The third column of the Table describes the trend of oil price in real term. Real oil price has been calculated by deflating the current oil price by the GDP deflator series. The price in real term also followed the same pattern of increasing in current term and get to 3582.69 crore taka in 2013 from 931.97crore taka in 1976.

Table 5.11
Oil (Petroleum) Price in World Market, 1976-2013

Year	Petroleum Price in World Market in Current Taka (per Barrel)	Petroleum Price in World Market in Real Taka (per Barrel)
1976	186.39	931.97
1977	207.37	1091.47
1978	205.48	856.17
1979	471.28	1745.51
1980	571.11	1784.74
1981	576.98	1648.53
1982	654.08	1721.27
1983	696.86	1514.92
1984	701.93	1493.48
1985	698.19	1317.35
1986	412.18	723.13
1987	540.31	857.64
1988	440.32	647.54
1989	545.09	736.61
1990	727.03	932.10
1991	651.33	784.74
1992	698.14	811.80
1993	625.45	727.28
1994	613.20	688.99
1995	667.19	694.92
1996	796.17	796.18
1997	794.64	771.50
1998	563.93	517.37
1999	836.72	733.97
2000	1368.43	1179.68
2001	1271.29	1077.37
2002	1399.28	1156.43
2003	1609.04	1266.96
2004	2114.76	1602.10
2005	3181.22	2288.65
2006	4253.54	2913.39
2007	4869.37	3121.40
2008	6566.73	3862.79
2009	4252.44	2349.42
2010	5455.53	2841.42
2011	7730.84	3734.71
2012	8735.80	3882.58
2013	8562.62	3582.69

Sources: *Monthly Economic Trends,* Statistics Department, Bangladesh Bank, various issues.

5.12 Chapter Summary

Data on determinants of inflation have been reported and discussed in this chapter. Along with the main data that have been used for econometric estimation, various components of these data have also been described. This has been done to obtain a clearer picture of the factors affecting inflation in Bangladesh. A summary of this chapter is given below.

i) Table 5.1 reports data on consumer price index. It is an officially accepted general measure of inflation in Bangladesh.

ii) Table 5.2 describes the data on money supply along with its different components in current crore taka while Table 5.4 reproduces the same data in real crore taka by deflating with GDP deflator presented in Table 5.3.

iii) Data on gross domestic product (GDP) in both nominal and real term is provided in Table 5.5.

iv) Table 5.6 exhibits data on real deposit interest rate. Real deposit interest rate is the deposit interest rate minus inflation rate and is constructed by the author of the thesis.

v) The nominal (official) exchange rate of Bangladesh is presented in Table 5.7.

vi) Table 5.8 shows data on nominal wage indices.

vii) Data on export and import prices are provided in Table 5.9.

viii) Table 5.10 shows value of imported raw materials in current and real term.

ix) Data of oil (petroleum) price in world market is given in Table 5.11.

As data of these variables are different in nature, these have been collected from various sources. These include various issues of *Monthly Economic Trends*, *Statistical Yearbook of Bangladesh*, *Bangladesh Economic Review*, and *World Development Indicators* among others sources.

Chapter 6
Empirical Results

The empirical results of the study are presented and analyzed in this chapter. At first, the estimates related to the time series properties of relevant variables are reported and discussed. Then, the estimates of macroeconomic determinants of inflation have been provided testing the hypothesis that cost-push factors explain inflation in Bangladesh better than that of monetary factors. The estimates of the demand-pull, cost-push and hybrid inflation equations with various alternatives provide the results of the determinants of inflation from different theoretical angles. This is followed by the ARDL and conditional error correction model (conditional ECM), which give both the short-run and long-run estimates of the specific inflation equation.

After this, the estimates related to causal relationship between nominal wage and inflation and between money supply and inflation are provided and analyzed using pair wise Granger causality.

Finally, the estimates related to impact of inflation on GDP growth is given by using econometric procedure of Granger causality based on vector error correction modeling (VECM), Toda-Yamamoto causality test, impulse response function (IRF), and variance decomposition (VDC).

6.1 Time Series Properties of Relevant Variables and Tests of Stationarity

With a view to identifying the stationarity of the data used in the econometric estimation, a unit root test has been done of the variables like inflation (P), real GDP (Y), broad money supply (M), nominal wage (W), real rate of interest (r), exchange rate (ER), import price (PM), value of raw materials (RAW) and world oil price (WPP).

The Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Dickey-Fuller generalized least squares (DF-GLS) unit-root tests using the intercept and trend variables have been conducted. These unit root tests are performed on both levels and first differences of all the variables. Augmented Dicky fuller test (ADF) and Dickey-Fuller generalized least squares (DF-GLS) test under Schwartz information criteria, and the Philip-Perron (PP) test under Bartlett Kernel and newly west bandwidth are conducted to test the stationary of the series. All the variables are in natural logs except real interest rate (r) due to negative numbers in the series. Unit root tests are performed using E-views 8.0. The results of the ADF, PP, and DF-GLS unit root tests are reported below in the Tables 6.1, 6.2 and 6.3 respectively.

6.1.1 ADF Unit Root Tests for Stationarity

The ADF tests results presented in Table 6.1 show that the series of inflation (P), real rate of interest (r), and value of raw materials (RAW) are stationary at level (i.e. integrated at zero order), I (0). Inflation is significant at 5 percent level of significance, value of raw materials at 1 percent level of significance, while the real rate of interest at the 10 percent level of significance, as their ADF critical values are greater than the computed p-values at the 5 percent, 1 percent, and 10 percent level of significance respectively (Table 6.1).

The real GDP (Y), broad money supply (M), nominal wage (W), exchange rate (ER), import price (PM), and world oil price (WPP) series are found to have unit root that is non-stationary at their level values. Therefore, the ADF regressions are run for these series in their first order difference form and are found to be stationary. The series of broad money supply, nominal wage, and import price are found to be differenced stationary at 5 percent level of significance, while real GDP and world oil price are found to be stationary at 1 percent level of significance (99 percent confidence level).

Thus, ADF unit-root test suggests that the series of inflation, real rate of interest, and value of raw materials are integrated of zero order, I(0) and are not eligible to form a cointegrating relationship (or long-run relationship) as suggested by Engle and Granger (1987: 251-52), while rest of the series are eligible to form a cointegrating set.

Table 6.1
ADF Unit Root Tests for Stationarity

Variables	ADF test statistic (with trend and intercept)			
	Log Levels	P-value	First Difference	P-value
Inflation (lnp)	-4.00**	0.01	-	-
Real GDP (lny)	-0.25	0.98	-6.52***	0.00
Broad Money Supply (lnm)	-2.39	0.37	-3.79**	0.02
Nominal Wage Index (lnw)	-2.38	0.37	-3.97**	0.01
Real Rate of Interest (r)	-3.35*	0.07	-5.67***	0.00
Exchange Rate (lner)	-2.04	0.55	-4.52***	0.00
Import Price (lnpm)	-0.67	0.96	-4.02**	0.01
Value of Raw Materials (lnraw)	-5.09***	0.00	-	-
World Oil Price (lnwpp)	-1.41	0.83	-6.06***	0.00

Notes: (i) ***, ** and * denotes the rejection of the null hypothesis that the series has a unit root against an alternative hypothesis of a stationary root, at 1 percent, 5 percent and 10 percent significance level respectively.

(ii) MacKinnon (1996) one-sided critical p-values at the 1 percent, 5 percent and 10 percent for ADF test statistic (with trend and intercept) are -4.24, -3.54 and -3.20 respectively.

6.1.2 Phillips-Perron (PP) Unit Root Tests for Stationarity

Table 6.2 shows that all the variables are stationary at first differences at 1 percent and 5 percent level of significance. However, the PP test shows that real interest rate and value of raw materials is stationary at levels. Therefore, it could be said that real rate of interest and value of raw materials is stationary at level while other variables are stationary at first differences. So, PP results confirm that lnp, lny, lnm, lnw, lner, lnpm, and lnwpp are integrated of order one, i.e. I (1), and r, lraw are integrated at level, I (0). The PP unit root test results differ from the results of ADF test in case of inflation series.

Table 6.2
Phillips-Perron (PP) Unit Root Tests for Stationarity

Variables	Phillips-Perron test statistic (with trend and intercept)			
	Log Levels	P-value	First Difference	P-value
Inflation (lnp)	-1.94	0.61	-4.53***	0.00
Real GDP (lny)	0.18	0.99	-9.83***	0.00
Broad Money Supply (lnm)	-2.42	0.36	-3.76**	0.03
Nominal Wage (lnw)	-2.03	0.56	-4.00**	0.01
Real Rate of Interest (r)	-3.45*	0.05	-7.41***	0.00
Exchange Rate (lner)	-1.49	0.81	-3.96**	0.01
Import Price (lnpm)	-1.05	0.92	-4.04**	0.01
Value of Raw Materials (lnraw)	-5.27***	0.00	-	-
World Oil Price (lnwpp)	-1.43	0.83	-6.06***	0.00

Notes: (i) ***, ** and * denotes the rejection of the null hypothesis that the series has a unit root against an alternative hypothesis of a stationary root, at 1 percent, 5 percent and 10 percent significance level respectively.

(ii) MacKinnon (1996) one-sided critical p-values at the 1 percent, 5 percent and 10 percent for Phillips-Perron test statistic (with trend and intercept) are -4.24, -3.54 and -3.20 respectively.

6.1.3 DF-GLS Unit Root Tests for Stationarity

Table 6.3 reports the results of DF-GLS unit root test. The results suggest that the null hypothesis of unit roots cannot be rejected for all the variables in levels with constant and trend. Two variables, real rate of interest (r) and value of raw materials (lnraw) are stationary at level. In order to make other variables first order (I (1)) stationary, first differencing is appropriate. And after first differencing all other variables in our study become stationary with varying significance levels of either 1 or 5 percent (Table 6.3).

Table 6.3
DF-GLS Unit Root Tests for Stationarity

Variables	DF-GLS test statistic (with trend and intercept)			
	Log Levels	P-value	First Difference	P-value
Inflation (lnp)	-2.04	0.04	-3.70**	0.00
Real GDP (lny)	-1.75	0.08	-5.72***	0.00
Broad Money Supply (lnm)	-2.20	0.03	-3.87***	0.00
Nominal Wage (lnw)	-2.11	0.04	-3.59**	0.00
Real Rate of Interest (r)	-3.21**	0.00	-	-
Exchange Rate (lner)	-1.31	0.19	-3.53**	0.00
Import Price (lnpm)	-0.86	0.39	-4.08***	0.00
Value of Raw Materials (lnraw)	-5.24***	0.00	-	-
World Oil Price (lnwpp)	-1.53	0.13	-6.20***	0.00

Notes: (i) Elliott-Rothenberg-Stock (1996) critical values at the 1 percent, 5 percent and 10 percent for DF-GLS test statistic are -3.77, -3.19 and -2.89 respectively.

The ADF tests (Table 6.1), the PP test (Table 6.2) and the GF-GLS tests (Table 6.3) confirm that some of the variables are integrated in order zero i.e. 1(0) while others are integrated in order one i.e. 1(1) or at first difference with varying significance levels, but no variables are integrated of order 2, i.e. I (2).[25] These variables are not integrated of same order, and for this reason, they are not eligible to form a cointegrating set as Johansen (1992), Engle- Granger (1987) but ARDL cointegrating set can be formed as Pesaran et.al (2001).

[25] The necessary condition to perform ARDL cointegration test is that the series not necessarily to be integrated of same order rather a mixture of I(0) and I(0), but no series can be integrated of second order, i.e. I(2). If so, ARDL approach does not work.

6.2 Empirical Results of the Models of Determinants of Inflation

Confirming the stationarity of the dependent variable and selected explanatory variables, the OLS technique is used to estimate various regression equations in time series data covering the period from 1976-2013. In the regression equations that are estimated in this thesis, the variables are given in logarithmic form. This implies that the estimated coefficients are all in elasticity. This interpretation is more meaningful to the economists because they usually prefer to percentage changes rather any number, which leads to elasticity. The estimates are given below.

6.2.1 The Monetarist (Demand-Pull) Inflation Model

The monetarist inflation model predicts that inflation is a function of money supply, real income (GDP), previous year inflation (as inertial or expectation factor), and real rate of interest (Darrat, 1986, p. 88).

The regression results of the monetarist model are presented in equations 6.1, 6.2, 6.3, 6.4, 6.5 with various alternatives. This inflation equation has been estimated with three different time span. Firstly for the whole period, 1976-2013, the equation is estimated without including lagged money supply (equation 6.1) and then with inclusion of one year and two year lagged money supply in the equation 6.1 (equation 6.2 and 6.3). Then the monetary inflation equation is estimated for the pre-liberalization period (1976-1990) and post-liberalization period (1991-2013) separately. The empirical results of which are given below.

6.2.1.1 Estimated Monetarist Inflation Model for the Period 1976-2013

Equation 6.1 reports the estimated monetarist equation for the period of 1976-2013 (whole period). The estimated coefficients of broad money, real income, inflation lagged by one period, and real rate of interest are found to be statistically significant at 1 percent level. It implies that all the explanatory variables and CPI inflation has strong relationship. It also suggests that a ten percent change in broad money and inflation lagged by one period causes 2.5 and 6.2 percent change in the rate of inflation respectively, while a ten percent change in real income and real rate of interest reduces the rate of inflation by 3.1 percent and 0.07 percent respectively (equation 6.1). The inclusion of expected rate of inflation (one period lagged inflation rate) as the explanatory variable has shown the strong relationship between price expectation and inflation rate.

The estimated monetarist inflation equation for the whole period is presented below. Figures in the parentheses denote t- statistic value in all equations.

$$\ln P = 2.694 + 0.25\ln M - 0.31\ln Y + 0.65\ln P_{t-1} - 0.007r \quad (6.1)$$

[26]

$$(4.72) \qquad (-5.00) \qquad (7.23) \qquad (-3.84)$$

$$R^2 = 0.99 \qquad D\text{-}W = 1.89$$

The regression results show that all the coefficients follow the prior expected sign. The coefficient of real interest rate (r) is negative which is consistent with the result of Kandel et al. (1996). The explanatory power of these

[26] Real (deposit) interest rate (r) is the difference between nominal interest rate and inflation rate. It is not in natural log form due to negative numbers in the series.

equations is at the high level i.e. 99 percent. The R^2 and adjusted R^2 of 0.99 mean that about 99 percent change in inflation has been explained by these equations. The significance of F-statistics tells that the variables in the above equations are jointly significant statistically at 99 percent confidence level. The results of Durbin-Watson (D-W) d statistics indicate that at 1 percent level of significance, there is no evidence of first-order serial correlation in the above equation (Gujarati, 2003).[27]

Moreover, Breusch-Godfrey serial correlation LM tests: BG test of detecting the presence of first order auto-correlation has been tested with the help of econometric package E-Views 8.0. But the coefficient of the first order auto – correlation is found to be statistically insignificant. The result implies that there is no evidence of first order auto-correlation problem in our models.

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[27] Durbin-Watson (D-W) d statistic significance points of d_L (lower limit) and d_U (upper limit) with number of period 38 and number of explanatory variables 4 are: 1.26, 1.72 and 1.07, 1.51 at 5 percent and 1 percent level of significance respectively. It is seen from equation 6.4 that the D-W d statistic is 1.89, which is greater than the upper limit of both 1.72 and 1.51. This concludes that there is no evidence of first-order serial correlation both at 5 percent and 1 percent level of significance. For the post-liberalization period, 23 years period, the D-W d statistic is seen 1.79 (equation 6.5), which is greater than the upper limit of both 1.78 and 1.53, means that there is no evidence of first-order serial correlation both at 5 percent and 1 percent level of significance. And in case of pre-liberalization period (equation 6.4), the D-W d statistic is 1.88, which is greater than the upper limit of 1.70 at 1 percent level of significance confirms that there is no first-order serial correlation in equation 6.4 See, Gujarati (2003) *Basic Econometrics*, fourth edition, Appendix D.5A and D.5B, pp. 970-973.

6.2.1.2 Estimated Monetarist Inflation Model with One Year Lagged Money Supply

Due to the lack of well developed financial market in Bangladesh, the adjustment of changes in the money supply is not instantaneous. Hence, one year lagged money supply variable is included into monetary inflation model.[28] Including one year lagged money supply into the equation 6.1, new estimates have been found that are reported with the help of equation 6.2 below. The estimated monetarist inflation model with one year lagged money supply for the whole period (1976-2013) is given below.

$$lnP = 1.42 + 0.12lnM - 0.15lnY + 0.80lnP_{t-1} - 0.007r + 0.013lnM_{t-1} \quad (6.2)$$

$$(1.66) \quad (-1.87) \quad (7.83) \quad (-3.89) \quad (2.54)$$

$$R^2 = 0.99 \quad D\text{-}W = 2.27$$

Equation 6.2 reports the adjustment in price level to change in money supply spreads over one year. It is seen from equation 6.2 that the coefficient of one year lagged money supply (M_{t-1}) is statistically significant at 95 percent confidence level. But the coefficient of current money supply (M_t) is now found to be statistically insignificant even at 90 percent confidence level. This may be due to lag in adjustment between money supply and price level. Next, we include two years lagged money supply variable into the equation 6.5 and the results are reported in the equation 6.3 below.

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[28] See, Saini 1982, 86; Nupane 1992; Cooray, 2008.

6.2.1.3 Estimated Monetarist Inflation Model with Two Years Lagged Money Supply

When financial institutions are relatively underdeveloped and economic activities are insufficiently monetized as in the case of Bangladesh, the adjustment specification should help to capture most of the delayed effects of an increase in money supply.

Therefore, such a specification is made including a two years lagged money supply variable into the equation 6.2, and this inclusion has also changed some sorts the quality of the estimation. The estimated results are presented in equation 6.3.

The estimated monetarist inflation model with two years lagged money supply during 1976-2013 is reported below.

$$lnP = 0.69 + 0.07lnM - 0.068lnY + 0.82lnP_{t-1} - 0.005r + 0.009lnM_{t-1} + 0.009lnM_{t-2} \quad (6.3)$$

(1.11) (-0.81) (8.60) (-3.09) (1.79) (2.50)

$R^2 = 0.99$ D-W = 2.00

Equation 6.3 shows the adjustment in price level to change in money supply spreads over two years. Equation 6.3 reports that the coefficients of one year and two years lagged money supply (M_{t-1} and M_{t-2}) are statistically significant at 90 percent and 95 percent confidence level respectively and both are found to be following expected signs. But the coefficients of current money supply (M_t) and real income (Y_t) are now found to be statistically insignificant even at 90 percent confidence level though they follow correct sign. The Durbin-Watson d statistics is now just 2.00.

Since the coefficient of current money supply (M_t) is insignificant statistically while the coefficients of lagged money supply (M_{t-1} and M_{t-2}) are statistically significant, it can be concluded from the equation 6.3 that people do not realize immediately the increase in money supply, and, as a results, money illusion is at work in the economy of Bangladesh.

Again, the sum of the coefficients of monetary variables M_t, M_{t-1}, and M_{t-2} is greater than zero but less than unity. This finding suggests that there are other non-monetary influences which have excreted stronger influence on the rate of inflation. This result also confirms that the price inflation in Bangladesh is essentially a monetary phenomenon is not a very robust hypothesis.

6.2.1.4 Estimated Monetarist Inflation Model for the Pre- and Post-Liberalization Period

The period 1976-1990 is regarded as the pre-liberalization period characterized by fixed interest rate, while the period 1991-2013 is considered as post-liberalization period when greater reliance has been placed on market mechanism that has led to variation in the interest rate. The monetarist inflation model is estimated for the pre- liberalization period (1976-1990) and post-liberalization period (1991-2013) separately to look into the impact of liberalization on determinants of inflation in Bangladesh. The estimates of the models are given in equation 6.4 and 6.5 below.

Equation 6.4 presents below the estimated monetarist inflation equation for the pre-liberalization period (i.e. 1976-1990).

$$\ln P = 1.70 + 0.28 \ln M - 0.21 \ln Y + 0.55 \ln P_{t-1} - 0.006r \qquad (6.4)$$

(2.33) (-0.31) (2.81) (-1.41)

$R^2 = 0.99$ D-W = 1.88

The estimated monetarist inflation equation for the post-liberalization period (i.e. 1991-2013) is reported here.

$$\ln P = 1.66 + 0.09 \ln M - 0.19 \ln Y + 0.94 \ln P_{t-1} - 0.008r \qquad (6.5)$$

(1.08) (-0.90) (8.29) (-4.88)

$R^2 = 0.99$ D-W = 1.79

The above regression results show that the estimated coefficient of money supply or money supply growth elasticity of CPI inflation for the pre-liberalization period is 0.28 (equation 6.4), which is higher than the value for the whole period, that is, 0.25 (equation 6.1). The coefficient of money supply growth is statistically significant at the 95 percent confidence level with t-value of 2.33 for the pre-liberalization period (1976-1990). But, the money supply growth elasticity of CPI for the post-liberalization period is 0.09 (equation 6.5), which is lower than that for the whole period and pre-liberalization period as well, that is, 0.25 and 0.28 respectively. And the coefficient of money supply growth for the post-liberalization period is no more significant statistically. This is perhaps due to the fact that there was greater intervention on the money supply growth by the monetary authority.

The coefficient of real interest rate or value of real interest rate elasticity is -0.006, whose absolute value is found to be lower than the value of -0.007 for the whole period and also than that of -0.008 for the post-liberalization period. The coefficient of real interest rate is not also significant statistically. But the coefficient of real interest rate for the post-liberalization period is higher than that for the whole period and pre-liberalization period. It is also found to be highly significant statistically with t-value -4.88. This is an important result. It is during the pre-liberalization period the interest rate was often deliberately held constant by the monetary authority. As a result, interest rate had a lesser impact on CPI than it had for the whole period. For the post-liberalization period, this was due to the fact that there was lesser intervention on the interest rate. Hence, a greater impact of interest rate on CPI was found and the statistical significance of the estimated coefficient is higher than that for the whole period.

Equation 6.4 and 6.5 also show that the expectation variable (P_{t-1}) has been found to be significant at 95 percent confidence level for the pre-liberalization period and highly significant at 99 percent confidence level for the post-liberalization period, while the coefficient of real income (Y_t) has turned to be insignificant statistically for both the pre-and post-liberalization periods. It implies that a low growth in real income gives rise to expectations of higher inflation.

6.2.2 The Cost-Push Inflation Model

The cost-push inflation model assumes that inflation is a function of cost-push factors like wage, exchange rate, prices of raw materials, and supply shocks among others. The regression results of cost-push inflation model with various alternatives are reported in this section. Equation 6.6, 6.7, and 6.8 present the regression results below.

6.2.2.1 Estimated Cost-Push (Wage-Push) Inflation Model as a Function of Nominal Wage

Today's rate of inflation should also depend on the nominal wage rate (W_t). When the nominal wage rate is increased, people develop inflationary expectations, which in turn may have an inflationary impact on current and future prices. Equation 6.6 shows the estimated cost-push inflation equation in terms of changes nominal wage rate.

The estimated wage-push inflation equation is given below

$$\ln P = 0.80 + 0.82 \ln W \qquad (6.6)$$

$$(128.47)$$

$R^2 = 0.99$ D-W = 0.95

The regression results show that the coefficient follows the expected sign and is also found to be highly significant statistically. The estimated wage-push inflation equation reports that Durbin-Watson (D-W) statistic is 0.95, this low value of D-W statistic cast some doubt about the presence of first order autocorrelation in the estimation. Besides, the value of D-W statistic is less than the R^2, which is the indication of first order autocorrelation problem (Gujarati, 2003).[29] Hence, an estimate corrected for autocorrelation is given below.

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[29] According to Granger and Newbold (1974), an R^2>D-W is a good rule of thumb to suspect that the estimated regression is spurious. This problem may cause from first order autocorrelation problem (Gujarati, 2003). Hence, an estimate corrected for autocorrelation is given in equation (6.7). The AR (1) has been used to reduce the degree of first order autocorrelation. After applying the AR (1) process, it is observed that the D-W statistics rises from 0.95 to 1.77, meaning that the autocorrelation problem is now corrected.

6.2.2.2 Estimated Autocorrelation Corrected Cost-Push (Wage-Push) Inflation Model as a Function of Nominal Wage

The first order autocorrelation problem of the equation 6.6 can be corrected using an AR (1) process. Inclusion of the AR (1) process in the equation reduces the degree of autocorrelation and increases the value of Durbin-Watson d statistic. The significance of AR (1) variable in the estimated equation indicates that the autocorrelation problem is now corrected. The estimated autocorrelation corrected inflation equation as a function of nominal wage is presented in equation 6.7 below.

$$\ln P = 0.80 + \underset{(65.73)}{0.82} \ln W \qquad (6.7)$$

$R^2 = 0.99$ D-W = 1.77

The estimated autocorrelation corrected inflation equation shows that the D-W statistic, now increases from 0.95 to 1.77, implying absence of autocorrelation. The result of this estimation is similar to our previous estimates. So, the problem of autocorrelation is now corrected and the revised estimates are given in equation 6.7 above.

6.2.2.3 Estimated Cost-Push Inflation Model as a Function of Nominal Wage, a Dummy Variable, and other Variables

Finally, the cost-push inflation equation is estimated in terms of the explanatory variables in the price equation include the nominal wage, exchange rate, value of imported raw materials and world oil price. In addition a dummy variable is included to account for exogenously induced inflation that occurred supply shock in different times in Bangladesh as a result of natural disasters. The dummy variable takes on the value 1 during natural disaster and is zero otherwise.

The estimated cost-push inflation equation is given below.

$$\ln P = 0.80 + 0.82 \ln W + 0.29 \ln ER + 0.01 \ln RAW + 0.0003 \ln WPP + 0.009\ \text{Dummy} \quad (6.8)$$

(16.41) (4.51) (0.80) (0.02) (0.92)

$R^2 = 0.99$ D-W = 1.20

The regression results of the cost push model reported in equation 6.8 reveals that all the coefficients of the four variables of cost-push model follow the expected sign, but the coefficients of only two variables (wage growth and exchange rate depreciation) are statistically significant at 99 percent level of confidence. Other variables (value of imported raw materials and world oil price) are found to be statistically insignificant even at 90 percent confidence level. The dummy variable is also statistically insignificant.

6.2.3 The Hybrid Inflation Model

The hybrid inflation model combines both the demand-pull (monetarist) and cost-push factors of inflation. Equation 6.9 and 6.10 present the estimated hybrid inflation models below.

$$\ln P = 2.28 + 0.15 \ln M + 0.20 \ln ER - 0.23 \ln Y + 0.51 \ln W + 0.08 \ln Pm + 0.001 r \quad (6.9)$$

(2.05) (2.49) (2.18) (6.53) (2.08) (0.90)

$R^2 = 0.99$ D-W = 1.45

Results of the equation 6.9 are somewhat satisfactory and signs of the coefficients are supporting the previous research findings except real interest rate. The coefficients of all variables in above regression are statistically significant except real interest rate which is not statistically significant even at 10 percent level of significance. The estimated equation (6.9) shows that inflation is positively related to money supply, nominal wage, import prices, real interest rate (r) and negatively related to real income as the expectation.

This study finds that the model is good and fit because the R square and the adjusted R square are 0.99 and 0.99, respectively. In overall, this means the 99 percent variation of the dependant variable can be explained by the variation of independent variables. The F-statistic in the equation 6.9 shows that the model is overall significant at 99 percent confidence level. Therefore, the possibility that the R square has arisen by chance is rejected and the relationship is considered true. The value of R^2 and F-value also shows that model is proper fitted to the data. This can be verified from the normal plot of the residuals which shows that residuals are normally distributed.

Since, today's rate of inflation should also depend on rates of inflation that existed in the recent past, when the rate of inflation is for a year or more, people develop inflationary expectation, which in turn have an inflationary impact on current and future inflation (Pindyck and Rubinfeld, 1981). Thus we include one year lagged inflation as expectation factor in the price equation 6.9 and the new results are given in equation 6.10 below. The results are consistent with that reported by Qayyum (2006), and Makochekanwa (2007).

The estimated hybrid inflation equation (with expectation variable) of this thesis is given below.

$$\ln P = 3.11 + 0.16\ln M + 0.06\ln E - 0.34\ln Y + 0.22\ln W + 0.10\ln Pm - 0.003r + 0.49\ln P_{t-1} \qquad (6.10)$$

(2.70) (0.84) (-3.90) (2.57) (3.27) (-1.52) (4.43)

$R^2 = 0.99$ D-W = 2.00

Equation 6.10 reports the results obtained from the model including expectation variable. When the expectation variable (P_{t-1}) has been included in the hybrid equation 6.9, the estimation result has shown a significant change. The value of D-W statistic increases from 1.45 to 2.00 indicates the non-existence of first-order autocorrelation problem in the model. Moreover, all the variables in the model follow the expected sign. The R^2 of 0.99 implies that 99 percent change in the inflation has been explained by the hybrid model. The F-statistic shows that the model is overall significant at 99 percent confidence level.

6.2.4 Diagnostic Tests and Stability of the Model

Breusch-Godfrey (B-G) serial correlation LM test of detecting the presence of first order autocorrelation has been applied and White Heteroskedasticity test has been performed to detect the presence of heteroskedasticity problem in the model with the help of the computer package E-Views 8.0. Besides this the cumulative sum (CUSUM) test has been conducted to test the stability of the hybrid inflation model. The results have been reported in the Tables 6.4, 6.5 and Figure 6.1 respectively below.

6.2.4.1 Breusch-Godfrey Serial Correlation LM Test

Table 6.4 reports the results of Breusch-Godfrey (B-G) serial correlation LM test. The p-value of Obs*R-squared is 0.93, which is more than 5 percent (p>0.05) implying that the null hypothesis of no serial correlation in the residuals cannot be rejected rather the null hypothesis is accepted. This means that the residuals of the model are not serially correlated and there is no existence of first-order autocorrelation in the above hybrid inflation model.

Table 6.4
Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.04	Probability	0.95
Obs*R-squared	0.13	Probability	0.93

6.2.4.2 White Heteroskedasticity Test

The results of the white heteroskedasticity test in the Table 6.5 reports that the p-value of Obs*R-squared is 0.11, which is more than 5 percent (p>0.05) and even 10 percent critical level. So, the null hypothesis of homoskedasticity (the variance of residual is constant) cannot be rejected rather accepted. This implies that the residuals of the model are homoskedastic.

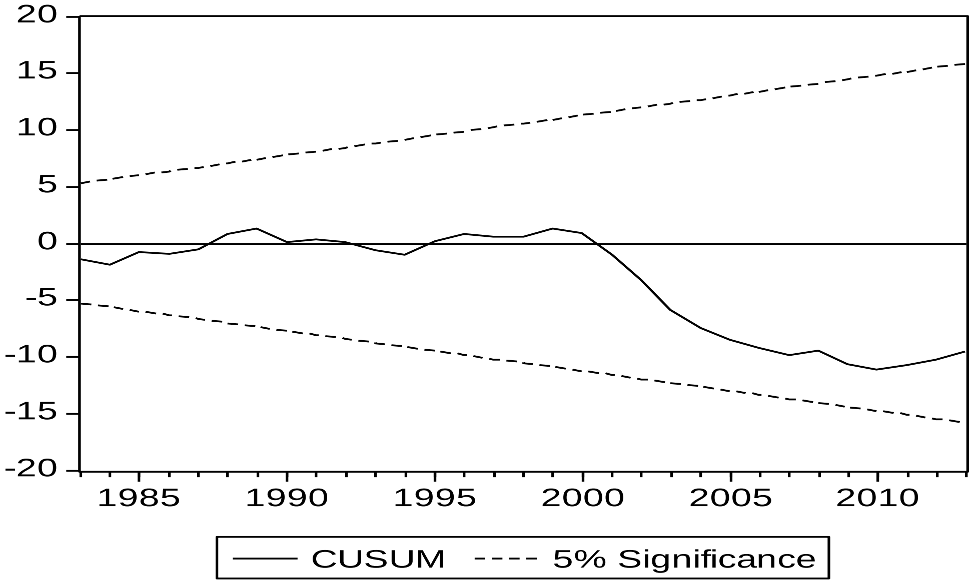
Table 6.5
White Heteroskedasticity Test

F-statistic	1.91	Probability	0.08
Obs*R-squared	18.11	Probability	0.11

6.2.4.3 Test of Stability: CUSUM Test

The cumulative sum (CUSUM) test is based on the cumulative sum of the recursive residuals and is applied to test stability of the estimated equation (Brown et al., 1975). The test checks the stability of the empirical model. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines. The CUSUM test result of the hybrid inflation model in Figure 6.1 shows that the plots of CUSUM lie within the two critical lines over the all time horizon. This result suggests clearly the stability of the inflation model.

Figure 6.1
CUSUM Test: Stability of the Hybrid Inflation Model



6.2.5 Estimation Results of ARDL Bound Tests for Cointegration

The regression results obtained from the inflation equations above depending on the assumption of stationarity may be unreliable unless it is specified by taking into account the time series properties of the variables. Because, most of the macroeconomic time series are non-stationary by their nature (Phillips, 1988; Hossain, 1996). The reason for applying the ARDL approach is that the bounds testing procedure does not require pre-testing variables included in the model for unit roots and it is applicable irrespective of whether the underlying regressors in the model are purely I(0), purely I(1) or mixture of both.

The results of the unit root tests in previous section (Table 6.1, 6.2 and 6.3) confirm that there is a mixture of I (0) and I (1) variables and none of the variables are I (2). This is the basic requirement for the application of the ARDL approach. Therefore, the ARDL bound testing approach has been employed to examine the long-run relationship among the variables rather than traditional static cointegration test (Asteriou and Monastiriotis, 2004). Basically, the ARDL approach to cointegration involves in estimating the conditional error correction (EC) version of the ARDL model for inflation and its determinants (Pesaran et al., 2001). The ARDL approach follows the steps below. First step is to select optimal lag length and to specify the ARDL model.

6.2.5.1 Lag Length Selection and ARDL Model Specification

The information criteria are often used as a guide in model selection. There are many lag length criteria can be employed to determine the autoregressive lag length but in this study, the autoregressive lag length is selected using Schwartz-Bayesian criterion (SBC) and Hendry's general to specific method of lag selection.

6.2.5.1.1 ARDL Model with Maximum Lag Order 2

Firstly, the ARDL bound testing model is examined starting from the higher lag length. As suggested by Pesaran and Shin (1999) and Narayan (2005), since the observations are annual and this model have only 38 observations, is considered as small size sample time series model. So, in order to avoid over parameter problem, it is started with the maximum order of lags 2 and then reduced to lag 1.

6.2.5.1.2 Diagnostic Checking for Serial LM Test of the ARDL Model with Lag Order 2

Since the p-value (0.03) of Obs*R-squared in Table 6.6 is less than 5 percent (p=0.03<0.05), null hypothesis of no serial correlation in the residuals (u) is rejected and the alternative hypothesis that there is serial correlation in the residuals is accepted. This model with serial correlation is not acceptable, so the ARDL modeling proceeds with lag 1.

Table 6.6
Diagnostic Checking for Serial LM Test of the ARDL Model with Lag Order 2

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.73	Probability	0.21
Obs*R-squared	4.41	Probability	0.03

6.2.5.1.3 ARDL Model with Lag Order 1

After the lag 2 model, the lag is reduced to be lagging 1 model and the results of the diagnostic tests in this regard are reported below with the help of Table 6.7.

6.2.5.1.4 Diagnostic Checking for Serial LM Test of the ARDL Model with Lag Order 1

Table 6.7 shows that the p-value of Obs*R-squared (0.19) is more than 5 percent (p=0.19>0.05). So, the null hypothesis of no serial correlation cannot be rejected rather accepted that the residuals in the model are not serially correlated.

Table 6.7
Diagnostic Checking for Serial LM Test of the ARDL Model with Lag Order 1

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.97	Probability	0.33
Obs*R-squared	1.67	Probability	0.19

The above estimated results show that the serial correlation problem is solved with lag 1 model but this model does not minimize SBC, the SBC is lower in the model at lag 2. Hence, other method has been reconsidered for choosing the optimum lag length such as Hendry's general to specific approach.

6.2.5.1.5 Hendry's General to Specific Approach and ARDL Model Specification

Again, the model has started with maximum lag 2. After that, the higher insignificant lag has been deleted for the changes variables. The D(LNER(-2)) has been dropped out from the model first and then following by D(LNP(-2)) D(LNY(-2)) D(LNW(-2)) D(R(-2)) D(LNER(-2)) and D(LNPM(-1)). At the end, the empirical results are as follow:

Table 6.8
Hendry's General to Specific Approach and ARDL Model

Dependent Variable: D(LNP)
Method: Least Squares
Sample(adjusted): 1979 2013
Included observations: 35 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNP(-1)	-0.45	0.11	-3.85	0.00
LNM(-1)	0.37	0.08	4.36	0.00
LNY(-1)	-0.58	0.11	-4.85	0.00
LNW(-1)	-0.01	0.08	-0.20	0.84
R(-1)	-0.00	0.00	-0.82	0.41
LNER(-1)	-0.16	0.07	-2.34	0.03
LNPM(-1)	0.17	0.04	3.97	0.00
D(LNP(-1))	0.13	0.15	0.87	0.39

D(LNM(-1))	-0.06	0.07	-0.82	0.42
D(LNY(-1))	0.71	0.27	2.62	0.01
D(LNW(-1))	0.09	0.07	1.20	0.24
D(R(-1))	-0.00	0.00	-1.96	0.06
D(LNER(-1))	0.15	0.06	2.22	0.03
D(LNM(-2))	-0.34	0.10	-3.38	0.00
D(LNPM(-2))	-0.11	0.04	-2.56	0.01
C	5.02	0.98	5.09	0.00

R-squared	0.92	Schwarz criterion	-4.92
Adjusted R-squared	0.86	F-statistic	15.77
Durbin-Watson stat	2.03	Prob(F-statistic)	0.00

6.2.5.1.6 Diagnostic Checking for Serial LM Test of the Specific ARDL Model

Since the p-value (0.78) of Obs*R-squared is more than 5 percent (p>0.05) in Table 6.9, the null hypothesis of no serial correlation in the residuals is accepted. This implies that the residuals of the model are not serially correlated.

Table 6.9
Diagnostic Checking for Serial LM Test of the Specific ARDL Model

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.03	Probability	0.84
Obs*R-squared	0.07	Probability	0.78

After the Hendry's method applied, the problems of serial correlation are overcome at 1 percent significance level and this also ensures minimum of SBC.[30] This fulfills one of the prerequisites given by Pesaran et al. (2001).

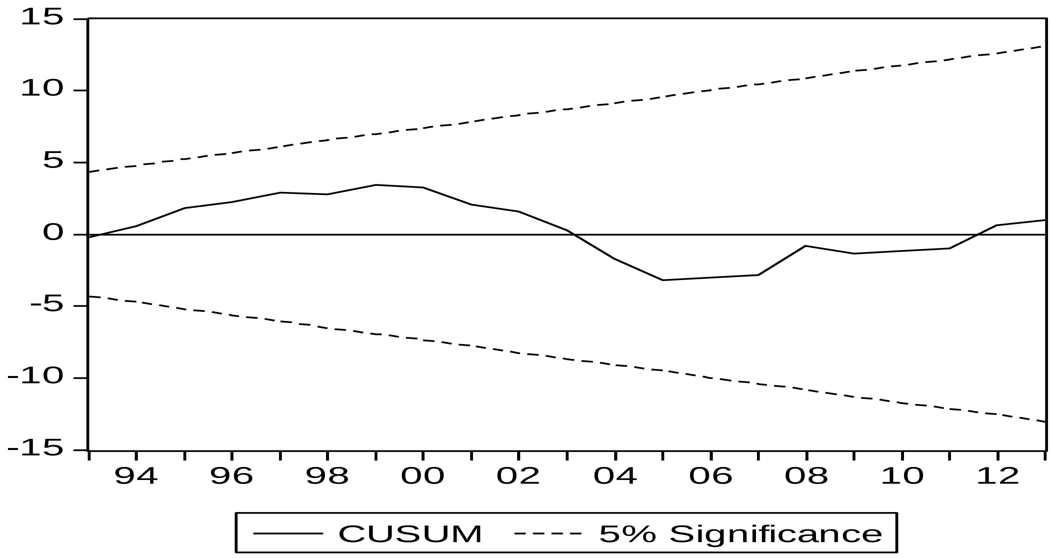
6.2.5.1.7 CUSUM Test and Stability of the Specific ARDL Model

The cumulative sum (CUSUM) test is based on the cumulative sum of the recursive residuals has been applied to test stability of the estimated model (Brown et al., 1975). The test checks the stability of the empirical model. The test finds

[30] SBC in models with maximum lag 2 and lag 1 were -4.81 and -4.38 respectively. But after the Hendry's method applied, the SBC was -4.93, was the lowest in among 3 models.

parameter instability if the cumulative sum goes outside the area between the two critical lines. The CUSUM test result of the specific ARDL model in Figure 6.2 shows that the plots of CUSUM lie within the two critical lines over the all time horizon. This result suggests clearly the stability of the model.

Figure 6.2
CUSUM Test: Stability of the Specific ARDL Model



6.2.5.2 Bound Tests for Cointegration: F-Statistic of Cointegration Relationship

After specifying the optimum lag model, we proceed to the ARDL cointegration bound testing. We want to test whether the coefficients of lagged variables are zero in our above estimated model.

6.2.5.2.1 Wald Test and Associated F-Statistic of Cointegration Relationship

Firstly, the Wald test is done to check whether there is long-run relationship among the variables and to compute the long-run elasticity and its t-statistic.[31]

[31] According to Pesaran et al. (2001) the long-run elasticity for inflation is equal to the ratio of sum of the independent coefficients divided by the 1-sum of the dependent coefficient.

Table 6.10
Wald Test and Associated F-Statistic of Cointegration Relationship

Wald Test:

Test Statistic	Value	df	Probability
F-statistic	7.37	(7, 19)	0.00
Chi-square	51.60	7	0.00

6.2.5.2.2 Results from Critical Value Bounds for the F-Statistics

Results from critical value bounds for the F-statistics testing for the existence of a long-run relationship between inflation and its determinants are presented below Table (6.11).

Table 6.11
Results from Critical Value Bounds for the F-Statistics (Testing for the Existence of a Long-Run Relationship)

Test statistic	Value	lag	Significance level	Narayan (2005) Bound Critical Values (intercept and no trend)		Pesaran and Pesaran (1997) Bound Critical Values (intercept and no trend)	
F –statistic	7.371	1		I(0)	I(1)	I(0)	I(1)
			1 percent	3.64	5.46	3.02	4.29
			5 percent	2.67	4.13	2.36	3.55
			10 percent	2.26	3.53	2.03	3.15

Notes: Asymptotic critical value bounds are obtained from Table F in appendix C from Pesaran (1997), Case II: intercept and no trend for k=7 (see Pesaran and Pesaran, 1997, p. 478). Lower bound I (0) = 3.02 and Upper bound I (1) = 4.29 at 1 percent significance level.

Table 6.10 reports the calculated F-statistics for the cointegration test. The critical values has been displayed together in the Table 6.11which based on critical values suggested by Narayan (2005) using small sample size between 30 and 80, and by Pesaran et al. (2001) in the sixth and seventh column respectively. The calculated F-statistic (F-statistic = 7.37) is higher than the upper bound critical value at 1 percent and 5 percent level of significance for both Narayan (2005) bound critical value (5.46) and Pesaran and Pesaran (1997) bound critical value

(4.29), intercept and no trend. Thus the null hypothesis of no cointegration is rejected at 1 percent and 5 percent level, implying long-run cointegration relationship among the variables.

Once we established that a long-run cointegration relationship existed, equation (4.44), the conditional ARDL long-run model for inflation can be estimated using the following ARDL (1, 0, 0, 0, 0, 0, 0) specification.

6.2.5.2.2.1 Bound Tests for Cointegration: F-Statistic of Cointegration Relationship (in Parsimonious Specification)

We also test the model using Hendry "General to Specific Approach" to get the parsimonious specification. In doing so, we set initially lag 1 (optimal lag length base on SBC) and we eliminate the variables which are not significant, except the intercept. The F-statistic (21.97) of Wald-test on the level variables of the new model, as displayed in Table 6.12 shows stronger result as compare to the previous model. This confirms the existence of long-run relationship among the variables used in ARDL model.

6.2.5.2.2.2 Wald Test and Associated F-Statistic of Cointegration Relationship

Wald test and associated F-statistic of cointegration relationship in parsimonious specification is given in the Table 6.12 below.

Table 6.12
Wald Test and Associated F-Statistic of Cointegration Relationship (in Parsimonious Specification)

Wald Test:

Test Statistic	Value	df	Probability
F-statistic	21.97	(5, 31)	0.00
Chi-square	109.86	5	0.00

6.2.5.2.2.3 Results from Critical Value Bounds for the F-Statistics

Results from critical value bounds for the F-statistics in parsimonious specification are presented in Table 6.13 below.

Table 6.13
Results from Critical Value Bounds for the F-Statistics (in Parsimonious Specification)

Test statistic	Value	lag	Significance level	Narayan (2005) Bound Critical Values (intercept and no trend)		Pesaran and Pesaran (1997) Bound Critical Values (intercept and no trend)	
F –statistic	21.973	1		I(0)	I(1)	I(0)	I(1)
			1 percent	3.64	5.46	3.02	4.29
			5 percent	2.67	4.13	2.36	3.55
			10 percent	2.26	3.53	2.03	3.15

6.2.5.3 Estimated Long-Run (ARDL) Model of Inflation

As the value of F-statistic in the Table 6.13 exceeds the upper bound at the 5 percent significance level, this results reinforces our conclusion that there is a long-run relationship among the variables (at this level of significance or greater). The estimated coefficients of the long-run ARDL inflation model are presented in equation 6.11 below.

$$lnP = 7.174 + 0.62\ lnM - 0.82\ lnY - 0.01r + 0.17\ lnPm \qquad (6.11)$$
$$(5.06) \qquad (-4.28) \qquad (-4.83) \qquad (2.65)$$
$R^2 = 0.779$ D-W = 2.30 F-statistic = 21.97 (Prob. = 0.00)

Equation 6.11 reports the empirical results of the long-run model, obtained by normalizing on inflation. The estimated coefficients of the long-run relationship show that money supply (M), real income (real GDP), real interest rate (r), and import price (Pm) have significant impact on inflation in Bangladesh in the long-run. The signs of the coefficients are also consistent to theories and assumptions.

Results of the estimated long-run ARDL model show that a 1 percent increase in money supply leads to approximately 0.62 percent increase in inflation, all other things being unchanged. The real income variable is negatively signed and highly significant at the 1 percent level. A 1 percent increase in real income leads to a 0.82 percent decrease in inflation in the long-run. Considering the impact of real interest rate for deposit, it is also significant at 1 percent significance level (t-statistic, 4.835), and has the negative impact on inflation. This result is consistent with Kandel et al. (1996, p. 1).

It is observed from the results that the wage variable and exchange rate variable have been dropped from the long-run model because they have been found to be highly insignificant to affect inflation in the long-run, but have the right signs. It is also found that the coefficient of import price has positive impact on inflation and is significant at 5 percent significance level. This relationship is consistent with the previous study by Rahman and Begum (1995), Hossain (1996), Akhtaruzzaman (2005), and Majumder (2006) among others.

6.2.5.4 Estimated Error Correction Model for Inflation

The results of the short-run dynamic coefficients associated with long-run relationships obtained from error correction model (4.45) for inflation are given in Table 6.14. However, this time the nominal wage variable is significant at 5 percent significance level (Table 6.14) and sign is positive. This means that nominal wage has positive short-run impact on the price level. One year lag money supply, real interest rate on deposit, and real income are also found to be significant but the sign of the coefficient real interest rate is still wrong whereas the coefficient of one year lag real income is positive now. This is an indication of non-linear relationship between inflation and real income.

Table 6.14
Error Correction Representation for the Selected ARDL Model

ARDL selected based on SBC. Dependent variable is D (LNP).

Regressor	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.03	0.02	-1.44	0.16
D(LNP(-1))	0.48	0.16	2.91	0.00
D(LNM(-1))	0.26	0.07	3.53	0.00
D(LNY(-1))	0.44	0.32	1.37	0.18
D(LNW(-1))	0.20	0.08	2.49	0.01
D(r(-1))	-0.00	0.00	-3.46	0.00
D(LNER(-1))	0.06	0.07	0.82	0.41
D(LNM(-2))	-0.11	0.08	-1.29	0.20
D(LNPM(-2))	0.01	0.05	0.22	0.82
ECT(-1)	-0.85	0.38	-2.19	0.03
R-squared	0.77	Schwarz criterion		-4.39
Adjusted R-squared	0.69	F-statistic		9.37
Durbin-Watson stat	2.24	Prob(F-statistic)		0.00

The equilibrium correction coefficient or error correction term (ECT), estimated -0.85 (t-statistic, -2.19) is significant at 5 percent level, has the correct sign (negative), and implies a fairly high speed of adjustment to equilibrium after a shock. Approximately 85 percent of disequilibria from the previous year's shock converge back to the long-run equilibrium in the current year. The significant of an error correction term (ECT) shows the evidence of causality in at least one direction.

6.2.5.5 ARDL-VECM Model Diagnostic Tests

The ARDL-VECM model passes the diagnostic tests against serial correlation (Table 6.15) at 5 percent level. The cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) plots (Figure 6.3 and 6.4) from a recursive estimation of the model also indicate stability in the coefficients over the sample period of the study.

6.2.5.5.1 Diagnostic Checking for Serial LM Test of the ARDL–VECM Model

The p-value of Obs*R-squared in the Breusch-Godfrey serial correlation LM test (Table 6.16) is 0.19. Since the p-value of Obs*R-squared is more than 5 percent (p=0.19>0.05), the null hypothesis of no serial correlation in the model cannot be rejected rather accepted at 5 percent level. This means that residuals (u) are not serially correlated which is desirable.

Table 6.15
Diagnostic Checking for Serial LM Test of the ARDL–VECM Model

Breusch-Godfrey Serial Correlation LM Test:

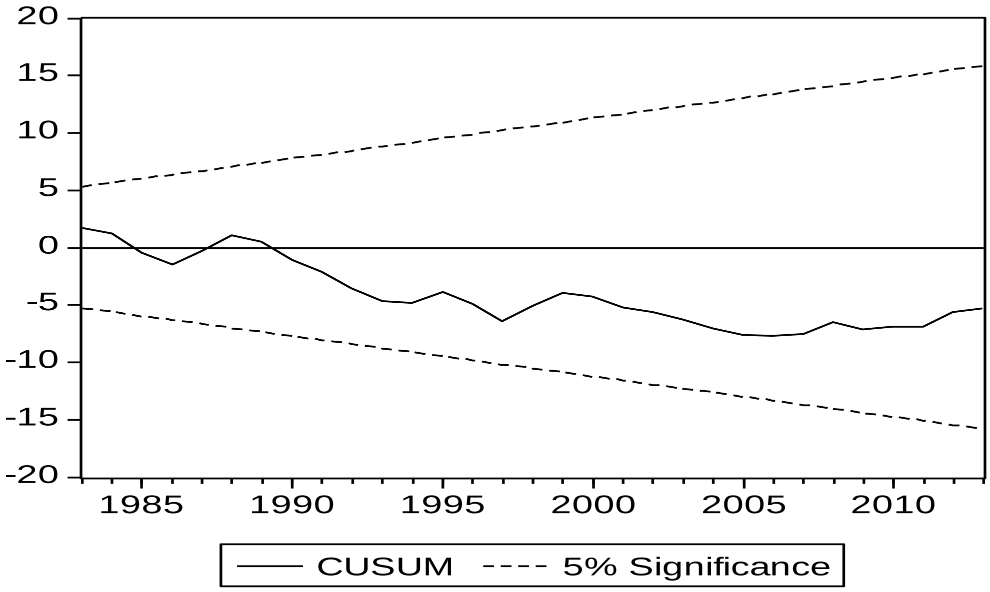
F-statistic	1.40	Probability	0.24
Obs*R-squared	1.65	Probability	0.19

6.2.5.5.2 CUSUM Test and Stability of the ARDL-VECM Model

The cumulative sums (CUSUM) test[32] finds (Figure 6.3) parameter instability if the cumulative sum goes outside the area between the two critical lines. The test clearly indicates stability in the ARDL inflation equation during the sample period because the plots of CUSUM lie within the two critical lines over the all time horizon.

[32] The CUSUM test is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5 percent critical lines.

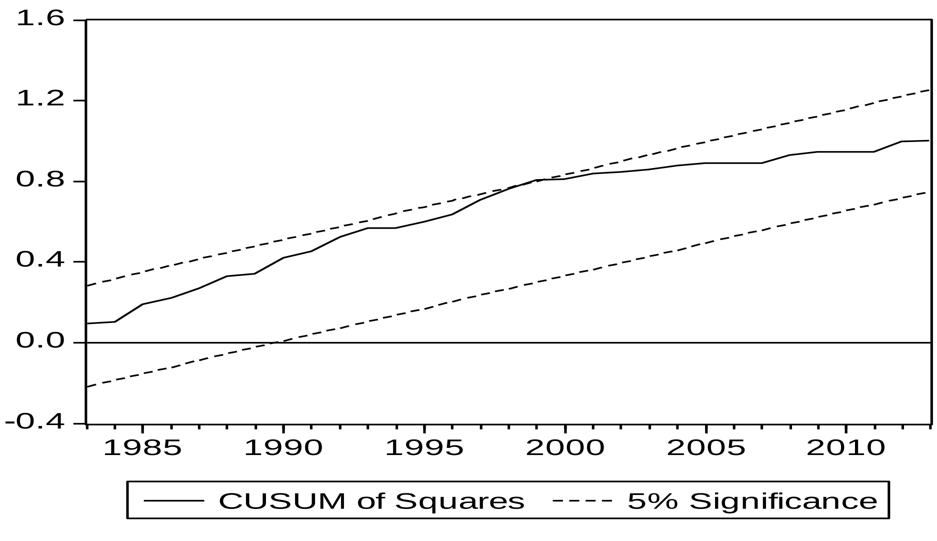
Figure 6.3
Plot of CUSUM for Coefficients Stability of the ARDL –VECM Model



6.2.5.5.3 CUSUMQ Tests and Stability of the ARDL–VECM Model

The cumulative sum of square (CUSUMQ) plots from a recursive estimation of the model also indicate somewhat stability in the coefficients over the sample period as the plots of CUSUMQ lie within the two critical lines in the Figure 6.4 below.

Figure 6.4
Plot of CUSUMQ for Coefficients Stability of the ARDL –VECM Model



6.3 Causality Tests between Wage (W) and Inflation (P) and between Money Supply (M) and Inflation (P)

It is a very important question whether increase in nominal wage caused rise in general price level or vice versa. Similarly, it is also an important question whether growth of money supply caused inflation or vice versa.

Using the pair-wise Granger causality method, these questions are pursued and empirical results are presented and discussed. The estimates of the pair-wise Granger causality test for both wage (W) and inflation (P) and money supply (M) and inflation (P) are as follows.

6.3.1 Causality Tests between Wage (W) and Inflation (P)

Causality test between wage and inflation can be written as

$$W = \sum_{i=1}^{n} \alpha_i P_{t-i} + \sum_{j=1}^{n} \beta_j W_{t-j} + u_{1t} \quad \text{......} \quad (6.3.1.1)$$

$$P = \sum_{i=1}^{m} \lambda_i P_{t-i} + \sum_{j=1}^{m} \delta_j W_{t-j} + u_{2t} \quad \text{......} \quad (6.3.1.2)$$

The empirical estimates are given in Table 6.17.

Table 6.16
Causality Tests between Wage (W) and Inflation (P)

Pair-wise Granger Causality Tests
Sample: 1976 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
LNW does not Granger Cause LNP	36	3.54	0.04
LNP does not Granger Cause LNW		4.98	0.01

The results of the pair wise Granger causality test given in Table 6.16 show that the null hypothesis, nominal wage (W) does not Granger cause inflation (P) and inflation does not Granger cause wage increase is rejected at 5 percent significance level. The results of the Granger causality tests, however, confirm that there is a two way or a bi-directional causality between inflation and nominal wage.

Many experts on economy argue that the increased wage increases the money supply flow in the market and hence fuels inflation. This result could also be due to the fact that when wages rise at higher rate, businessman and employees tend to build rapid rate of inflation into their price and wage decisions. People forms their expectations that price must increase. If everyone expects average costs and prices to rise, prices should rise (Samuelson and Nordhaus, 2004). This may be the case of wage-price spiral in Bangladesh.

6.3.2 Causality Tests between Money Supply (M) and Inflation (P)

Causality test between money supply and inflation can be written as

$$M = \sum_{i=1}^{n} \alpha_i P_{t-i} + \sum_{j=1}^{n} \beta_j M_{t-j} + u_{1t} \quad \text{..} \quad (6.3.2.1)$$

$$P = \sum_{i=1}^{m} \lambda_i P_{t-i} + \sum_{j=1}^{m} \delta_j M_{t-j} + u_{2t} \quad \text{..} \quad (6.3.2.2)$$

The empirical estimates of causality between money supply and inflation are given in Table 6.17 below.

Table 6.17
Causality Tests between Money Supply (M) and Inflation (P)

Pair-wise Granger Causality Tests
Sample: 1976 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
LNM does not Granger Cause LNP	36	12.64	0.00
LNP does not Granger Cause LNM		2.31	0.11

The results as depicted in Table 6.17 indicate that the null hypothesis of money supply growth (M) does not Granger cause inflation (P) is rejected at both the 5 percent and 1percent level while the null hypothesis of inflation does not Granger cause money growth cannot be rejected. This means the causality between money growth and inflation is unidirectional and runs from money growth to inflation not the other way round implying that money growth is important factor in predicting future inflation where inflation is not helpful in the prediction of money growth. This is a fairly well established result and similar result was obtained by other authors.

On the basis of the empirical evidence obtained by employing Granger test for causality, it has been found that there is a two-way causal link that runs from consumer prices to wages and vice versa. But there is an evidence of unidirectional causality that runs from money to consumer prices. These findings support both the cost-push and monetarist view that inflation during the period 1976-2013 has been caused by increases in the money supply and wages. Thus inflation in Bangladesh is primarily a demand-pull as well as a cost-push phenomenon. Our results agree with Friedman's assessment that “long-period changes in i.e. quantity of money relative to output determine the secular behavior of prices" and also the cost-push view that "rising prices are results of wage-push: labor unions' extracting nominal wage rate increases greater than the increase in the productivity of labor" (Shapiro, 1982). These empirical results also indicate that the wage and money supply are important causal agents in the inflationary process in Bangladesh, one can question the effectiveness of relying heavily, on i.e. wage and price controls of the economic stabilization program to moderate inflation.

6.4 Empirical Results of the Impact of Inflation on GDP Growth

Empirical results of the impact of inflation on GDP growth during the period 1976-2013 are discussed in this section. Our empirical study contains unit root tests, cointegration tests, and Granger causality tests in light of the econometric methodology. The first step of this process is to establish the order of integration and for this; we have used ADF test, PP test, and the DF-GLS unit root test. In the second step, Johansen and Juselius cointegration test is applied. Finally error correction modeling (ECM) approach is applied to assess the Granger causality from inflation to GDP growth and also the Wald test to find out the short causality from inflation to growth. Estimated results are reported below in details.

6.4.1 Unit-Root Tests

In the first section of this chapter the time-series properties of these two variables have been analyzed using different unit root tests for the period of 1976-2013, the results of the unit root tests have been discussed then. The Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), Dickey-Fuller Generalized Least

Square (DF-GLS) unit root tests has been tested. These unit-root tests are performed on both levels and first differences of the variables.

The results of PP test (Table 6.2) and DF-GLS tests (Table 6.3) confirm that both the inflation and real GDP growth are stationary at first difference. However, DF-GLS unit root test reports stationarity of inflation at 10 percent level of log level variable, after first differencing of the variable shows stationary at 1 percent significance level under the test. Since, the variables are integrated of same order (first order, i.e. I (1)), on the basis of the above unit-root tests, we can apply the Johansen (1988 and 1991) and Johansen and Juselius (JJ) (1990, 1992, and 1994) method of cointegration to obtain the cointegrating vector. Moreover, Gonzalo (1994) provided Monte Carlo evidence that Johansen-Juselius method performed better than others according to different statistical criteria.

6.4.2 Cointegration Tests

Before undertaking cointegration tests, the relevant order of lags (p) of the Vector Autoregression (VAR) model is specified. Given the annual nature of the data, p = 1 seems to be a reasonable choice (Pesaran and Pesaran, 1997).

Table 6.18
Johansen-Juselius Maximum Likelihood Cointegration Tests

Null Hypothesis	Alternative Hypothesis	Statistic	5 Percent Critical Value
Trace Test			
r=o	r=1	50.14	15.41
r≤1	r=2	21.33	3.76
Max-Eigen Test			
r=o	r=1	28.81	14.07
r≤1	r=2	21.33	3.76

Notes: The test has been conducted using E-Views 8.0; *r* stands for the number of cointegrating vectors.

Table 6.18 presents the results obtained from the Johansen and Juselius (JJ) (1990, 1992, and 1994) cointegration test between GDP growth and inflation for the period 1976-2013. Results of both the Trace test and Maximum-Eigen value test are reported in the Table (6.18). Results show both the Trace statistic and Max-Eigen statistic are greater than the corresponding critical value in both case when r=0 and r=1 at 5 percent level of significance. This implies that the null hypothesis of no cointegration ($r \leq 1$) among the two variables of real GDP and inflation is rejected and the alternative hypothesis of cointegration (r=2) is accepted at the 5 percent significance level. Therefore, the results of trace test and the max-Eigen value test confirm that there are two cointegrating long-run or equilibrium relation between the GDP growth and inflation.

Estimates of long-run cointegrating equilibrium relation are given below in equation 6.12:

$$\ln Y = -0.53 \ln P \qquad (6.12)$$

$$(-17.66)$$

Equation 6.12 exhibits the long-run cointegrating equilibrium relationship between inflation and GDP growth. In the estimated equation (6.12), inflation on real GDP growth has emerged as significant determinants of the real GDP growth model for Bangladesh. The growth is found to be inflation-inelastic, the coefficient estimates being -0.53 (less than 1).

6.4.3 Granger Causality Tests based on Vector Error Correction Model

Following Granger, we estimate a vector error correction model for the Granger causality test because we found a cointegration relationship between inflation and real GDP growth in Bangladesh. Engle and Granger suggest that if cointegration exists between two or more variables in the long-run, then there must be either unidirectional or bi-directional Granger causality between these variables.

To test the stability of the long-run relationship and to find out the direction of causality we estimate VEC model. The short-run causality can be examined by looking significance of the relevant lagged independent variable(s) while long-run causality can be checked by observing the significance of the coefficients of the error correction term (ECT) of VECM (Oh and Lee, 2004; Awokue, 2007).

Firstly, the optimal number of lag is selected through sequential modified LR test statistic (each test at 5 percent level), final prediction error (FPE), Akaike information criterion (AIC), and Hannan-Quinn information criterion (HQ), with these lag selection criteria for VEC model it has been observed that lag 3 is selected. So, we first include 3 lags of the explanatory variables, and then following Hendry's (1995) general-to-specific modeling approach we gradually eliminate the insignificant variables.

After experimenting with the general form of the ECM, the following model is found to fit the data best (Table 6.19):

Table 6.19
Granger Causality Tests Results

Dependent Variable	ECT	T-Ratio	P-Value
ΔlnY	-0.25	-2.44	0.02
Serial Correlation	F-Statistic 1.48		0.17
Heteroskedasticity	F-Statistic 1.61		0.19

The estimated coefficient of the error correction term (-0.25) is statistically significant at the 5 percent significance level and with the appropriate (negative) sign. This suggests the validity of a long-run equilibrium relationship among the variables in equation (4.17) and causality between inflation and GDP growth runs from the inflation to GDP growth. This implies that inflation Granger causes GDP growth negatively in the long-run. The estimated coefficient value of -0.25 also indicates that the system corrects its previous period's disequilibrium by 25 percent a year. Diagnostic test statistics show no evidence of serial correlation, nor any problem of heteroscedasticity (6.19).

6.4.4 Short-run Granger Causality: Wald Test

The short-run causality between inflation and GDP growth has been examined by looking at the significance of the coefficient of the relevant lagged independent variable. Wald test statistic examines the joint significance of the relevant lagged independent variable. We conduct the null hypothesis test that the coefficients of lagged inflation are zero. The results of Wald test are reported below.

Table 6.20
Wald Test: Short-run Causality from Inflation to GDP Growth

Wald Test:

Test Statistic	Value	df	Probability
F-statistic	0.81	(3, 25)	0.49
Chi-square	2.43	3	0.48

Table 6.20 reports an F-statistic and a Chi-square statistic with associated p-values. We focus on the Chi-square statistic which fails to reject the null hypothesis. Chi-square value and corresponding probability of Wald test statistic are 2.43 and 0.48 (<0.10) respectively, so we can reject the null hypothesis, that the coefficient of CPI lag 1, CPI lag 2 and CPI lag 3, that is c(5), c(6) and c(7) are jointly zero at 5 percent significance. This means CPI lag 1, CPI lag 2 and CPI lag 3 cannot jointly influence GDP growth in the short- run, meaning that there is short-run Granger causality running from lag values of inflation to GDP growth in Bangladesh.

6.4.5 Toda-Yamamoto Causality between Inflation and GDP Growth

A bi-variate Granger causality procedure developed by Toda and Yamamoto is also applied to determine the direction of causality between inflation and GDP growth. Table 6.21 reports the optimal lag length (k), VAR order (k+dmax), M Wald statistics p values and direction of causality for the VAR model. The results in Table 6.21 suggest that both null hypothesis of ‘Granger no-causality from inflation to real GDP’ and ‘Granger no-causality from real GDP to inflation’ can be rejected at the 1 percent and 5 percent significance level respectively. This indicates that there is a two-way causality between inflation and real GDP. The fact that there is a two-way causality between inflation and GDP in the Bangladesh economy indicates that inflation causes GDP, as argued in the literature, and GDP also causes inflation.

Table 6.21
Toda-Yamamoto Causality between Inflation and GDP Growth

Null Hypothesis	Lag (k)	k+d_{max}	MWald Statistics	P-Values	Direction of Causality
Inflation does not Granger Cause GDP	2	2+1=3	12.44	0.00	Inflation ↔ GDP
GDP does not Granger Cause Inflation	2	2+1=3	8.18	0.01	GDP ↔ Inflation

Notes: The (k+dmax) denotes VAR order. The lag length selection was based on LR: sequential modified LR test statistic (each test at 5 percent level), SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion.

6.4.6 Variance Decomposition and Impulse Response Function

From an estimated VAR, we compute variance decompositions and impulse-response functions, which serve as tools for evaluating the dynamic interactions and strength of causal relations among variables in the system. The Granger causality tests do not sufficiently answer the question on what is the extent of causality and as such, is it destabilizing in nature but the variance decomposition helps to determine the proportion of the total variance in the volatility of one variable explained by innovations in the volatility of the other variables (Datta and Mukhopadhyay, 2011).

In simulating variance decompositions and impulse response functions, it should be noted that the VAR innovations may be contemporaneously correlated. This means that a shock in one variable may work through the contemporaneous correlation with innovations in other variables. The responses of a variable to innovations in another variable of interest cannot be adequately represented since isolated shocks to individual variables cannot be identified due to contemporaneous correlation (Lutkepohl, 1991).

Therefore, we are using Cholesky factorization that orthogonalizes the innovations as suggested by Sims (1980) to solve this identification problem. The strategy requires a pre-specified causal ordering of the variables. The results from variance decomposition and impulse response functions may be sensitive to the variables' ordering unless the error terms' contemporaneous correlations are low. The ordering of variables suggested by Sims (1980) is started with the most exogenous variables in the system and ended by the most endogenous variable. The results of variance decomposition and impulse response functions are displayed in Table 6.22.

6.4.6.1 Variance Decomposition

The variance decomposition is an alternative method to IRF for examining the effects of shocks to the dependent variables. It determines how much of the forecast error variance for any variable in a system is explained by innovations to each explanatory variable, over a series of time horizons. Usually own series shocks explain most of the error variance, although the shock will also affect other variables in the system. Table 6.22 (a) shows that the VDC substantiate the significant role played by LNP in accounting for fluctuations in Bangladesh GDP growth (LNY). At 3 year horizon, the fraction of Bangladesh GDP growth forecast error variance attributable to variations in the CPI inflation is 6.12 percent. The explanatory power of CPI inflation increases further at 4-year horizon. However, the portion of real GDP growth variations explained by innovation in inflation continuously increase at longer horizon and reaches its peak more than 13 percent at 7 year horizon. On the other hand, more than 14 percent variability of inflation is accounted by growth innovations over the time horizon (Table 6.22 b). Datta and Mukhopadhyay (2011) found that more than 13 percent variability of inflation is accounted by growth over the time horizon. This result is consistent partly with this study.

Looking along the main diagonal, the results reveal that the own shock is relatively high for both growth and inflation, with more than 86 percent and 85 percent respectively. The small difference of the range of own shock's contribution means that neither inflation nor growth is highly exogenous or highly endogenous, at least after a 10-year post-shock horizon.

Table 6.22
Variance Decomposition

(a) Variance Decomposition of LNY:

Period	S.E.	LNY	LNP
1	0.01	100.00	0.00
2	0.01	99.67	0.32
3	0.01	93.87	6.12
4	0.01	92.57	7.42
5	0.01	89.19	10.80
6	0.01	87.99	12.00
7	0.01	86.79	13.20
8	0.01	86.37	13.62
9	0.01	86.09	13.90
10	0.01	86.01	13.98

(b) Variance Decomposition of LNP:

Period	S.E.	LNY	LNP
1	0.02	20.85	79.14
2	0.03	17.53	82.46
3	0.03	14.74	85.25
4	0.03	14.56	85.43
5	0.03	14.17	85.82
6	0.03	14.46	85.53
7	0.03	14.56	85.43
8	0.03	14.73	85.26
9	0.03	14.80	85.19
10	0.03	14.84	85.15

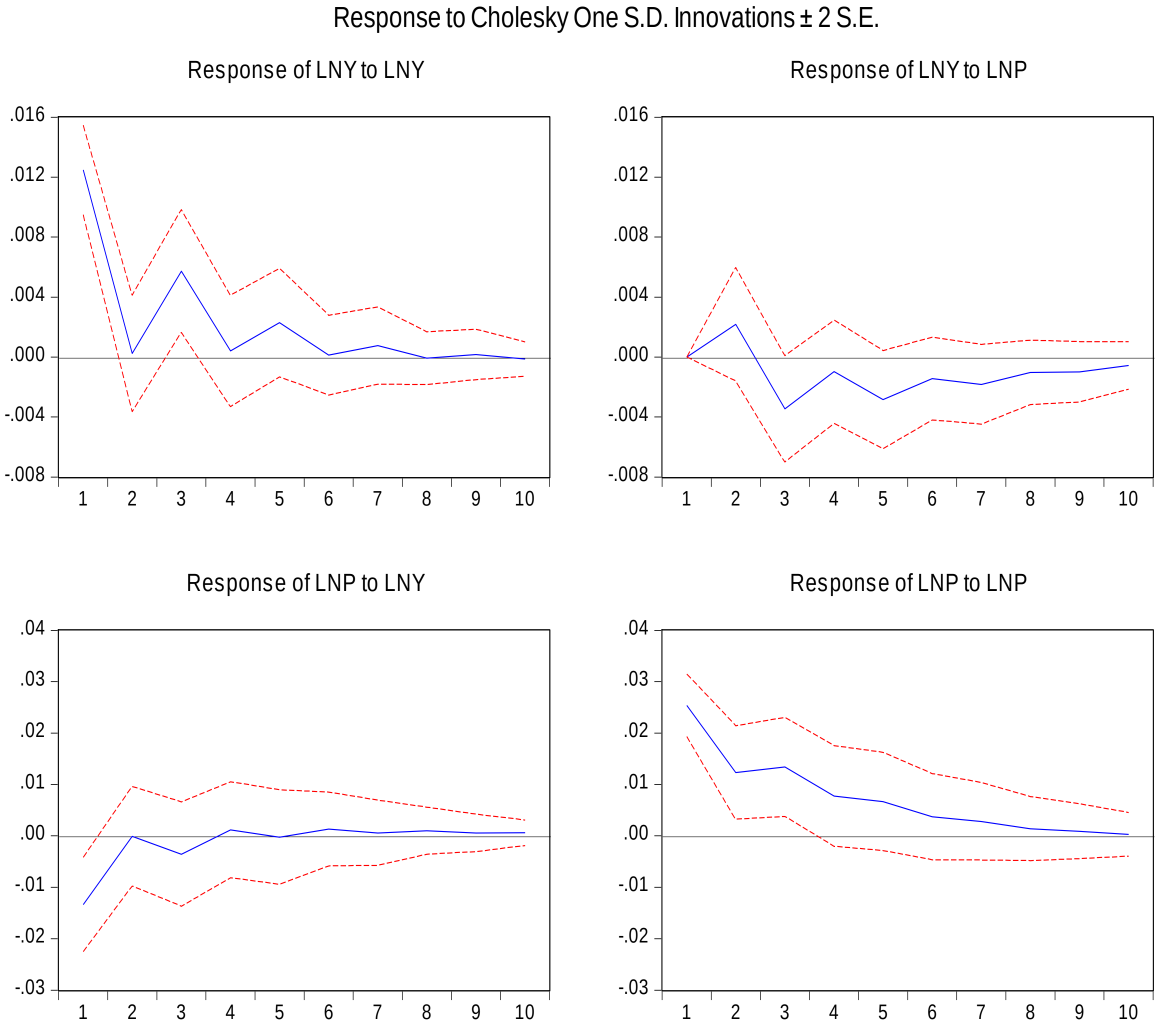
Cholesky Ordering: LNY LNP

6.4.6.2 Impulse Response Function

The IRF can produce the time path of dependent growth in the VAR, to shocks from inflation. It could be seen from Figure 6.5 that, at any dependent variable, any shock of the explanatory variable makes the impulse responses dies out to zero. This implies that the system of equation developed, i.e. the VECM, is a stable system. Furthermore, from the Figure, the directions of variables' responses to innovations in the system are theoretically reasonable in most cases. Real income growth reacts significantly to inflation innovations as it respond negatively for the most of years and then subsides to zero afterwards.

As mentioned in the OLS and ARDL model earlier, this result conforms to our expectation that a growth in real income decreases inflation. This result is consistent with Akhtaruzzaman (2005). The result also shows that the responses of inflation to growth is not linear rather non-linear in nature that confirms the results obtained by Ahmed and Mortaza (2005). Figure 6.5 reveals another important response that inflation responds significantly and positively to a shock in inflation itself over the time horizon before it subsided to zero. These results are consistent with the most of the estimated inflation equation using OLS. These results have important policy implications.

Figure 6.5
Impulse Response Function



6.5 Chapter Summary

A number of significant empirical results have been obtained with respect to different econometric specification of the inflation models, the short-and the long-run inflation equation, causality between wage and inflation, and money supply and inflation, and impact of inflation on GDP growth. It is important to give a summary of these results, which are presented below.

i) At first, the stationary properties of the relevant variables have been examined using the three unit root tests (ADF, PP, and DF-GLS). The unit root test results suggest that some of the series are stationary at their levels I(0), and some are stationary at first difference I(1), a mixture of I(0) and I(1) series but none of the series is I(2).

ii) Results of the estimated monetary inflation equation show that money supply (M), real income (GDP), inflation lagged by one period, and real rate of interest are important determinants of inflation in Bangladesh. The money supply variable and inflation lagged by one period are positively related to inflation while the real income and real rate of interest are negatively related to inflation.

iii) When one period lagged money supply variable has been included in the monetary inflation equation, the coefficient of one year lagged money supply is found to be statistically significant but the coefficient of current money supply is found to be statistically insignificant then.

iv) The same results are observed when one and two period lagged money supply variables have been included in monetary inflation equation; both the lagged money supply variables are significantly and positively related to inflation but the coefficient of current money supply is no more significant. Besides, real income turns to be insignificant now. It can be concluded from the above results that people do not realize immediately the increase in money supply in Bangladesh, and as a result, money illusion is at work in the economy. This result is consistent with Nupane (1992) for Nepal.

v) An analysis of sub-periods results (pre- and post-liberalization period) exhibits that money elasticity of inflation is higher during the pre-liberalization period (1976-1990) than the post-liberalization period (1991-2013) and interest elasticity is higher in the post-liberalization period than the pre-liberalization period. But, the money supply elasticity of CPI for the post-liberalization period is lower than that for the whole period and pre-liberalization period as well. The coefficient of money supply for the post-liberalization period has even found to be insignificant statistically. This is perhaps due to the fact that there was greater intervention on the money supply by the monetary authority. On the other hand, during the pre-liberalization period the interest rate was often deliberately held constant by the monetary authority while during the post-liberalization period, there was lesser intervention on the interest rate.

v) The regression results of the cost-push inflation equations confirm that the nominal wage and exchange rate are the important cost-push determinants of inflation in Bangladesh. Other variables such as value of imported raw materials, world oil price, and a dummy variable (proxy of supply shock) are found not to be related to inflation significantly.

vi) Estimates of hybrid inflation equations show that money supply, nominal wage, real income, unit price of import, real deposit interest rate, and previous year inflation are important determinants of inflation in Bangladesh. The exchange rate is not found significant determining inflation in Bangladesh. The results prove that the cost-push factor like wage is stronger affecting inflation in Bangladesh than monetary variables as its higher coefficient value.

vii) Hendry’s general to specific approach has been applied in ARDL - VEC model specification framework to have a specific long-run inflation equation for Bangladesh along with its short-run dynamics.

viii) The results of ARDL cointegration indicates that in the long-run, inflation in Bangladesh is found to be influenced by the money supply growth, real income growth, real interest rate (with wrong sign), and import price growth. The results of conditional VECM exhibit that, in the short-run, however, the inflation in Bangladesh, is mainly determined by the nominal wage, one year lag money supply, real income, and real rate of interest. An interesting result is that the sign of the coefficient of one year lag real income is now positive, that means in the short-run, real income is positively related to inflation in Bangladesh. But, in the long-run real income is found negatively related to inflation. This is an indication of non-linear relationship between inflation and real income in Bangladesh.

ix) One causality test results substantiate that there is two-way or bi-directional Granger causality between wage and inflation in Bangladesh, implying that inflation in Bangladesh is wage-push and wage in Bangladesh is also pushed by the inflation or price level. There is the case of wage-price spiral in Bangladesh.

x) Another causality test results confirm that money supply Granger causes inflation in Bangladesh but inflation does not Granger cause money supply. This means there is one way causation between money supply and inflation, and it runs from money supply to inflation.

xi) The Johansen and Juselius (1990, 1992, and 1994) cointegration test results provide evidence that there is long-run equilibrium relationship between inflation and GDP growth in Bangladesh.

xii) The results of Granger causality test based on VECM show that inflation Granger causes growth negatively in the long-run in Bangladesh and this finding is consistent with previous results. The Wald test result also proves that inflation has no short-run effect on economic growth in Bangladesh. In addition, the Toda-Yamamoto causality test results confirm a two-way causality between inflation and real GDP in Bangladesh.

xiii) The variance decomposition (VDC) result confirms that inflation plays the significant role in accounting for fluctuations in GDP growth in Bangladesh.

xiv) The result of the impulse response function (IRF) indicates that the responses of inflation to growth are not linear rather non-linear in nature and this result is consistent with previous research findings.

xv) To test stability of the estimated equations the cumulative sum (CUSUM) test has been applied and the results of CUSUM test validate that the estimated equations are somewhat stable.

xvi) The Breusch-Godfrey (B-G) Serial Correlation LM test has been used to detect the presence of autocorrelation problem of the estimates. There is also evidence for autocorrelation problem and it has been also corrected by using different methods. When corrected, this leads to some changes in the estimated function.

In a nutshell, considerable insights could be obtained from these estimates of the various aspects of inflation in Bangladesh.

Chapter 7
Summary and Conclusion

In this thesis, various aspects of inflation in Bangladesh have been empirically studied. The relative importance of the factors affecting inflation in Bangladesh has been examined using demand-pull, cost-push, and hybrid inflation models. Besides, providing the estimates for the whole period of 1976-2013, estimates are also provided for the pre-liberalization (1976-1990) and post-liberalization period (1991-2013) separately. Particular focus has been given on determining the long-run and short-run determinants of inflation applying ARDL-VEC models.

The causality analysis, an important part of this type of study has been done between wage and inflation, and money supply and inflation using Granger causality test.

A key emphasis of this study has been also placed on investigating the long-run and short-run effect of inflation on GDP growth.

A summary of these empirical results, some policy implications, and concluding remarks are given below.

7.1 Summary

In the main body of the thesis, each chapter contains a summary. These summaries have been brought together in this section and presented below chapter by chapter.

Chapter 1

This is the introductory chapter, which contains the main outline of the thesis. It includes the statement of the problem, research questions, objectives, hypotheses, and rationale. This also discusses the organization of the thesis.

Chapter 2

Chapter 2, the background chapter, includes discussion on the composition and structure of the CPI inflation in Bangladesh. This is followed by an analysis of inflation in Bangladesh, as well as a breakdown of inflation into trend, cyclical and random components.

Chapter 3

A review of some selected works on inflation is given in chapter 3. This contains a review of works on various aspects of inflation in general and on Bangladesh. The general works shed light on large number of issues, and reported a large number of results. The growing number of works on inflation in Bangladesh, though still few in number, also shed light on both the demand-pull and cost-push inflation, the two mainstream inflation analyses. Besides, with few exceptions, proper importance was not given on cost-push inflation analysis and on ARDL- error correction modeling approach.

Chapter 4

After completing the review of empirical literatures, the general models of inflation in Bangladesh are transformed into equations with various alternatives and are discussed relevant econometric methodology in chapter 4. These include the following.

1. The monetary inflation model, which is used in this study, is described first. It has three versions. It is first shown that inflation is a function of money supply, real GDP, real deposit interest rate, and inflation lagged by one year (expectation factor). The second and third incorporate one year and two year lagged money supply into previous equation. There are three variations in (first) monetary inflation equation because there are three time frames: for the whole period (1976-2013), for the pre-liberalization period (1976-1990), and for the post-liberalization period (1991-2013).

2. The cost-push inflation model is stated after this, which shows inflation is a function of wage, exchange rate, value of imported raw materials, and world oil price among others.

3. The hybrid inflation model, a combination of both the demand-pull and cost-push factors, is presented next where inflation is shown as a function of money supply, exchange rate, wage, real GDP, import price, real (deposit) interest rate in the first version, and in the second version previous year inflation (as an expectation factor) is incorporated into first version as a function of inflation.

4. The modeling strategy adopted in this study also involves different steps. First, the Augmented Dickey-Fuller (ADF), Dickey-Fuller Generalized Least Squares (DF-GLS), and Phillips-Perron (1988) unit-root tests are described which are

needed to determine the order of integration of the variables. Then Johansen – Juselius (1990, 1992, 1994) maximum likelihood method of cointegration and ARDL cointegration approach are discussed. These two tests determine the long-run relationship among the variables.

5. Vector error correction modeling (VECM) approach is also presented and analyzed which has been applied to test Granger causality and to have short-run dynamics of long-run relationship.

6. After this, the causality analysis framework is stated in terms of pairs of relationship between wage and inflation, and money supply and inflation.

7. Lastly, the impact of inflation on GDP growth is presented and discussed in terms of causal relationship between inflation and GDP growth using Granger causality, Toda-Yamamoto causality tests.

Chapter 5

A discussion of the data on CPI inflation, money supply, real GDP, wage indices, real interest rate, exchange rate, import price, value of imported raw materials, and oil price in the world market for econometric estimation is given in chapter 5. Data on these time series variables are in annual frequency covers the period from 1976-2013. As data of these variables are different in nature, these have been collected from various sources. These include mainly various issues of *Monthly Economic Trends*, *Statistical Yearbook of Bangladesh*, *Bangladesh Economic Review*, and *World Development Indicators*.

Chapter 6

The empirical results, the main trust of this thesis, have been presented and analyzed in chapter 6 in terms of econometric estimates.

1. At first, the stationary properties of the relevant variables have been examined using the three unit root tests (ADF, PP, and DF-GLS). The unit root test results suggest that some of the series are stationary at their levels I(0), and some are stationary at first difference I(1), a mixture of I(0) and I(1) series but none of the series is I(2).

2. Results of the estimated monetary inflation equation show that money supply (M), real income (real GDP), inflation lagged by one period (P_{t-1}), and real rate of interest (r) are important determinants of inflation in Bangladesh. The money supply variable and inflation lagged by one period are positively related to inflation while the real income and real rate of interest are negatively related to inflation. But real interest rate is expected to be positively related to inflation and vice versa.

3. When one period lagged money supply variable has been included in the monetary inflation equation, the coefficient of one year lagged money supply is found to be statistically significant but the coefficient of current money supply is found to be statistically insignificant then.

4. The same results are observed when one and two period lagged money supply variables have been included in monetary inflation equation; both the lagged

money supply variables are significantly and positively related to inflation but the coefficient of current money supply is no more significant. Besides, real income turns to be insignificant now. It can be concluded from the above results that people do not realize immediately the increase in money supply in Bangladesh, and as a results, money illusion is at work in the economy. This result is consistent with Nupane (1992) for Nepal.

5. An analysis of sub-periods results (pre- and post-liberalization period) exhibits that money elasticity of inflation is higher during pre-liberalization period (1976-1990) than post-liberalization period (1991-2013) and interest elasticity is higher in post-liberalization period than pre-liberalization period. But, the money supply elasticity of CPI for the post-liberalization period is lower than that for the whole period and pre-liberalization period as well. The coefficient of money supply for the post-liberalization period has even found to be insignificant statistically. This is perhaps due to the fact that there was greater intervention on the money supply by the monetary authority. On the other hand, during the pre-liberalization period the interest rate was often deliberately held constant by the monetary authority while during the post-liberalization period, there was lesser intervention on the interest rate.

6. The regression results of the cost push inflation equations confirm that the nominal wage and exchange rate are the important cost-push determinants of inflation in Bangladesh. Other variables such as value of imported raw

materials, world oil price, and a dummy variable (proxy of supply shock) have not found to be significantly related to inflation.

7. Estimates of hybrid inflation equations show that money supply, nominal wage, real income, unit price of import, real deposit interest rate, and previous year inflation are important determinants of inflation in Bangladesh. The exchange rate is not found significant determining inflation in Bangladesh. The results prove that the cost-push factor like wage is stronger affecting inflation in Bangladesh than monetary variables as its higher coefficient value.

8. Hendry's general to specific approach has been applied in ARDL -VEC model specification framework to have a specific long-run inflation equation for Bangladesh along with its short-run dynamics.

9. The results of ARDL cointegration indicates that in the long-run, inflation in Bangladesh is found to be influenced by the money supply growth, real income growth, real interest rate, and import price growth. The results of conditional VECM exhibit that, in the short-run, however, the inflation in Bangladesh, is mainly determined by the nominal wage, one year lag money supply, real income, and real rate of interest. An interesting result is that the sign of the coefficient of one year lag real income is now positive, that means in the short-run, real income is positively related to inflation in Bangladesh. But, in the long-run real income is found negatively related to inflation. This is an indication of non-linear relationship between inflation and real income in Bangladesh.

10. One causality test results substantiate that there is two-way or bi-directional Granger causality between wage and inflation in Bangladesh, implying that inflation in Bangladesh is wage-push and wage in Bangladesh is also pushed by the inflation or price level. There is the case of wage-price spiral in Bangladesh.

11. Another causality test results confirm that money supply Granger causes inflation in Bangladesh but inflation does not Granger cause money supply. This means there is one way causation between money supply and inflation, and it runs from money supply to inflation.

12. The Johansen and Juselius (1990, 1992, and 1994) cointegration test results provide evidence that there is long-run equilibrium relationship between inflation and GDP growth in Bangladesh.

13. The results of Granger causality test based on VECM show that inflation Granger causes growth negatively in the long-run in Bangladesh and this finding is consistent with previous results. The Wald test result also proves that inflation has no short-run effect on economic growth in Bangladesh. In addition, the Toda-Yamamoto causality test results confirm a two-way causality between inflation and GDP growth in Bangladesh.

14. The variance decomposition (VDC) result confirms that inflation plays the significant role in accounting for fluctuations in GDP growth in Bangladesh.

15. The result of the impulse response function (IRF) indicates that the responses of inflation to growth are not linear rather non-linear in nature and this result is consistent with previous research findings.

16. To test stability of the estimated equations the cumulative sum (CUSUM) test has been applied and the results of CUSUM test validate that the estimated equations are somewhat stable.

17. The Breusch-Godfrey (B-G) Serial Correlation LM test has been used to detect the presence of autocorrelation problem of the estimates. There is also evidence for autocorrelation problem and it has been also corrected by using different methods. When corrected, this leads to some changes in the estimated function.
18. In a nutshell, considerable insights could be obtained from these estimates of the various aspects of inflation in Bangladesh.

Chapter 7

In chapter 7, summary of the study, which is discussed above, some policy implications, scope for further extension, and conclusion are given.

7.2 Policy Implications

The empirical results obtained in this study have also important policy implications for developing countries in general and for Bangladesh in particular. Different demand-pull and cost-push, and hybrid models of inflation in Bangladesh have been estimated empirically and the causal link of inflation with its some important determinants has been also examined, implication of these empirical results is discussed below.

Money supply (M2) is found to be an important factor affecting inflation in Bangladesh and it causes inflation positively but not vice versa. Beside this, statistically significant lagged money supply indicates that money illusion is at work in the economy. This implies that over the long period sustain reduction in the inflation will require reduction in the money supply growth and the monetary authority in Bangladesh may be able to control inflation to some extent by monetary targeting.

The estimates of sub-periods demonstrate that money elasticity of inflation is higher during pre-liberalization period (1976-1990) than post-liberalization period (1991-2013) and the coefficient of money supply for the post-liberalization period has even found to be insignificant statistically. This is perhaps due to the fact that there was greater intervention on the money supply growth by the monetary authority.

The estimated coefficient of real GDP is found to be significant in every model except in models of sub periods. The results of OLS and ARDL –VECM suggest that in the short-run real GDP is positively related to price level while in the long-run it appears to be negative. It can be also observed that the coefficient value of real income (GDP) is stronger than the coefficient of money supply (M2) in the most equations. This means that the hypothesis that inflation in Bangladesh is essentially a monetary phenomenon is not a very robust hypothesis. This implies that income policy should also be emphasized for Bangladesh and a policy of keeping inflation low is also good for supporting higher GDP growth.

The coefficient of one-period lagged inflation or the inflation expectation variable has been consistently found to be a significant determinant that influences inflation positively. The implication of the results is that the inflation expectation variable has a substantial role in price formation in Bangladesh which means inflation in Bangladesh is downward sticky and very rigid to adjustment by any policy and may be an alternative way to reduce inflation. This finding is also consistent with Pindyck and Rubinfeld (1985), Samuelson and Nordhaus (2004) that when the rate of inflation is high for a year or more, people develop inflationary expectations, which in turn have an inflationary impact on current and future prices. Wage rise may also work influencing inflation through expectation channel.

The real deposit interest rate (r) has been found to be significantly and negatively related to the inflation but its coefficient value is not very strong. It is also observed from monetary model for pre-and post-liberalization period that the coefficient of real interest rate is insignificant in monetary model for pre-liberalization period while highly significant in case of post-liberalization monetary model. The reason behind this may be that the interest rate has not been determined by the market forces for a long time till 1990 (pre-liberalization period) in Bangladesh and the period 1991-2013 is thought of as post-liberalization period when greater reliance was placed on market mechanism that led to variation in the interest rate. From the above discussion it appears that interest rate is less strong policy tool in Bangladesh but with initiating of flexible interest rate by 1991(post-liberalization period) interest rate is likely to be a more strong policy apparatus.

This contradicts Fischer (1979) but is consistent with the theories of Mundell (1963) and Tobin (1965), Darby (1975) and Feldstein (1976), and Stulz (1986).

The estimated cost-push model and hybrid model reports the very high coefficient values of wage variable while the ARDL-VEC models results indicate that nominal wage has only short-run influence on inflation in Bangladesh. This implies nominal wage, the cost-push factor as the most pertinent variable to bring significant positive change in the inflation. These findings are in line with an empirically established fact that wage is important for understanding inflationary process in developing countries at least in the short-run (Montiel, 1989; Agenor et al., 1997; Metin, 1998; Adu and Marbuah, 2011). Moreover, the causality results imply that wage and inflation are mutually interactive with one another and there is a feedback or bidirectional relationship between them. This proves the traditional wage-price spiral relationship by Blanchard (1986), Mehra (1991). It also appears that if the inflationary pressure is not controlled at the desired level over time, it may generate spiralling effect on nominal wage.

A long-run positive relationship has been found between the price level and import prices, the important supply side factor. Alexius (1997) has found that in a small open economy such as Sweden, the nominal exchange rate and import prices are central factors affecting the price level. The effects of exchange rate movements on import prices appear to be influenced by country size according to Alexius. The country size argument could also perhaps be applied to Bangladesh. Thus domestic inflation in Bangladesh can be controlled by influencing the imported inflation that is the import price index through exchange rate stability.

The exchange rate has been found as an important determinant of inflation, according to the cost-push and hybrid inflation model results. But, when inflation expectation variable is included in hybrid model, the coefficient of exchange rate turns to be insignificant. In addition, the ARDL-VEC models have found the exchange rate to be insignificant in determining inflation in Bangladesh. This result is in line with Ahmed, Mujib, and Roy (2013). This may be the fact that the official exchange rate has not been determined by the market forces for a long time in Bangladesh.

The estimates of cost-push model show that world oil (petroleum) price, value of imported raw materials, and the dummy variable accounts for supply shock have no significant role determining inflation in Bangladesh in the long-run. The implication of this result may be simple because one of the important imports is petroleum and share of the petroleum products (hereafter POLs) is more than 10-percent of total imports. Although the POLs' international price is highly fluctuating but its local supply price is administered by the government and has been adjusted occasionally. Bangladesh government gives subsidy for petroleum oil at the end-user level. Moreover, the weight given to POLs is very small (about 4 percent) in CPI. Thus it has a very limited influence that is weak pass-through effect on the CPI.

The empirical evidence demonstrates that inflation has a statistically significant long-run negative effect on real GDP growth in Bangladesh but the evidence shows no significant short-run effect running from inflation to growth. These results are more or less consistent with the predictions of Mallik and Chowdhury (2001) but are not in agreement with the findings of Datta and Mukhopadhyay (2011). The Toda-Yamamoto causality test results indicate a two – way causality between real GDP and inflation. One of the important results is obtained from the IRF estimates that real GDP is positively related to price level in the short-run but in the long-run it appears to be negative. This concludes that the relationship between inflation and real GDP is somewhat non-linear in nature. These results have important policy implications that higher rate of GDP growth does not require higher inflation and higher inflation may take GDP growth downstairs in the long-run in Bangladesh.

To control inflation in Bangladesh, fiscal policy should be consistent with the targets of prudent monetary management.

7.3 Limitation of the Study and Scope for Further Extension

This study empirically examines the relative importance of different sources of inflation in Bangladesh and the causal relationship between inflation and its major sources for the period of 1976-2013 using time series econometrics. As a macro variable the research field of inflation is quite vast and there are several areas that need to be extended further in the future work.

First, to keep the analysis simple, focus has been given only on the key demand-pull and cost-push determinants of inflation. Therefore, the chosen variables might not be the only variables in the economy capable of influencing inflation. Further research on Bangladesh may focus on other variables. Some other important variables which are believed to have important effect creating inflationary pressure in the countries like Bangladesh, as corruption, political unrest, smuggling activities, dishonesty of business men, market syndication, and some other volatile and trend components of inflation.

Second, this study has not examined the relationship between inflation and inflation uncertainty in Bangladesh. Further study can be done thoroughly on this problem.

Third, this thesis did not test for the threshold level of inflation. Further research can be done on the threshold level for growth-inflation trade-off.

Finally, the impact of inflation on the level of unemployment and on level of poverty in Bangladesh can be investigated in future study.

7.4 Conclusion

This study empirically examines the relative importance of different sources of inflation in Bangladesh. In particular, it tests the widely held view that the cost-push factors are no less important than demand-pull factors in stimulating inflation in Bangladesh. In addition, this study also examines the causal connection between wage and inflation, money supply and inflation, and feedback causal effect of inflation on GDP growth as well.

The main empirical result of this study is partially analogous to the above popular conception. The results conclude that Bangladesh's inflation is due to the combined effect of both the demand-pull and cost-push factors.

Money supply, real income or excess aggregate demand[33], inflation expectations, and real interest rate, which are regarded as the key demand-pull variables determining inflation appear to be the significant policy variables maintaining macroeconomic stability through price stability in Bangladesh.

Similarly, nominal wage, import price, and exchange rate which are considered as important cost-push variables have been also found significant affecting inflation in Bangladesh.

However, the relative importance of the variables is not equal. For example, inflation expectations, wage, real GDP, money supply appear to be stronger factors while interest rate, exchange rate are observed less strong variables. Beside this, the ARDL-VEC models confirm exchange rate as a statistically insignificant variable and nominal wage as a short-run significant variable.

The analysis of causal link between the variables, which is also a large part of this type of study, confirms that the causality between money supply and inflation is unidirectional running from money supply to inflation while the causality between wage and inflation is bidirectional.

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[33] Changes in real income serve as a measure of excess demand for goods and services in the economy. See, Pindyck and Rubinfeld (1985), *Econometric Models and Economic Forecasts, p.* 420.

Another important finding is that the inflation has significant negative impact on real GDP growth in the long-run but not in the short-run. Moreover, the relationship between these two variables appears to be non linear in nature.

These findings suggest that income and monetary policy remains a powerful tool in the fight against inflation in Bangladesh though interest rate policy appears not to be a potent weapon. This result also provides a further rationale for tightening monetary policy.

The empirical results ascertain the idea that both the demand-pull and cost-push models are useful individually, and jointly to study inflation in Bangladesh as well as both sets of factors are relevant in explaining the inflation in Bangladesh. The findings of this empirical study may also play an important role in forecasting the future inflation rate, impact of inflation on GDP growth and thus contribute to the design of the monetary policy.

Bangladesh has been grappling, and is likely to grapple with inflation in future. In order to confront this problem, it is necessary to understand the relative importance of cost-push and demand-pull inflation, which is now regarded as more important of the two aspects of inflation. It is hoped that this study will shed enough light on these issues and will be of interest to the academics, researchers and policy makers.

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