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# Monetary policy in India during crisis: impact on inflation

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## Abstract

**Objectives**: The study aims to compare the effectiveness of monetary policy in controlling inflation in India during pre and post global financial crisis by analysing the long term and short-term relationship between inflation gap, output gap, fiscal deficit, nominal exchange rate, money supply and interest rate.
**Methods/Statistical analysis**: The study employs Auto Regressive Distributed Lag (ARDL) to co-integration. It is an advanced technique since it allows the flexibility to use variables of different order of integration (I(0) and I(1)) as compared to other methods such as VAR or VECM, which work on differenced variables and therefore led to loss of data. It also takes sufficient number of lags to avoid the problem of endogeneity in the models.
**Findings:** The ARDL co-integration results suggest that interest rate isan effective tool of monetary policy in controlling inflation in India. The effectiveness however does reduce in the post-crisis period. It implies fiscal dominance of the monetary policy, where fiscal deficit per se does not cause inflation; still it can impact the latter through its transmission to the monetary policy, as was the case in the post global financial crisis period. The co-integration results also suggest that output gap, foreign exchange rate and money supply all have a significant impact on inflation gap, with no change in the behaviour of former two on inflation gap in the pre- and post-crisis period. While the money supply variable becomes less effective in the latter period. Crude oil price is found to be insignificant during the pre-crisis period but becomes significant during post crisis, while fiscal deficit remains insignificant in both the periods.
**Application/Improvements:** This study supports the use of interest rate as a monetary policy tool, which is extremely relevant in wake of the shift of Indian monetary policy to inflation targeting. It highlights the need to control fiscal deficit for controlling inflation.
***Keywords*:** Monetary Policy, Inflation gap, Interest Rate, Financial Crisis, ARDL.

## 1. Introduction

Indian economy has always been concerned about soaring prices due to its effect in terms of political concerns, economic objectives and social aftermaths. The last decade, which witnessed one of the largest world economic crises, has been the one of the most challenging periods for the policy makers. During this period, the policy decisions could address only one of the two primary macroeconomic issues viz., controlling inflation vs. maintaining economic growth. Inflation control has been at the heart of the policy building during this period. “Ifeconomic growth is the primary indicator of a country’s macroeconomic performance, inflation must surely be a close second” [1]. The present study is an attempt to study the factors affecting inflation and analyse the monetary policy performance in controlling inflation during pre-and post-global financial crisis period.

## 2. Plan of the work

This paper is structured in the following manner. Section 1 gives a brief explanation of the theoretical paradigms explaining inflation, which also helps in the formulation of the inflation model and equation used in the study. It also provides a brief outlay of the situation in India during the decade of crisis and after that in terms of the macroeconomic performance and monetary policy framework. Section 2 reviews the related literature and also identifies the gaps in literature and includes contribution to literature of the present study. In Section 3, objectives are defined and the analytical framework is presented.

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The econometric specification, methodology and data analysis have been provided in Section 4. The empirical results derived and their discussion has been taken up in Section 5. Finally, the conclusion drawn from the present study is recorded in Section 6.

## 3. Theories of inflation and performance of Indian economy

### 1. Theoretical paradigms

In [2] stresses that understanding the source and cause of inflation is important before we try to curb it. Several schools of thought provide different reasons for inflation and the factors causing them. The Monetarists who favour the quantity theory of money assume 'inflation is always and everywhere a monetary phenomenon' [3]. They pose the demand-pull inflation as a result of excessive money supply in the economy. Monetarists therefore argue that controlling inflation comes mainly under the purview of the monetary authority. In [4] explanation for rising prices lays in both demand pull and cost push factors. The demand-pull factors could be a result of expansionary fiscal policy, a cut in the interest rate leading to excessive money supply or any kind of shortage in general. The theory sees money supply as one of the important causes of increase in the total expenditure. He also explains the cost push version, which is a result of increase in the cost of production. Any increase in wages, corporate taxes, or a depreciation of the currency can contribute to cost push factors.The Monetarist version of the inflation is further confronted by the proponents of the fiscal theory of inflation, who suggest that inflation is determined, at least partially, by budgetary policies of the fiscal authority and they argue that long-run price stability is not fully in the purview of the monetary authority. Macroeconomic theory postulates that contemporary governments grappling with mounting fiscal deficits will (sooner or later) end up financing those deficits by creating money, thus causing inflation [5]. This makes the fiscal policy designing and framework necessary for the monetary policy and vice a versa.

This also challenges the use of only monetary policy in the control of inflation. It is a debatable issue especially in the presence of large and soaring budget deficits or even public debt. Structural economists, on their part, argue that in less developed countries, in addition to money, structural factors such as supply and demand conditions also play an equally important role in determining price in the economy. This theory emphasis on factors causes the excess demand or shortages in the economy e.g., financing public investment through money expansion increases productive capacity and real output, while real output, at the same time, would increase the demand for money. Another class of models explaining inflation is referred to as 'untidy models' as they incorporate the structural parameters along with the prior theories using monetary and fiscal nexus. In India, the cause of inflation is neither purely monetarist, nor fiscal or even completely structural [6]. It is rather untidy. Hence it becomes extremely important to understand the nature of inflation confronting an economy, before any policy action is used to curb it. Minsky argued on the ineffectiveness of monetary policy to control inflation, either through raising interest rate or reserve requirement. Interest rate increase raises the cost of credit and reduces the capacity of borrowers to pay, which creates a fear of debt burden. This results in sudden contraction of credit and distress sales for repayment of bank finance, leading to falling asset prices and debt deflation, and eventually crisis sets in [7]. This leads to an indirect trigger of crisis by monetary policy. Minsky's Financial Instability Hypothesis therefore argues against placing excessive reliance on the ability of monetary policy to attain financial stability in the economy.This translates into monetary policy being supplemented with other policies both with central banks and government, which can work counter-cyclically to escape from financial instability.It is thus worth while exploring Indian inflation episodes to check which of these theories fits best. It would also help us to compare, whether there has been any change in nature of inflation during the pre-and post-global financial crisis periods, which in turn would guide us with an appropriate policy to curb or control it.

### 2. Macroeconomic performance and monetary policy in India before and after the financial crisis

In the year 2007, the US economy faced a crisis in the subprime mortgage market in the USA which developed into a full-blown international banking crisis with the collapse of the investment bank Lehman Brothers on September 15, 2008. Excessive risk taking by banks such as Lehman Brothers magnified the financial impact which started spilling over to major economies of the world. India was no exception. It could not isolate itself from the adverse developments in the international financial markets, despite having no link with structured financial instruments related to subprime mortgages.

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There was a sequence of events as explained by [8] which had started affecting the policy decisions. There came about a slump in export demand which affected aggregate demand. There was also reversal of capital flows which led to liquidity crunch followed by currency depreciations. The world economy realized global liquidity tightening, which reduced external credit flows, market rigidities which widened the credit spreads. In [9] divides the monetary stance for the 10-year period from 2003-04 to 2012-13, which covers the pre-and post-global crisis period into four phases based on the growth-inflation behaviour and the monetary policy responsiveness.

1. Phase I of 5 years of 2003–08 of high growth but rising inflation concern towards the later part of the period when repo rate was raised from 6 % to 9 % and the cash reserve ratio (CRR) was raised from 4.5 % to 9%.
2. Phase II of 2 years of 2008–10 of loose monetary policy following the global financial crisis when the repo rate was reduced from 9% to 5.25% and CRR was reduced from 9% to 5.75%.
3. Phase III of 2 years of 2010–12 of monetary tightening responding to rising inflation when policy rate was raised from 5.25% to 8.5% but CRR was reduced to 5.5%.
4. Phase IV of over a year of monetary easing in 2012–13 and 2013–14 with the repo rate reduced to 7.25% and CRR lowered to 4.0%; though since mid-July 2013, the RBI has tightened the monetary and liquidity conditions without changing the policy repo rate and CRR to address exchange market volatility.

One important development during this period was comprehensive fiscal stimulus package by Government of India including tax reliefs for boosting aggregate demand and increased government expenditure to create employment and enhance total production. The result of the combined monetary-fiscal policy stimulus policies could be seen with the revival of the economic growth rate, with 8.6% growth rate in the fourth quarter of 2009-10.The fiscal support to the economy during this period led to mounting of fiscal deficit. There were hard facts to accept following this. The expansionary policies impact converted into surge of the demand side components, where the combined private and government sector consumption was around 50%. The inflation situation became alarming due to the above changes. The WPI increased from 0.5 % in August 2009 to 10.4% in March 2010. The impact on the economy of the monetary-fiscal policy actions makes it extremely relevant to study fiscal policy implications on monetary policy. This fiscal slippage was termed as “unprecedented” [8], which constrained the monetary policy expansion stance even during periods of reduced GDP growth. Such a situation can be characterized as fiscal dominance of monetary policy, which reduces the effectiveness of monetary policy in controlling inflation. As mentioned in the Fiscalist theory of inflation, according to [5], a high fiscal deficit through its crowding out effect leads to inflationary patterns in the economy with a simultaneous reduction in the overall output.

*Table 1. Important macroeconomic and monetary indicators*

| Macroeconomic Indicators/Monetary Variables | GDP | IIP | Inflation (%) | GFD/ GDP | Current Account Balance/GDP (%) | Foreign Investment / GDP% | Call Rate | M3 | Repo |
|---|---|---|---|---|---|---|---|---|---|
| 2001-02 | 5.4 | - | 3.6 | 5.98 | 0.7 | 1.7 | 7.16 | 14.1 | 7.79 |
| 2002-03 | 3.9 | - | 3.4 | 5.72 | 1.3 | 1.2 | 5.89 | 14.7 | 7.8 |
| 2003-04 | 8.0 | - | 5.5 | 4.34 | 2.3 | 2.6 | 4.62 | 16.7 | 7 |
| 2004-05 | 7.1 | 8.4 | 6.4 | 3.88 | -0.3 | 2.1 | 4.65 | 12 | 6 |
| 2005-06 | 9.5 | 8.6 | 6.6 | 3.96 | -1.2 | 2.6 | 5.60 | 21.1 | 6 |
| 2006-07 | 9.6 | 12.9 | 4.4 | 3.32 | -1.0 | 3.1 | 7.22 | 21.7 | 6.85 |
| 2007-08 | 9.3 | 15.5 | 4.7 | 2.54 | -1.3 | 5.0 | 5.60 | 21.4 | 7.6 |
| 2008-09 | 6.7 | 2.5 | 8.1 | 5.99 | -2.3 | 2.3 | 7.26 | 19.3 | 5.25 |
| 2009-10 | 8.6 | 5.3 | 3.8 | 6.46 | -2.8 | 4.8 | 3.29 | 16.9 | 4.8 |
| 2010-11 | 8.9 | 8.2 | 9.6 | 4.80 | -2.8 | 3.5 | 5.89 | 16.1 | 5.75 |
| 2011-12 | 6.7 | 2.9 | 8.9 | 5.91 | -4.2 | 2.8 | 8.22 | 13.5 | 7.85 |
| 2012-13 | 4.5(5.4) | 1.1 | 7.4 | 4.93 | -4.8 | 3.0 | 8.09 | 13.6 | 9.39 |
| 2013-14 | 4.7(6.2) | -0.1 | 6.0 | 4.46 | -1.7 | 1.9 | 8.28 | 13.4 | 7.54 |
| 2014-15 | (6.9) | 2.8 | 2.0 | 4.09 | -1.3 | 3.8 | 7.97 | 10.9 | 7.96 |
| 2015-16 | (7.8) | 2.4 | -2.5 | 3.94 | -1.1 | 2.0 | 6.98 | 10.1 | 8.04 |

*Source: RBI, Handbook of Statistics*

*Note: The figures for GDP, IIP, and M3 are their growth rates. GFD/GDP is the Gross Fiscal Deficit to the GDP ratio.*

*Notes: 1. Data on GDP is available till 2013-14 with base 2004-05. After this Gross Value Added at basic prices are available as an alternative with base year 2011-12, which are reported above since 2012-13 in brackets.*

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In such a situation, even if accommodative stance of monetary policy is followed to offset the impact of higher interest rates by increasing the money supply, it may not increase the output but it may push up the price level in the short run. This largely indicates a Fiscalist pattern of inflation in India in the post- global financial crisis.In [10] his study of Minsky's financial instability theory derives some important insights for the pre-and post-global financial crisis in India. He finds Indian experience underscores Minsky's insight of effective monetary-fiscal policy mix which worked counter-cyclically before 2007-08, and which therefore helped Indian domestic banking system insulate from the financial crisis of 2007–08. The economy could recover its growth in 2009-10. However, the pursuit of fiscal policy, even when the economy revived growth, represented a pro-cyclical fiscal policy which posed constraints to the operation of monetary policy. Table 1 presents the performance of Indian economy in terms of some important macroeconomic indicators from 2004-05 to 2014-15. It clearly reflects the impact of recession in terms of all the chosen variables.

## 3. Studies on general determinants of inflation

The literature offers multiple sources of inflation in various economies. The inflation is linked with money supply, exchange rate, fiscal variables, and supply shocks as few of the important factors. This section discusses some of the studies on general determinants of inflation in developing economies and in India. Some studies on East Asian economies found a mix of factors like money growth, foreign interest rate, inflationary expectations; exchange rate depreciation [11-17] tested the impact of interest rate on inflation for the period 1996 to 2016. In the New- Keynesian model, inflation is stable under an interest rate peg. The paper therefore attempts to check whether inflation rises due to an interest rate rise. His study concluded, an increase in interest rate has helped reduce the inflation in the US economy. The increase in interest rate thus does not exacerbate recession; instead it fosters employment, via promoting output growth.Some studies have analyzed the impact of open economy on inflation [18,19]. In found as an economy opens, the monetary authority impact on inflation reduces. The paper uses the case of 114 economies and concludes the above relation for most of the economies, except few very developed economies. In [19] his study of 15 developing economies for the period of 1980's and 1990's also found the open economy parameters (import to GDP and Export to GDP) as important factors affecting inflation, besides the conventional factors (interest rate, money stock, agricultural output, national income, external debt, exchange rate, fuel imports, foreign investment as a proportion of GDP and domestic investment public expenditure), especially for large economies and those experiencing hyperinflation.For the Indian economy, [20] and [21] observe inflation increasing with development of the economy and propose multiple policies such as control of money supply, raising production, check on speculation for control of inflation. This was further supported by [22] who also put the onus of inflation on the development of the economy. In [23-25] found fiscal deficit to be an important factor causing inflation over different periods. In [26] made a detailed empirical study on the relationship between money, output and prices. Their study found money supply affects price more than it affects output. They further proved, as the inflation increases, it increases the deficit (as expenditure of government is responsive to inflation than revenue), thus leading to a deficit-inflation spiral in the economy.

In [1,27-29] suggest the crucial role of monetary policy and greater autonomy to monetary authority in controlling inflation. In [30,31] on the contrary argue on the inefficiency of monetary policy in controlling inflation when it comes from the primary articles or is non-core inflation (food and oil prices) and thus is from supply side. A set of studies around the reform period have reasoned multiple factors to be cause of inflation viz., excessive money supply due to deficit financing, Gulf crisis pushing up prices of petroleum products, devaluation of the rupee resulting in higher import costs, significant increases effected in the prices of fertilizers, coal, food grains, supplied through public distribution system and stepping up of power rates and tariff increases in telephone and other services sector [32-35]. In [36], in their study of the Indian economy for the period 1989-2013, show money supply, depreciation and negative output gaps cause of inflation. In [37] a comparison of India and Bangladesh found monetary factors to be the most important cause for inflation in both the countries, with the coefficient being higher for Bangladesh for the period 1970 to 2010. In [38-40] found a negative relation between output gap and prices. In [41-48] found supply side factors to be a cause of inflation. In [49] on the contrary found the demand side factors to be more important. In [50] observed the supply side factors to have only transitory effect on inflation. In [51] recommends the interest rate policy of the monetary authority to be important factor causing and also in controlling inflation.

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In [52] find oil prices positively affecting inflation for the period 2004 till 2014, with the relation turning to negative during financial crisis of 2007-09. Thus, it is clear from the studies that any single theory of inflation is not sufficient to explain the source of inflation in India. It is neither the monetarist or structuralist or Phillips curve alone, rather a combination of factors which must be used to understand the phenomenon of inflation in India.

### 4. Contribution to the literature

There is huge literature on monetary policy impact on inflation, but the comparison of impact on inflation during normal and recessionary is thin. It helps us understand the change in the nature and impact of all the factors affecting inflation during normal and recessionary times, which in turn is crucial to the detailed understanding of monetary policy actions towards inflation during such periods. The study considers the impact on inflation gap, which is the important in the wake of the shift from discretionary policy rule to 'New Monetary Framework' which emphasizes inflation targeting. The study makes an important contribution in assessment of fiscal deficit on monetary policy effectiveness in controlling inflation, wherein the former is expected to raise inflation directly by keeping aggregate demand high or indirectly either via the fiscal dominance of monetary policy or Minsky's proposition of pro-cyclical support of fiscal policy to monetary policy which reduces latter's effectiveness in controlling inflation.

## 5. Analytical framework

### 1. Objectives

The study explores the impact of monetary policy action on inflation for the period May 2001 to March 2015 using monthly time series data. Under this broad objective, the study analyses the monetary policy effectiveness in controlling inflation during the recent global financial crisis. Accordingly, a comparison of the monetary policy stance before and after global financial crisis period has been done both theoretically and empirically. The study discusses various theories of inflation and analysis these theories for the Indian economy and checks whether any of these theories is applicable per se or is it a mix of various theories, viz., monetarists, fiscalists and structuralist (referred to as untidy) which is applicable for Indian economy. The study attempts to find out whether the fiscal dominance of monetary policy and the applicability of Minsky's pro-cyclical fiscal proposition wherein expansionary fiscal policy when growth rates are high or improving, reduces the effectiveness of monetary policy in controlling inflation.

### 2. Framework of analysis

#### 2.1. Evidence on key macro indicators of inflation

Based on the review of literature, the primary factors which seem to affect inflation in India are output gap, fiscal deficit, exchange rate, oil prices, money supply and interest rate, where the last two factors, money supply aggregate and interest rate are the monetary policy variables. The focus of the present study is the responsiveness of inflation gap to change in interest rate policy, but it also incorporates some other important factors affecting the output level in an economy, which emerge as important determinants of inflation from theoretical paradigms and review of literature. The model built to study the monetary policy impact on inflation gap is given as:Inflation gap = f (Output gap, Fiscal Deficit, Foreign Exchange Rate, Crude oil Price, Money Supply Aggregate, Rate of Interest). The expected behaviour of all the factors and how they impact inflation is discussed below.Interest rate may have varying impact on inflation as explained according to different schools of thought. According to the cost of credit approach, arise in interest rate is believed to control consumer demand, by curtailing the demand for credit and total amount of liquidity, thus controlling inflation in the economy [53].However, according to the monetary approach,interest rate is inflation enhancing. It considers the money supply to be endogenous i.e. a function of the interest rate. An increase in the interest rate would raise the total money supply in the economy and this will create inflation according to the quantity theory of money. This may not be true in the recession period, but certainly so in the medium or the short run. Money supply is the most important factor affecting inflation according to monetary theorists. It is expected to positively affect inflation. Monetarists argue that money supply creates inflation in developing economies since they have supply-side bottlenecks, due to which money cannot impact output.

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The model here expects a direct relationship between money supply and inflation gap. Fiscal deficit is expected to positively impact the inflation level in the economy, whether directly by raising interest rate, or indirectly via fiscal dominance over monetary policy, wherein, it reduces monetary policy effectiveness to control inflation. In [54] also took due note of the above. Understanding the threats which high fiscal deficits can pose for monetary management, it recommended as a pre-condition to implementing inflation targeting, strict compliance to the fiscal responsibility budget management, 2013, and thereby fixing the upper limit of fiscal deficit to 3% of GDP by 2016-17. This has been well taken care of in the union budget of 2016-17. Output gap, defined as the difference between actual and potential output, sets inflationary pressures in the economy, according to Keynes theory of inflationary gap. The underlying reasoning is that if actual output rises above potential output, this will create an upward pressure on wages in the labour market. Higher wages, in turn, will lead to higher production costs and hence higher prices. Crude oil is an important component of production level of any economy and the oil prices contribute to cost push inflation. According to an [24] a unit dollar increase in crude oil price causes WPI inflation to rise by 30 basis point. According to IMF, 2000, a US $ 5 per barrel increase in the price of oil leads to 1.3% point increase in inflation. If the increase in crude oil prices is subsidized, causing increase in fiscal deficit again it can be a cause of inflation. Exchange rate depreciation causes inflation since it leads to increase in import prices which in turn would increase domestic inflation.

### 2.2. Theoretical background

This model is based on the [55], which was also recently used by [48] to show the impact of the 'New Monetary Framework' under which it has been mutually decided by the central government and the monetary authority to provide greater autonomy to the central bank, and so a shift to inflation targeting. The study uses a dummy variable to show the impact of the shift to the new monetary policy rule.

Lucas considered aggregate price to be a function of aggregate demand (AD) and supply (AS). Lucas explained as a function of the output gap. The relation can be presented in the following form:

$$\Pi^* = \alpha + \beta\,(y - y*) \quad \text{.....(1)}$$

Where, y* is the potential output level. An increase in the output gap, leads to increase in inflation.

Lucas explained AD as a function of the IS-LM model, where it can shift due to monetary and fiscal policies and variations in export demand. In [48] presented the AD as explained by Lucas in the following form:

$$y_t = y_{t-1} + \boldsymbol{\beta}1sei_t + \boldsymbol{\beta}2i_t + \boldsymbol{\beta}3def_t + \boldsymbol{\beta}4\,k_t \quad \text{.....(2)}$$

$sei_t$ is the seignior age, $i_t$ is the real rate of interest, $def_t$ is fiscal deficit and $k_t$ is capital flows.

Equating the AD and AS equations,

$$\Pi^*_t = \alpha + \theta_1\,(y-y^*) + \theta_2 seig_t + \theta_3 i_t + \theta_4 def_t + \theta_5 k_t + \mu \quad \text{.....(3)}$$

Although the empirical model used in this study is based on the above-mentioned equation, it is different from the earlier works not just in terms of the variables selected to show the relationship, but also in terms of its objectives.

## 6. Econometric specification, methodology and data analysis

### 1. Data analysis

The inflation is measured with whole sale price index (WPI), which was the widely-used measure of inflation before March 2015. The output is measured using Index of Industrial Production (IIP). The choice of the variable has been done, due to non-availability of data on Gross Domestic Product (GDP) on monthly basis. Output gap and Inflation gap are the difference between Log of IIP/WPI and the Log of Trend IIP/WPI, where the trend value is calculated using the Hodrick-Prescott (HP) filter. The movement over time of both the variables is given in Figures 1,2.

The interest rate is represented by repo, which is the policy interest rate since the introduction of LAF in year 2000. Repo came to be recognized as the active policy rate, showing the policy actions, with all the other rates, following it as benchmark. The fiscal parameter used in the study is the Gross Fiscal Deficit of the Central Government. The impact of the external sector on output is analysed using Nominal Exchange rate (Rupee to Dollar value). Broad money supply, M3 represents the money supply variable. The impact of international prices is seen with rising import bill, due to crude oil prices, which is also a supply side factor. The movement of all the variables overtime is shown in Figure 3.

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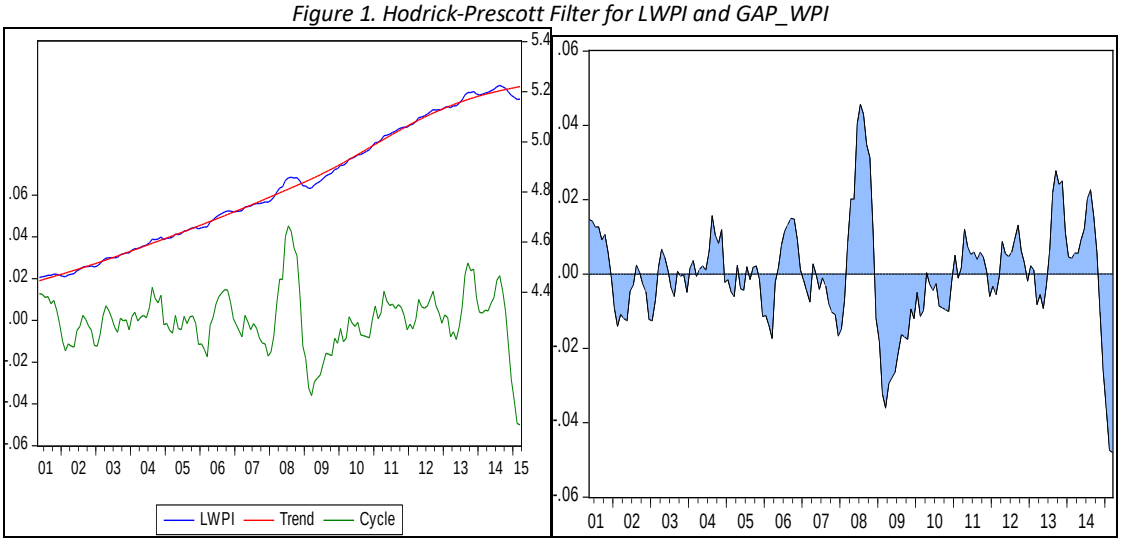
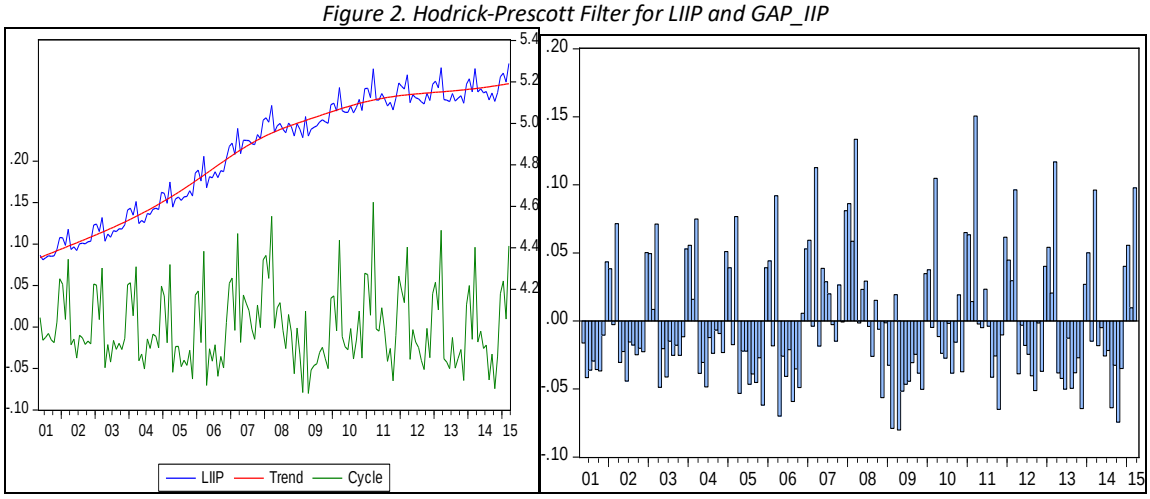
*Figure 1. Hodrick-Prescott Filter for LWPI and GAP_WPI*




**Hodrick-Prescott – LWPI** **GAP_WPI**

*Source: Designed by the authors using appropriate statistical software package*

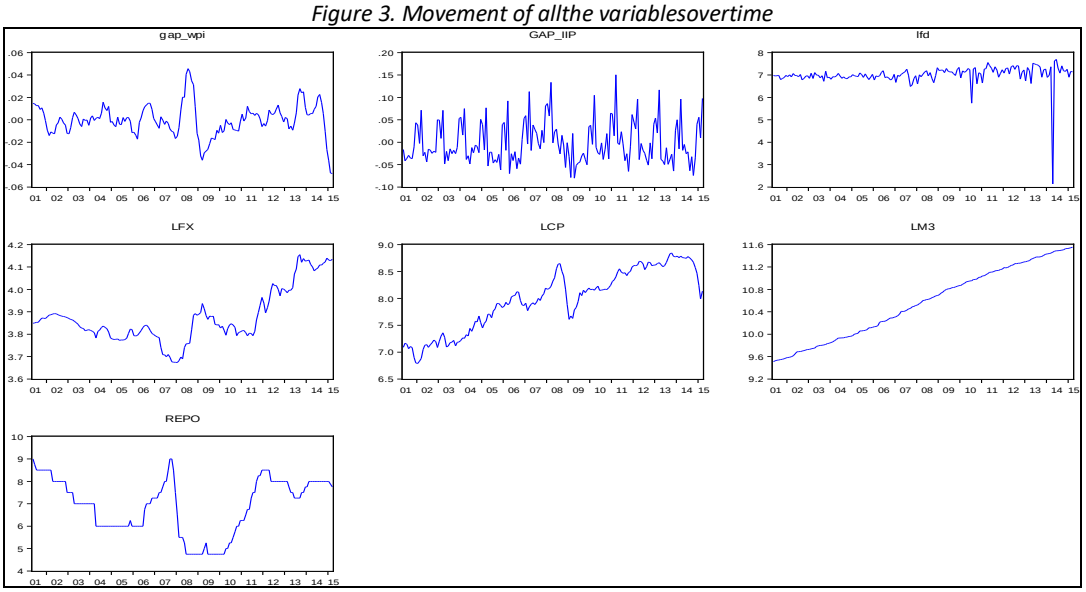
*Figure 2. Hodrick-Prescott Filter for LIIP and GAP_IIP*




**Hodrick-Prescott Filter-LIIP** **GAP_IIP**

*Source: Designed by the authors using appropriate statistical software package*

*Figure 3. Movement of allthe variablesovertime*

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## 2. Methodology and Data Sources

In order to investigate the dynamics of the short-run and long-run relationship between inflation, and its factors the study employs co-integration using an Autoregressive Distributed Lag (ARDL) model. The study uses monthly time series data for examining the relationship for the period May 2001 to March 2015. The choice of the period is done in order to assess the study using repo which is the operational policy interest rate since 2001, after the introduction of LAF in the year 2000. The data on the policy interest rate (Repo), and all the related domestic variables like IIP, WPI, fiscal deficit, nominal foreign exchange, broad money supply has been collected from the handbook of statistics on the Indian economy, data base on Indian economy from the RBI, National Accounts Statistics of the Central Statistical Organization (CSO), and the various issues of Monthly Bulletin of the RBI. The data on crude oil prices has been collected from data base of Indian Oil Corporation. The data on all the variables is available on monthly basis, except REPO which is available on daily basis, and so a monthly average of it has been used. Out of all the variables, only REPO is at level, rest all the variables are in log form. The seasonality adjustment has been attempted by introducing Seasonal dummies.

The ARDL approach to co-integration was proposed by [56]. This model has few advantages over the previous techniques. The main advantage of ARDL modelling lies in its flexibility that it can be applied when the variables are of different order of integration [57] and so avoids problems resulting from use of non-stationary time series data [58] and also avoids loss of data due to use of differenced variables. The regressors may be a mix of I (0) and I (1) series or fractionally co-integrated [57]. Another advantage of this approach is that the model takes sufficient numbers of lags to capture the data generating process in a general-to-specific modelling framework [58,59]. This leads to a further benefit of no endogeneity problem in the models. As noted by [56], "appropriate modification of the orders of the ARDL model is sufficient to simultaneously correct the residual serial correlation and the problem of endogenous regressors".

## 3. Econometric specification

Inflation gap is determined in the following functional form:

$GAP\_WPIt = f(GAP\_IIP_{t-1}, LFD_{t-1}, LFX_{t-1}, LCP_{t-1}, LM3_{t-1}, REPO_{t-1})$ .....(4)

GAP_WPI (Inflation gap) is the Log of WPI – Log of trend WPI[1];
GAP_IIP (Output gap) is the Log of IIP – Log of trend IIP;
LFD is the Log of Gross Fiscal Deficit of the Central Government;
LFX is the Log on Nominal Foreign Exchange Rate (Rupee to Dollar);
LCP is the Log of Crude Oil Prices;
LM3 is the log of Broad Money Supply;
REPO is the Repurchase rate of the RBI.

Where, all the independent factors are one month lagged, since we do not expect the macroeconomic variables to respond instantaneously to the changes in the same month. The contemporaneous effect of the independent factors is not being considered in the study. In order to incorporate the structural break in the form of crisis, a dummy variable is included and the responsiveness of all the variables is also seen using interactive dummies during the post crisis financial crisis. The model in complete form (including Dummy variables, D2 representing break for crisis and D_S_1 to D_S_11 representing seasonal dummies) is given in the following equation:

$$GAP\_WPI = \alpha + \boldsymbol{\beta}_1 GAP\_IIP + \boldsymbol{\beta}_2 LFD + \boldsymbol{\beta}_3 LFX + \boldsymbol{\beta}_4 LCP + \boldsymbol{\beta}_5 LM3 + \boldsymbol{\beta}_6 REPO + \eta D2 + \vartheta_1 D2GAP\_IIP + \vartheta_2 D2LFD + \vartheta_3 D2LFX + \vartheta_4 D2LCP + \vartheta_5 D2LM3 + \vartheta_6 D2REPO + \theta_1 D\_S\_1 + \theta_2 D\_S\_2 + \theta_3 D\_S\_3 + \theta_4 D\_S\_4 + \theta_5 D\_S\_5 + \theta_6 D\_S\_6 + \theta_7 D\_S\_7 + \theta_8 D\_S\_8 + \theta_9 D\_S9 + \theta_{10} D\_S\_10 + \theta_{11} D\_S\_11 + \mu \quad \text{.....(5)}$$

The following is the specification of ARDL as used in the study:

$$\Delta GAP\_WPIt = \alpha + \gamma T + \eta D2 + \beta 1 GAP\_WPIt-1 + \beta 2 GAP\_IIPt-1 + \beta 3 LFDt-1 + \beta 4 LFXt-1 + \beta 5 LCPt-1 + \beta 6 LM3t-1 + \beta 7 REPOt-1 + \sum_{i=1}^{m} \partial 1 \Delta GAP\_WPIt-i + \sum_{i=0}^{n} \partial 2 \Delta GAP\_IIPt-i + \sum_{i=0}^{o} \partial 3 \Delta LFDt-i + \sum_{i=0}^{P} \partial 4 \Delta LFXt-i + \sum_{i=0}^{q} \partial 5 \Delta CPt-i + \sum_{i=0}^{r} \partial 6 \Delta LM3t-i + \sum_{i=0}^{s} \partial 7 \Delta REPOt-i + \vartheta 1 D2GAP\_IIPt-i + \vartheta 2 D2LFDt-1 + \vartheta 3 D2LFXt-1 + \vartheta 4 D2LCPt-1 + \vartheta 5 D2LM3t-1 + \vartheta 6 D2REPOt-1 + \theta 1 D\_S\_1 + \theta 2 D\_S\_2 + \theta 3 D\_S\_3 + \theta 4 D\_S\_4 + \theta 5 D\_S\_5 + \theta 6 D\_S\_6 + \theta 7 D\_S\_7 + \theta 8 D\_S\_8 + \theta 9 D\_S\_9 + \theta 10 D\_S\_10 + \theta 11 D\_S\_11 + \mu t \quad \text{.....(6)}$$

Δ - denotes the first difference operator; γ, βi's, ∂i 's, (i = 1 to 7) are the coefficients for the exogenous variables affecting GAP_WPI; ηis the intercept coefficient representing introduction of a dummy variable representing a

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structural break and $\vartheta i$ 's are the differential slope coefficients, representing interactive dummy variables;$\theta j$'s are the coefficients for the seasonal dummies, (j = 1 to 11); α is intercept term and μt is the error term. After estimation of the equation (6), the Wald test (F-statistic) can be computed by imposing linear restrictions on the estimated long run coefficients of the calculated lagged level according to AIC as mentioned before. The null and the alternative hypothesis are as follows:

$H_{0:}\ \beta 1 = \beta 2 = \beta 3 = \beta 4 = \beta 5 = 0$ (no long-run relationship);
$H_{1:}\ \beta 1 \neq \beta 2 \neq \beta 3 \neq \beta 4 \neq \beta 5 \neq 0$ (a long-run relationship).

Once we identify the long-run relationship, the long run coefficients from the above equations are estimated in the following manner:

$$GAP\_WPIt = \alpha + \gamma T + \eta D2 + \sum_{i=1}^{m} \beta 1 GAP\_WPIt - i + \sum_{i=0}^{n} \beta 2 GAP\_IIPt - i + \sum_{i=0}^{o} \beta 3 LFDt - i + \sum_{i=0}^{p} \beta 4 LFXt - i + \sum_{i=0}^{q} \beta 5 LCPt - i + \sum_{i=0}^{r} \beta 6 LM3t - i + \sum_{i=0}^{s} \beta 7 REPOt - i + \vartheta 1 D2GAP\_IIPt - 1 + \vartheta 2 D2LFDt - 1 + \vartheta 3 D2LFXt - 1 + \vartheta 4 D2LCPt - 1 + \vartheta 5 D2LM3t - 1 + \vartheta 6 D2REPOt - 1 + \theta 1 D\_S\_1 + \theta 2 D\_S\_2 + \theta 3 D\_S\_3 + \theta 4 D\_S\_4 + \theta 5 D\_S\_5 + \theta 6 D\_S\_6 + \theta 7 D\_S\_7 + \theta 8 D\_S\_8 + \theta 9 D\_S\_9 + \theta 10 D\_S\_10 + \theta 11 D\_S\_11 + \mu t \quad (7)$$

Where expected value of GAP_WPI (E(GAP_WPI)) depends on whether D2 = 1 or 0.

$$E(GAP\_WPIt|D2 = 1) = (\alpha + \eta) + \gamma T + \sum_{i=1}^{m} \beta 1 GAP\_WPIt - i + (\sum_{i=0}^{n} \beta 2 + \vartheta 1) GAP\_IIPt - i + (\sum_{i=0}^{o} \beta 3 + \vartheta 2) LFD\,t - i + (\sum_{i=0}^{p} \beta 4 + \vartheta 3) LFX\,t - i + (\sum_{i=0}^{q} \beta 5 + \vartheta 4) LCP\,t - i + (\sum_{i=0}^{r} \beta 6 + \vartheta 5) LM3t - i + (\sum_{i=0}^{s} \beta 7 + \vartheta 6) REPOt - i + \theta 1 D\_S\_1 + \theta 2 D\_S\_2 + \theta 3 D\_S\_3 + \theta 4 D\_S\_4 + \theta 5 D\_S\_5 + \theta 6 D\_S\_6 + \theta 7 D\_S\_7 + \theta 8 D\_S\_8 + \theta 9 D\_S\_9 + \theta 10 D\_S\_10 + \theta 11 D\_S\_11 \quad (8)$$

$$E(GAP\_WPIt|D2 = 0) = \alpha + \gamma T + \sum_{i=1}^{m} \beta 1 GAP\_WPIt - i + \sum_{i=0}^{n} \beta 2 GAP\_IIPt - i + \sum_{i=0}^{o} \beta 3 LFDt - i + \sum_{i=0}^{p} \beta 4 LFXt - i + \sum_{i=0}^{q} \beta 5 LCPt - i + \sum_{i=0}^{r} \beta 6 LM3t - i + \sum_{i=0}^{s} \beta 7 REPOt - i + \theta 1 D\_S\_1 + \theta 2 D\_S\_2 + \theta 3 D\_S\_3 + \theta 4 D\_S\_4 + \theta 5 D\_S\_5 + \theta 6 D\_S\_6 + \theta 7 D\_S\_7 + \theta 8 D\_S\_8 + \theta 9 D\_S\_9 + \theta 10 D\_S\_10 + \theta 11 D\_S\_11 \quad (9)$$

In the final step, we obtain the short-run dynamic parameter. Arising from this is the need to develop an Error Correction Model (ECM). An ECM has two important parts. First, estimated short-run coefficients and second, error correction term (ECT) that provides the feedback or the speed of adjustment whereby short-run dynamics converge to the long-run equilibrium path in model. It is estimated as following

$$\Delta GAP\_WPIt = \alpha + \gamma \Delta T + \eta \Delta D2 + \sum_{i=1}^{m} \beta 1 \Delta GAP\_WPIt - i + \sum_{i=0}^{n} \beta 2 \Delta GAP\_IIPt - i + \sum_{i=0}^{o} \beta 3 \Delta LFDt - i + \sum_{i=0}^{p} \beta 4 \Delta LFXt - i + \sum_{i=0}^{q} \beta 5 \Delta LCPt - i + \sum_{i=0}^{r} \beta 6 \Delta LM3t - i + \sum_{i=0}^{s} \beta 7 \Delta REPOt - i + \vartheta 1 \Delta D2GAP\_IIPt - i + \vartheta 2 \Delta D2LFDt - 1 + \vartheta 3 \Delta D2LFXt - 1 + \vartheta 4 \Delta D2LCPt - 1 + \vartheta 5 \Delta D2LM3t - 1 + \vartheta 6 \Delta D2REPOt - 1 + \theta 1 \Delta D\_S\_1 + \theta 2 \Delta D\_S\_2 + \theta 3 \Delta D\_S\_3 + \theta 4 \Delta D\_S\_4 + \theta 5 \Delta D\_S\_5 + \theta 6 \Delta D\_S\_6 + \theta 7 \Delta D\_S\_7 + \theta 8 \Delta D\_S\_8 + \theta 9 \Delta D\_S\_9 + \theta 10 \Delta D\_S\_10 + \theta 11 \Delta D\_S\_11 + \omega ECT\,t - 1 + \mu t \quad (10)$$

Where, $E(\Delta GAP\_WPIt|D2 = 1) = \alpha + \gamma \Delta T + \eta \Delta D2 + \sum_{i=1}^{m} \partial 1 \Delta GAP\_WPIt - i + (\sum_{i=0}^{n} \partial 2 + \vartheta 1) \Delta GAP\_IIPt - i + (\sum_{i=0}^{o} \partial 3 + \vartheta 2) \Delta LFDt - i + (\sum_{i=0}^{p} \partial 4 + \vartheta 3) \Delta LFXt - i + (\sum_{i=0}^{q} \partial 5 + \vartheta 4) \Delta LCPt - i + (\sum_{i=0}^{r} \partial 6 + \vartheta 5) \Delta LM3t - i + (\sum_{i=0}^{s} \partial 7 + \vartheta 6) \Delta REPOt - i + \theta 1 \Delta D\_S\_1 + \theta 2 \Delta D\_S\_2 + \theta 3 \Delta D\_S\_3 + \theta 4 \Delta D\_S\_4 + \theta 5 \Delta D\_S\_5 + \theta 6 \Delta D\_S\_6 + \theta 7 \Delta D\_S\_7 + \theta 8 \Delta D\_S\_8 + \theta 9 \Delta D\_S\_9 + \theta 10 \Delta D\_S\_10 + \theta 11 \Delta D\_S\_11 + \omega ECT\,t - 1$ (11)

and

$$E(\Delta GAP\_WPIt|D2 = 0) \alpha + \gamma \Delta T + \sum_{i=1}^{m} \beta 1 \Delta GAP\_WPIt - i + \sum_{i=0}^{n} \beta 2 \Delta GAP\_IIPt - i + \sum_{i=0}^{o} \beta 3 \Delta LFDt - i + \sum_{i=0}^{p} \beta 4 \Delta LFXt - i + \sum_{i=0}^{q} \beta 5 \Delta LCPt - i + \sum_{i=0}^{r} \beta 6 \Delta LM3t - i + \sum_{i=0}^{s} \beta 7 \Delta REPOt - i + \theta 1 \Delta D\_S\_1 + \theta 2 \Delta D\_S\_2 + \theta 3 \Delta D\_S\_3 + \theta 4 \Delta D\_S\_4 + \theta 5 \Delta D\_S\_5 + \theta 6 \Delta D\_S\_6 + \theta 7 \Delta D\_S\_7 + \theta 8 \Delta D\_S\_8 + \theta 9 \Delta D\_S\_9 + \theta 10 \Delta D\_S\_10 + \theta 11 \Delta D\_S\_11 + \omega ECT\,t - 1 \quad (12)$$

Where, all the variables are as previously defined, ω is the coefficient of speed of adjustment which is expected to have a negative sign.

## 7. Results and Discussion

The results are presented in two parts. The first part comprises of the preliminary tests necessary to carry on with the ARDL co-integration test. It includes the test for presence of structural breaks, unit root test and the

maximum lag selection. The second part consists of the main results including the Bounds test for testing the presence of long run relationship and the Long run co-integration results.

### 7.1. Results of Preliminary Tests

**1. Chow Test**

The study period is divided into pro-and post-global crisis. The break has been introduced in September 2008. The chow test presented in Table 2 was done to check the whether this break time is significant. The F-value is significant at one percent showing presence of a structural break (indicating crisis in this case) for which we incorporate a dummy variable D2.

*Table 2. Chow test*

| Break Time | F-Value |
|---|---|
| September 2008 | 4.712*** (0.0021) |

*Compiled by the authors*

**2. Testing for unit roots (Break Point Test and ADF)**

Before testing whether any co-integration exists between the inflation gap and the other independent factors, the Break Point and Augmented Dickey-Fuller (ADF) unit root test have been exercised to check the order of integration of variables, as shown in Table 3.According to Break point test, all the variables including GAP_WPI have a unit root. ADF test shows GAP_WPI is non-stationary at 1%, which fulfils the necessary condition for co-integration. All the independent factors except GAP_IIP are found to be non-stationary at level. Hence, according to ADF test, we have a mix of I(0) and I(1) variables which is makes use of ARDL technique most suitable.

*Table 3. Unit root test*

| Variables | Level | | First difference | |
|---|---|---|---|---|
| | ADF | Break-point | ADF | Break-point |
| GAP_WPI | -3.618(0.315) | -4.206(<0.10) | -4.633(0.0013) | -4.6459(<0.025) |
| GAP_IIP | -3.4612(0.0473) | -3.4202(<0.10) | -3.854(0.0163) | -3.540(<0.01) |
| LFD | -1.4004(0.8556) | -1.850(>0.50) | -9.835(0.000) | -6.752(<0.01) |
| LFX | -1.619(0.7814) | -3.579(NA) | -9.240(0.000) | -9.304(<0.01) |
| LCP | -2.1775(0.4984) | -2.369(>0.50) | -6.6985(0.0000) | -6.801(<0.01) |
| LM3 | -0.9422(0.9477) | -0.3872(>0.50) | -5.23(0.0001) | -8.113(<0.01) |
| REPO | -2.075(0.5554) | -2.737(>=0.50) | -8.5215(0.0000) | -8.733(<0.01) |

*Compiled by the authors, Note – Brackets show MacKinnon (1996) one-sided p-values*

**3. Maximum lag selection**

The maximum dependent and dynamic regressors lag limit according to the automatic lag selection for the monthly sample data chosen, is 9. Table 4 shows the optimal lags both for the dependent and independent variables. The graph for the automatic lag selectionshown in Figure 4 using Akaike Information Criterion (AIC), shows that out of the top 20 models chosen, the lags chosen through this process are minimum and hence optimal.

*Table 4. Maximum Lag Selection*

| Variables | No. of Lags (4, 8, 5, 0, 0, 1, 4) |
|---|---|
| GAP_WPI | 4 (GAP_WPI (-1), GAP_WPI (-2), GAP_WPI (-3), GAP_WPI (-4)) |
| GAP_IIP | 8(GAP_IIP (-1), GAP_IIP (-2), GAP_IIP (-3), GAP_IIP (-4), GAP_IIP (-5), GAP_IIP (-6), GAP_IIP (-7), GAP_IIP (-8) |
| LFD | 5 (LFD (-1), LFD (-2), LFD (-3), LFD (-4), LFD(-5)) |
| LFX | 0 |
| LCP | 0 |
| LM3 | 1 (LM3(-1)) |
| REPO | 4 (REPO (-1), REPO (-2), REPO (-3), REPO (-4)) |

*Compiled by the authors*

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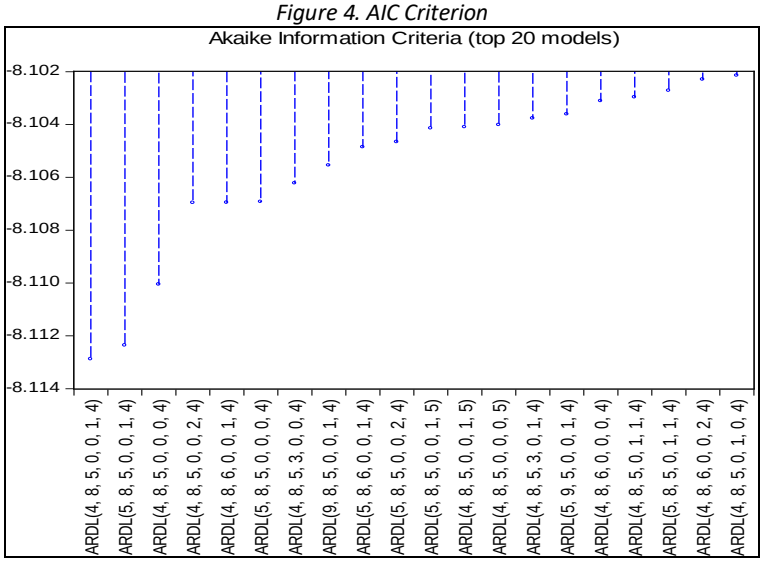
*Figure 4. AIC Criterion*




*Source: Designed by the authors using appropriate statistical software package*

### 7.2. ARDL specification results

**1. Bound testing approaches to co-integration**

The F-statistic presented in Table 5 shows that all the statistics cross the upper band of the critical values as tabulated by [56], thereby rejecting the null hypothesis of no co-integration in all the models. This implies that there exists a long run relationship among the variables in the respective models.

*Table 5. Result of Bounds Test*

| ARDL ModelGAP_WPI = f (GAP_IIP, LFD, LFX, LCP, LM3, REPO) | | |
|---|---|---|
| | F Statistics | K |
| GAP_WPI (2001M5-2015M3) | 15.05596*** | 6 |
| Critical Values | LOWER BOUND I(0) | UPPER BOUND I(1) |
| 10% | 2.53 | 3.59 |
| 5% | 2.87 | 4 |
| 2.5% | 3.19 | 4.38 |
| 1% | 3.6 | 4.9 |

*Compiled by the authors*

**2. Results for the estimated long run coefficients**

Once the long run relation is evident from the bounds test, we proceed to determine the estimated long-run results, given in Table 6,7.The long run co-integration relation from the above two tables is traced in the form of following equations for the pre-global financial Crisis and the Post-Crisis period.

Pre-Crisis, D2 = 0

GAP_WPI = -1.838***- 0.00173 T*** + 0.2826 GAP_IIP*** - 0.0104 LFD + 0.1313 LFX*** - 0.0113LCP + 0.1633 LM3*** - 0.0093 REPO*** .....(13)

Post-Crisis, D2 = 1

GAP_WPI = -1.838***- 0.00173 T*** + 0.2826 GAP_IIP*** - 0.0104 LFD + 0.1313 LFX*** + 0.05 CP*** + 0.113LM3*** - 0.005 REPO*** .....(14)

The long run results show the impact of all variables on output gap except fiscal deficit in both pre-financial crisis and post-financial crisis is significant. The coefficients for Output gap (GAP_IIP), Foreign Exchange rate (LFX) and Money supply (LM3) are positive, but that of Interest Rate (Repo) is negative. The signs of all the significant variables realized are as per our expectation and hence follow the explained economic logic.

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*Table 6. Long-Run co-integration results*

| Dependent variable is GAP_WPI, ARDL (4, 8, 5, 0, 0, 1, 4) selected based on Akaike information criteria | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| GAP_IIP | 0.282581*** | 0.060862 | 4.642970 | 0.0000 |
| LFD | -0.010385 | 0.007140 | -1.454434 | 0.1486 |
| LFX | 0.131309*** | 0.031162 | 4.213752 | 0.0001 |
| LCP | -0.011281 | 0.008311 | -1.357366 | 0.1774 |
| LM3 | 0.163391*** | 0.038385 | 4.256604 | 0.0000 |
| REPO | -0.009385*** | 0.001418 | -6.617734 | 0.0000 |
| D2 | 0.189043 | 0.242290 | 0.780234 | 0.4369 |
| D2GAP_IIP | 0.002115 | 0.026033 | 0.081240 | 0.9354 |
| D2FD | -0.000302 | 0.006622 | -0.045649 | 0.9637 |
| D2FX | -0.056802 | 0.035939 | -1.580512 | 0.1168 |
| D2CP | 0.060700*** | 0.009970 | 6.088396 | 0.0000 |
| D2M3 | -0.049955*** | 0.018444 | -2.708508 | 0.0078 |
| D2REPO | 0.004350** | 0.001844 | 2.358975 | 0.0201 |
| D_S_1 | -0.002922 | 0.005488 | -0.532431 | 0.5955 |
| D_S_2 | -0.006509 | 0.004736 | -1.374227 | 0.1721 |
| D_S_3 | -0.001708 | 0.005556 | -0.307318 | 0.7592 |
| D_S_5 | 0.001801 | 0.005829 | 0.308894 | 0.7580 |
| D_S_6 | 0.000159 | 0.004958 | 0.031975 | 0.9745 |
| D_S_7 | -0.000378 | 0.004934 | -0.076548 | 0.9391 |
| D_S_8 | -0.000049 | 0.005493 | -0.008944 | 0.9929 |
| D_S_9 | 0.007642* | 0.004358 | 1.753552 | 0.0822 |
| D_S_10 | 0.001192 | 0.004005 | 0.297570 | 0.7666 |
| D_S_11 | 0.006063 | 0.006572 | 0.922574 | 0.3582 |
| C | -1.838902*** | 0.349848 | -5.256292 | 0.0000 |
| @TREND | -0.001703*** | 0.000514 | -3.315586 | 0.0012 |

*Compiled by the authors*

*Table 7. Long Run Results- Impact of Crisis*

| Variable | Coefficient for Pre-Crisis | Interactive Dummy Coefficient (IDC) | | Coefficient for Post-Crisis |
|---|---|---|---|---|
| GAP_IIP | 0.282581*** | D2GAP_IIP | 0.002115 | 0.282581 |
| LFD | -0.010385 | D2FD | -0.000302 | -0.010385 |
| LFX | 0.131309*** | D2FX | -0.056802 | 0.131309 |
| LCP | -0.011281 | D2CP | 0.060700*** | 0.05 |
| LM3 | 0.163391*** | D2M3 | -0.049955*** | 0.113 |
| REPO | -0.009385*** | D2REPO | 0.004350** | 0.005 |

*Compiled by the authors*

The magnitude of the coefficients can be interpreted as Pre-Financial Crisis (D2 = 0) and Post-Financial Crisis (D2 = 1). For output gap, given ceteris paribus, a one percent increase in the output gap increases inflation by 0.3 percent (approx.) beyond its target level in the pre-crisis period. Since, its slope dummy coefficient is insignificant, it implies that output gap continues to influence the inflation gap by the same level even in the post-crisis period. The coefficient of foreign exchange rate shows, controlling for other factors,a 1% depreciation of the rupee as against dollar, imports 0.13% inflation (approx.) in both the periods (slope dummy is insignificant). The coefficient for crude oil prices is insignificant in the Pre-Crisis period, but it becomes significant, in the Post-Crisis period. The results show, when the economy is hit by crisis, a one percent increase (decrease) in the oil prices, leads to a 0.05 increase (decrease) in the inflation gap.

The money supply coefficient shows, controlling for all other factors, a one percent increase in the money supply, leads to approx. 0.16% increase in the inflation gap if economy is in the Pre-Crisis period. However, in the Post-Crisis period, its coefficient reduces slightly to 0.14. This implies, the effectiveness of monetary policy reduces in controlling inflation reduces in the Post-crisis period. Lastly, the result for interest rate shows a unit increase in the REPO leads to a 0.9% correction of inflation to its target level in the pre-crisis period, but the value reduces to 0.5% when the economy in the Post-Crisis period. The results for money supply and interest rate variables show reduced effectiveness of monetary policy in the Post-Crisis period.

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Thus, we see that the coefficients for the variables, GAP_IIP, LFD and LFX do not change when we incorporate the post crisis impact since their interactive dummy coefficient values are found to be insignificant. However, the coefficient for LCP is significant and also changes its sign of the relation with the dependent variable, showing a positive impact of increase in oil prices on inflation gap in the Post-Crisis period. We derive two most important conclusions in terms of monetary policy implications and effectiveness during normal and recessionary times. First, the fiscal deficit variable is found to be insignificant in the study for the entire study period, which indicates, when controlled for other factors especially money supply or when fiscal deficit is not monetized, it fails to impact inflation. This helps us conclude that fiscal deficit would be inflationary only when it is backed by money supply (higher public borrowings or central bank financing of treasury bills). Second, which are the monetary policy variables, viz., LM3 and REPO are found to be significant in terms of interactive dummies. It is seen that the total effect of both these variables reduce in the post-crisis period which implies, reduced monetary policy effectiveness to control inflation in the post-crisis period.

From theory and stylized facts presented earlier, this can be interpreted as, a) fiscal dominance of monetary policy in the post-crisis period where, if the money supply increases either to finance the rising fiscal deficit or public borrowings created due to impact of crisis for which the government follows expansionary fiscal policy, the impact is inflationary; b) the Mishkin's theory of lesser effectiveness of monetary policy in controlling inflation, due to pro-cyclical fiscal support; c)relevance of Fiscalist theory of inflation in the post-crisis period. The results help us conclude that out of the variables, REPO has the highest impact on the inflation gap, justifying the RBI's attempts to control inflation by raising the interest rate.

**3. Error correction term**

The error correction term is given in Table 8.

*Table 8. Error correction representation of the selected ARDL model*

| | Coefficient | Standard Error | T-Ratio | (Prob) |
|---|---|---|---|---|
| CointEq(-1) | -0.597671*** | 0.063769 | -9.372427 | 0.0000 |

*Compiled by the authors*

For the study period, the equilibrium correction coefficient, is -0.59. It is both negative and significant, at one percent level. It implies approx. 60% of the disequilibrium from the previous period, converges back to long-run equilibrium in the current period. It also implies, that it would take 1.76 (1/0.59) months (periods) for the disequilibrium to converge to long-run equilibrium.

**7.3. Diagnostic Tests of the ARDL Models**

The robustness of the estimated model has been carried out by several diagnostic tests such as serial correlation, Ramsey RESET specification test; Heteroscedasticity test and ARCH test (Table 9).

*Table 9. Diagnostic tests*

| Diagnostic Tests | F-stat | LM-version | Jarque-Bera |
|---|---|---|---|
| Serial correlation | 0.868***(0.3535) | 1.238***(0.267) | ___ |
| Heteroskedasticity | Breusch-Pagan-Godfrey | | |
| | 1.202***(0.2167) | 52.55***(0.2353) | ___ |
| | ARCH | | |
| | 0.062***(0.8025) | 0.064***(0.801) | ___ |
| Ramsey RESET Test | 0.0622***(0.8035) | ___ | ___ |
| Normality Test | ___ | ___ | 0.4903***(0.7825) |

*Compiled by the authors*

In both the models, no serial correlation has been found (according to Breusch-Godfrey Serial Correlation LM Test) and Correlogram-Q. The models also pass the Ramsey Reset Specification implying linearity of the equation. The stability test (CUSUM AND CUSUMSQ) has also been done.

The CUSUM AND CUSUMSQ plotted against the critical bound of the 5% significance level show that both the models are stable over time (Figure 5). The error terms were found to be Homoscedastic both according to Breush- Pagan- Godfrey and ARCH criteria. Hence all the results reported are valid for reliable interpretation.

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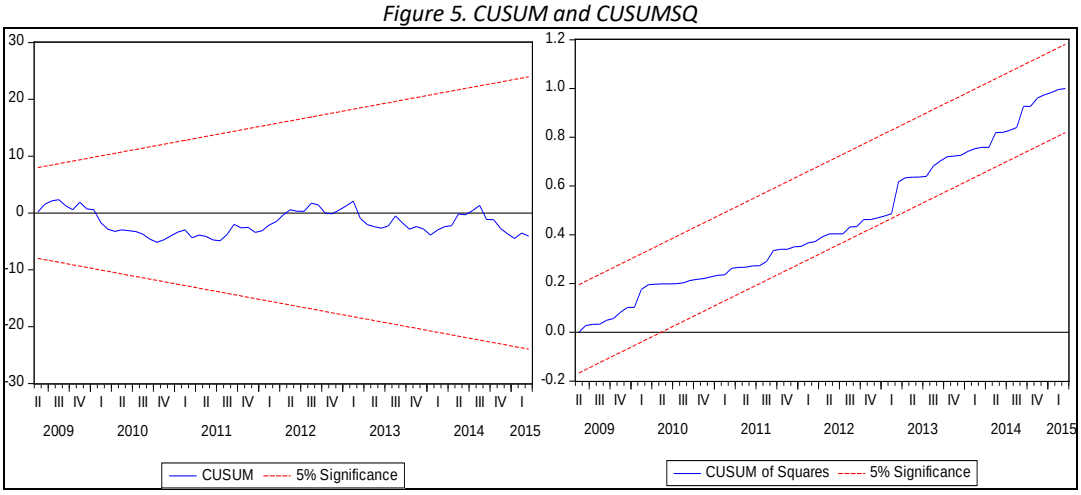
*Figure 5. CUSUM and CUSUMSQ*




*Source: Designed by the authors using appropriate statistical software package*

## 8. Conclusion

The study analysed the effectiveness of the interest rate policy of the RBI as a tool to control inflation. The last decade witnessed one of the worst global financial crises during 2008-09. The most important policy decision around this time was to stabilize decelerating growth due to liquidity shortage as a result of large scale capital outflow. The RBI along with the Government of India took instant measures and introduced large scale expansionary monetary and fiscal to combat the liquidity crunch by reducing interest rate and providing budgetary support, leading to large scale demand pressures causing inflation. The problem was further aggravated due to supply side pressures in the form of food and fuel inflation. The data around this period shows inflation crossing its single-digit modest level and behavior. RBI then took corrective measures in 2010-11, by increasing interest rate in several rounds for checking the pace of inflation growth. However, the inflation level had become quite stubborn by then and was not responding to increase in interest rate. This was the time, when many questioned the efficacy of policy during recessionary phases. The study also tests the policy effectiveness during recessionary phases. It compares its effectiveness during pre-and post-global financial crisis period in the Indian economy and also discusses and empirically analysis the important factors affecting inflation. The results support the interest rate tool as a mechanism to control inflation both during normal and recessionary time periods. However, the results show the effectiveness does reduce in the post-crisis period. The result derives its relevance from a) the fiscal dominance of monetary policy, where increase in money supply to support rising fiscal deficit is inflationary in nature b) pro-cyclical support of fiscal policy has made monetary policy less effective in controlling inflation, according Minsky financial instability hypothesis. An important implication which follows from the study is that, even if fiscal deficit per se does not cause inflation, as is the case, still it can impact the latter through its transmission to the monetary policy. This is supported by the results found in our study, where fiscal deficit variable is found to be insignificant (holding the other variables constant) in affecting inflation gap both in the pre-and post-financial crisis periods. This in turn indicates, rising fiscal deficit, if not backed by rising money supply to finance it, will not be inflationary. Output gap, foreign exchange rate and money supply all have a significant and expected (direction of) impact on inflation gap. There is no change in the marginal effect of the output gap and foreign exchange rate on inflation gap in the pre-and post-crisis periods, once we control for other factors in the regression, as their coefficient values do not change in the post-crisis period. Crude oil price is found to be insignificant during the pre-crisis period but becomes significant during post crisis. The study thus concludes that the recent shift of Indian monetary policy framework to inflation targeting can be termed as a step in the right direction, since it would help subdue inflationary expectations, which otherwise can hamper other related macroeconomic variables.

The policy seems to have realized that for achieving sustainable growth level in the medium-run, it is crucial to control inflation in the short-run. The policy would then be growth-enhancing in the medium-run.

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