Inflation Dynamics in India: An Analysis

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Abstract

India has exhibited high variability in inflation during the last eight years owing to both internal and external factors. The Global Financial Meltdown, recurrent increase in global oil prices, wage employment programmes, widening current account deficits etc resulted in fluctuations in inflation. These factors have a direct influence on variables like output, money supply, exchange rate which in turn affect inflation. In this context, the study employs a Cointegrated Vector Auto Regression framework to analyse inflation dynamics in India. The determinants identified to affect inflation in India include broad money supply, exchange rate and output, which is substantiated by the existing theories of inflation. There exists a cointegrating relation between inflation and its determinants and in the short run inflation adjusts to past changes and policy fundamentals as inferred from the Error Correction Model. The Impulse Response Function traces out a stable relationship of inflation with its identified determinants.

1. Introduction

Inflation is a process of sustained rise in prices. In a developing economy, inflation is determined by a multiplicity of factors that are inter-related in an intricate manner (Patra & Partha, 2010). Monetary Policy in India, as a major component of economic policy has aimed at maintaining a reasonable degree of price stability. To meet the growing needs of a developing economy, monetary policy also has to ensure an adequate expansion of credit to assist economic growth and employment. Economic growth in turn increases the demand for goods and services, fuelling inflation. Structural changes adopted in the economy since 1990s, opened up the economy and hence factors outside domestic policy purview also affects inflation. Thus inflation has become a complicated and complex phenomenon in India. The present paper, therefore, attempts to empirically understand the inflation dynamics in India, with particular focus on determinants. A Cointegrated Vector Auto Regression framework is used for empirical estimation. The rest of the paper is designed as follows. Section 2 discusses the trends in inflation in India. The theoretical model of inflationary process used in the empirical work is outlined in Section 3. Section 4 presents the variables, data base and methodology and the estimation results are provided in Section 5. The last section gives the concluding observations.

2.Trends in Inflation in India

a) Measures of Inflation

Three different price indices are published in India : the whole sale price index (WPI); the consumer price index (CPI), which is calculated for different types of workers (those in the industrial, urban non-manual, and agricultural/rural sectors); and the GDP deflator. The WPI is available weekly, with a lag of two weeks for the provisional index and ten week lag for the final index. The WPI is used to measure the change in the average price level of goods traded in the wholesale market, it includes a basket of commodities comprising of 676 items. The major commodities included are primary articles, fuel and power, and manufactured products. Weight given for primary article is 20.12 (14.34 for food articles and 5.78 for non food and minerals), fuel and power is 14.91 and for the manufactured products is 64.97. Since WPI is producer's price index it is argued by economists that the WPI has lost its relevance and cannot be the barometer to calculate inflation.

CPI is meant to represent the cost of a representative basket of goods and services consumed by an average household. It is captured on the basis of consumer price of selected goods and services on which a particular group of people spend most of their income, the different measures of CPI are - CPI - Industrial Workers (CPI-IW), CPI-Urban Non-Manual Employees (CPI- UNME), CPI- Agricultural Labour (CPI-AL) and CPI- Rural Labour (CPI-RL). The number of items or basket of commodities taken for the calculation of CPI-IW is 320, CPI- UNME is 365, CPI-AL is 260 and for CPI-RL is 260.

In most countries, the main focus is placed on the CPI for assessing inflationary trends, both because it is usually the index where most statistical resources are placed and because it most closely represents the cost of living (and is therefore most appropriate in terms of welfare of individuals in the economy). In India, however, the main focus is placed on the WPI because it has a broader coverage and is published on a more frequent and timely basis

b) Recent Inflationary Developments in India (April 2005 and November 2013)

The mean value of WPI in India during the period under consideration was 6.94 per cent. Within the WPI, the highest increase is felt in the index for primary products, the inflation rate in this sector was 11.42 per cent followed by WPI in fuel and power. The index of manufacturing products rose only by 4.96. Highest variability as estimated by the standard deviation is experienced by WPI in the fuel and power sector followed by the. primary products sector. The CPI for industrial workers during this period rose by an annual average amount of 9.56 percent.

Table 1

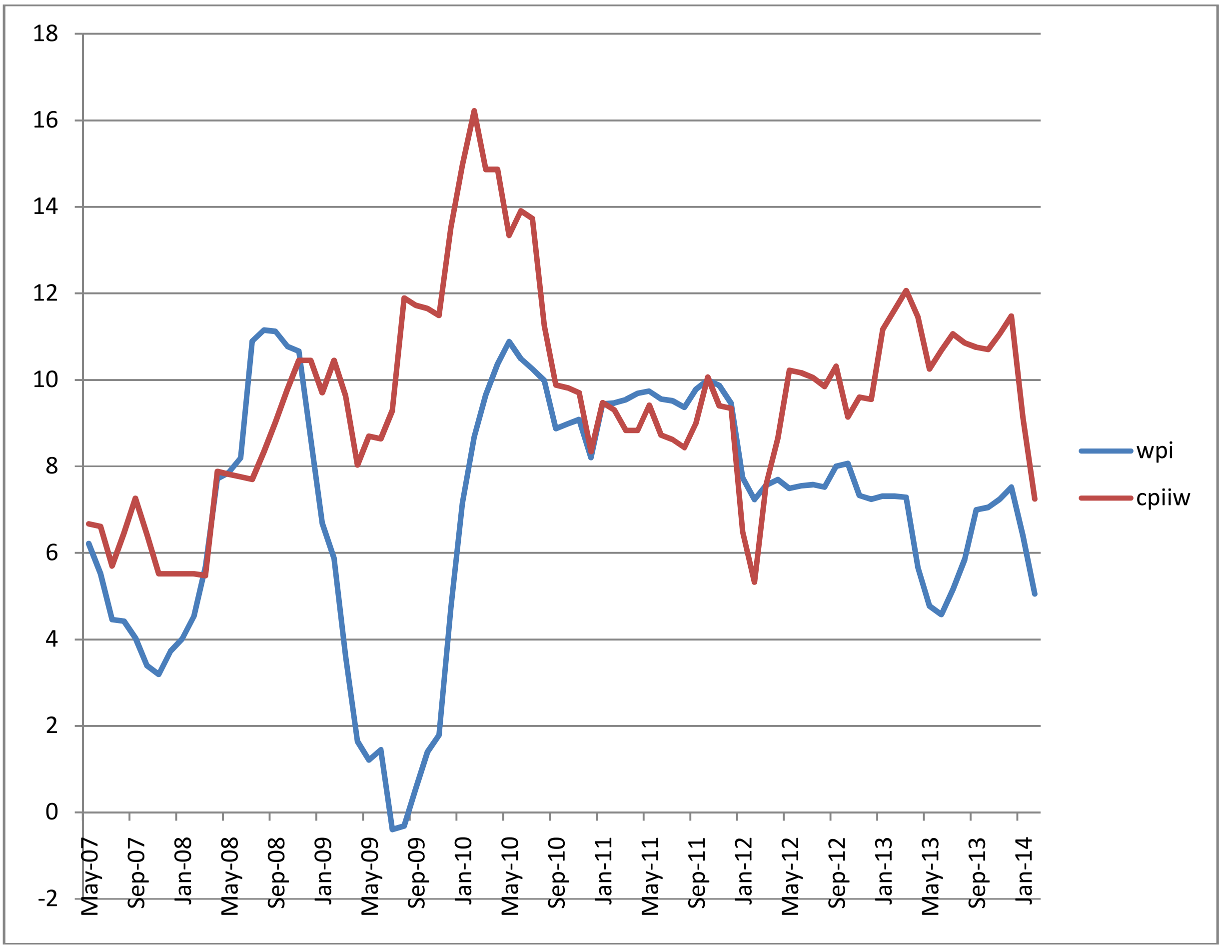
Mean and Standard Deviation of Various Measures of Inflation in India

Measures of Inflation	Minimum	Maximum	Mean	Standard Deviation
WPI	-.39	11.15	6.943	2.87373
WPIP	2.76	22.16	11.41	4.52428
WPIFP	-11.29	21.84	8.083	7.54128
WPIM	-.25	8.46	4.946	2.12007
CPIW	5.32	16.22	9.563	2.37369

Note : WPI = Wholesale Price Index, WPIP = Wholesale Price Index for Primary Products, WPIFP= Whole Sale Price Index for Fuel and Petroleum, WPIM = Wholesale Price Index for Manufacturing Products, CPIW = Consumer Price Index for Industrial Workers

Source : Author’s calculations

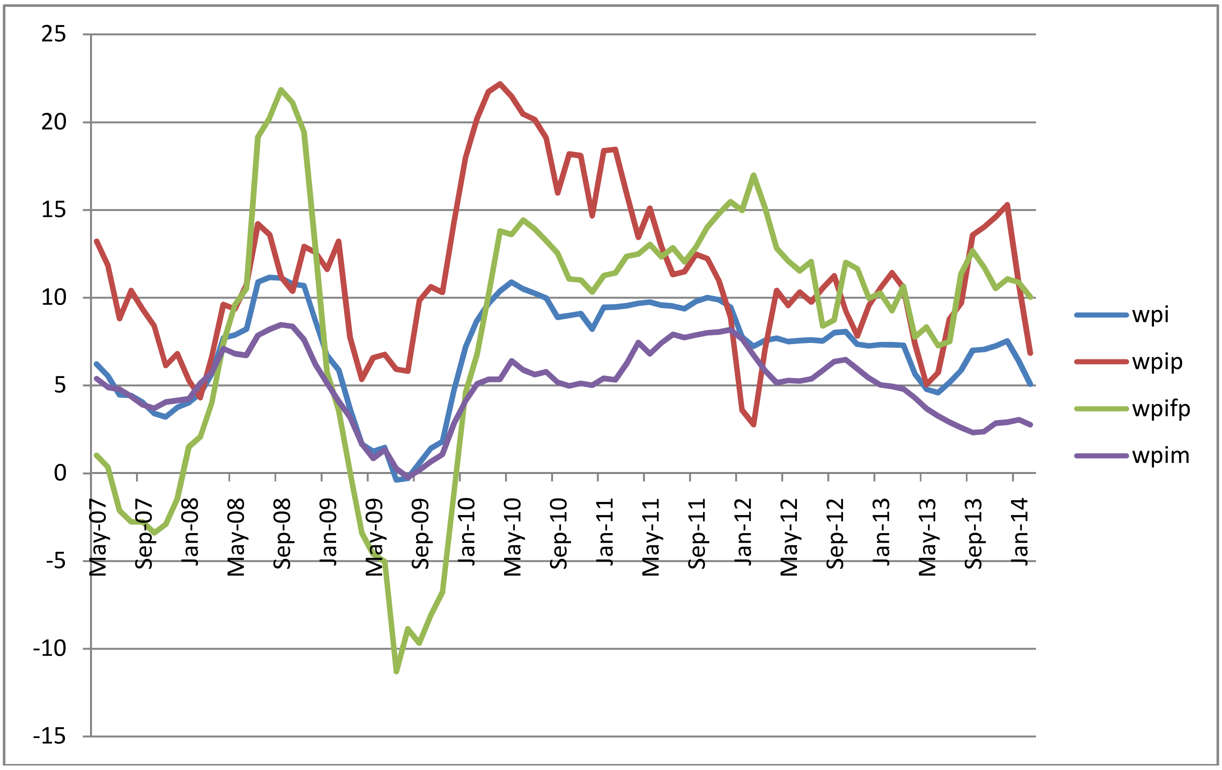
Fig 1
Trends in WPI and CPI (IW) in India



Source : Author's calculations

Figure 1 shows that in most of the time periods, the CPI (IW) has been higher than the WPI index. Sharp decline in WPI is noted during the period of financial crisis, however, during this period the CPI did not decline much. CPI recorded its highest level during April 2010 and crossed 16 per cent mark. Beginning of 2014 witnessed a decline in both the indices.

Fig 2
Trends in different WPI indices



Source : Author's calculations

Figure 2 shows that all the whole sale price indices fell sharply during the year 2009, reflecting the impact of the global financial crisis. Generally all indices move in the same direction, expect for the end of 2011 and the beginning of 2014. Towards the end of 2011, although WPI for food products was declining, the index for fuel and power was at a very high rate. By the end of 2013, prices of primary products reached very high levels; however for the manufactured products the index remained low. Highest variability as per the figure is shown by the prices of fuel and power, followed by prices of primary products.

3. Literature Review and Theoretical Underpinnings

Attempts at modeling inflation in India on a monetarist approach have provided mixed results. Callan and Chang (1999) used a VAR framework to assess the indicators of inflation in India and concludes that developments in the monetary aggregates remain an important indicator of future inflation. Exchange rates and import prices are also relevant, particularly for inflation in the manufacturing sector. John (2003) used the post liberalization data to study the causality between monetary aggregates and exchange rates using VAR framework and concludes that there is sufficient reason to believe that broad money measure is better. Sahadudheen (2012), using quarterly data (1996 Q1 to 2009 Q3) studied the determinants of inflation in India by employing the cointegration and VEC model and established that GDP and broad money have positive effects on inflation, however exchange rate and interest rate negatively affects inflation. A long run negative relationship between inflation and GDP growth in India has been empirically observed by Salian and Gopakumar (2004).

Thus, based on the relevant studies it is identified that inflation is determined by money supply, exchange rate and GDP. This is substantiated by theoretical justification as elaborated below.

A simple model of price determination is one where the price level P_t is a weighted average of tradable prices P_t^T and non tradable prices P_t^N

$P_t = \beta P_t^T + (1-\beta) P_t^N$,

where β is the weight on tradable prices in the price index. The price of tradable goods is determined in the world market, with their price in the domestic economy being a function of foreign currency and the exchange rate. The price of non tradables is determined in the domestic money market

$P_t^N = \alpha(M_t - M_t^d)$,where M_t is the outstanding stock of money

M_t^d = the demand for real money balances and α = scale factor

The demand for real money balances is assumed to be determined by the level of real income Y_t.

Consequently the price of non tradables can be written as

$P_t^N = \alpha(M_t - a_1 Y_t)$

An increase in the outstanding money stock is expected to result in higher prices, an increase in real income is expected to expand the demand for money for transactions and in turn affects prices. Exchange rate is expected to influence the price of tradable goods in the economy. Hence prices can be modeled as a function of money supply, real income and exchange rate.

4.Variables, Data Base and Methodology

As a measure of inflation, CPI is used since it is the most comprehensive measure of inflation and most closely represents the cost of living index. Since the study is based on monthly data, GDP cannot be used as a measure of demand in the economy as this measure is not available monthly wise. Hence industrial production is used as proxy for GDP in the estimation work since Index of Industrial Production (IP) holds strong positive correlation with GDP. According to Quantity Theory of Money, there exists a direct and proportionate relationship between money supply and inflation and broad money (M3 which includes currency and coins in circulation and demand and time deposits) is considered as the most important indicator of money supply. To capture the influence of external factors, exchange rate (RER) is considered as a determinant of inflation.

Monthly data for the period April 2005 to November 2013 is used for the study. This period encompasses high as well as moderate inflation, hence represent adequate variation in data. Data is obtained from the website of MOSPI and RBI. CPI and IP are used in index format and the base year for indices is 2004-05. Analysis is done with E Views Econometric Package.

Methodology

The first step of empirical analysis involves determining the order of integration. Most time series are trended and therefore in most cases are non stationary. The problem with non stationary or trended data is that the standard OLS regression procedure can lead to incorrect conclusion. A series of Augmented Dickey Fuller unit root tests is performed to determine the order of integration of the variables.

The Augmented Dickey-Fuller Test

Depending upon the nature, a time series can be represented as in the equation (1) or equation (2) or equation (3).

$\Delta Y_t=\delta Y_{t-1}+u_t$ … (1)

$\Delta Y_t=\beta_1+\delta Y_{t-1}+u_t$ … (2)

$\Delta Y_t = \beta_1 + \beta_{2t} + \delta Y_{t-1} + u_t$ … (3)

The Augmented Dickey Fuller (ADF) test under the null of non stationarity can be conducted to test whether a given series is stationary or not. This test is conducted by augmenting either of the above three equations by adding the lagged value of the dependent variable ΔYt. Thus each of the above equation will be as follows:-

$\Delta Y_t = \delta Y_{t-1} + \alpha_i \Sigma \Delta Y_{t-i} + e_t$ … (4)

$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \alpha_i \Sigma \Delta Y_{t-i} + e_t$ … (5)

$\Delta Y_t = \beta_1 + \beta_{2t} + \delta Y_{t-1} + \alpha i \Sigma \Delta Y_{t-i} + e_t$ … (6)

Where e_t is a pure white noise error, and the number of lagged difference term to include is determined empirically (Gujarati, 2004). In each of the above equations if $\delta=0$, the series is non stationary. The Dickey Fuller tables is used to test the significance of the hypothesis. If the time series is non stationary, the order of integration (which implies the number of times that the time- series has to be differenced to make it stationary) becomes very significant.

Cointegration

It is possible that a linear combination of non stationary time series data turns out to be stationary, if such is the case, the variables are said to be integrated. Economically speaking, two variables will be cointegrated if they have a long term or equilibrium relationship between them

Two methods are widely used for testing cointegration

a) Single equation method or Residual Based Method given by Engel Granger
b) System based method called Johansen Test

Engel Granger Test

If the residuals obtained from the regression on linear combination of integrated variables doesn’t possess unit root, then the variables are said to be cointegrated, by the Engel Granger Test

Johansen Test

This test is based on Likelihood estimation in a Vector Autoregressive model framework.

If the vector yt has n time series, each of which is I(1) and if the vector can be expressed as

$y_t=\pi_1 y_{t-1}+\ldots\pi_k y_{t-k}+\varepsilon_t$ … (7)
where, π_1 are NxN matrices of unknown constants and the error term εt has the multivariate normal distribution, equation (7) can be converted into the following equation:-
$\Delta y_t= \Gamma 1\Delta y_{t-1}+\ldots+ \Gamma_{k-1}\Delta y_{t-k}+1+\pi\Delta y_{t-k}+\varepsilon_t$ … (8)
Johansen (1988) shows that the rank r of π in the equation (8) is equal to the number of cointegrating vectors in the system. (Nachane, 2006). Further, the π may be factorised as $\pi = \alpha\beta'$. Under the null hypothesis of no cointegration the hypothesis testing of the number of cointegrating vectors 'r' is done using two test statistics λmax and λtrace derived from β. Johansen and Juselius (1991), have provided the critical values of λmax and λtrace statistics. If the Test statistics is greater than the critical value at a significance level then the null hypothesis of r cointegrating vectors is rejected for the alternative hypothesis.(Panda, 2008).

Error Correction Model (ECM)

Existence of a cointegrating vector among variables establishes a long run relationship among them. Engle and Granger (1987), showed that an equilibrium specification is missing when these cointegrated variables are represented in a Vector Autoregression specification, but when lagged disequilibrium terms are included as explanatory variables the model becomes well specified. The model is called an error correction model because it has a self-regulating mechanism whereby deviation from the long-term equilibrium is automatically corrected.

Vector Autoregression (VAR)

VAR is useful in forecasting systems of interrelated time series and for analysing the dynamic impact of random disturbances on the system of variables. The VAR approach models every endogenous variable as a function of lagged values of all the endogenous variables in the system. Impulse Response Function and Forecast Error Variance Decomposition (FEVD) are then estimated from the VAR system.

Impulse Response Functions (IRF)

The IRF traces the impact of one standard error change in a variable on all endogenous variables. A shock in the i^{th} variable directly affects the i^{th} variable and is also transmitted to all of the endogenous variables through the dynamic structure of the VAR. The IRF can be used to produce the time path of the dependent variables in the

VAR. If the system of equation is stable any shock should decline to zero, an unstable system would produce an explosive time path.

Forecast Error Variance Decomposition (FEVD)

The FEVD decomposes variations in an endogenous variable into component shocks giving information about the relative importance of each random shock to the variable. The FEVD tells us the proportion of movement in a sequence due to its "own" shocks versus the shocks due to other variables (Enders, 1995).

5. Results of empirical estimation

Step I

Stationarity test of the variables using ADF test.

The first step of empirical analysis involves determining the order of integration. ADF is used to determine the order of integration of the variables.

Table 2
ADF tests for the presence of unit root

Variables	Intercept only		Intercept and trend	
	Level (p value)	First difference (p value)	Level (p value)	First difference (p value)
CPI	1.0000	0.0002	0.9688	0.0002
IP	0.1349	0.0972	0.8850	0.0603
M3	0.9401	0.0000	0.1129	0.0000
RER	0.8431	0.0000	0.8097	0.0000

Source : Author's calculations

The reported result in table reveals that the hypothesis of a unit root can't be rejected in all variables in levels. However, the hypothesis of unit root is rejected in first differences at 0.05 level of significance (except for IIP for which the level of significance is 0.06) which indicates that all variables are integrated of degree one I(1). It means that all variables achieve stationarity only after first differencing

Step II

Lag order selection of the cointegrated VAR system, using the AIC and SBC criteria.

The lag order using the AIC and SBC criteria was found to be two.

Step III

Testing for cointegration.

a.Engel Granger Test

To understand whether the variables are integrated, the residual terms obtained from the OLS equation of CPI on IP, M3 and RER is tested for stationary. The results of the stationarity test of the error term is given in Table 3.

Table 3
Unit root result of residual term of regression of CPI on other variables

Null Hypothesis : Residual has a unit root			
		t statistic	Prob*
Augmented Dickey Fuller statistic		-4.177957	0.0012
test critical values	1 % level	-3.496346	
	5% level	-2.890327	
	10 % level	-2.582196	

Source : Author's calculations

The test result indicates that the null hypothesis of existence of unit root in residual term is rejected. It implies that the error term is stationary, hence there exists a relationship between these variables in the long run.

b) Johansen test for cointegration

The empirical results of the cointegration analysis derived from Johansen test involving the four variables chosen in the study is given in Table 4. Trace statistics shows that the likelihood ratio for no cointegrating vector is larger than the critical values leading to the conclusion that null hypothesis of no cointegrating vector is rejected. Testing the hypothesis of at most one cointegrating vector is accepted. Max- Eigen value statistic corroborates the earlier result of one cointegrating vector.

Table 4
Cointegration based on Johansen Maximum Likelihood Approach

April 2005 to November 2013.				
Unrestricted cointegration rank test (Trace)				
Null hypothesis	Eigen value	Trace statistics	5% critical value	Prob
r=0*	0.269076	54.85982	47.85612	0.0096
r<=1	0.140951	23.82868	29.79707	0.2078
r<=2	0.073897	8.787671	15.49471	0.3854
r<=3	0.011923	1.187460	3.841466	0.2758
Unrestricted cointegration rank test (Maximum Eigen value)				
Null hypothesis	Eigen value	Max Eigen value	5% critical value	Prob
None*	0.269076	31.03114	25.58434	0.0173
At most 1	0.140951	15.04101	21.13162	0.2861
At most 2	0.073897	7.600211	14.26460	0.4208
At most 3	0.011923	1.187460	3.841466	0.2758

*indicates rejection of the hypothesis at 5 per cent level of significance. Trace and Maximum Eigen value indicates one cointegration equation at 5 per cent significance level.

Source : Author's calculations

Step IV
Estimating the ECM equation for CPI and the IRF and FEVD of CPI.

Cointegration regression shows that there exists a long run relation between inflation and it's identified determinants. If there is any deviation from long run relation, within a short period of time the system has a tendency to come back to the original level, i.e. if there is a change in inflation as a result of these variables, inflation will adjust in the next period - this percentage of correction is called error correction model. To explain the VAR model for inflation, output, exchange rate, and money supply, the lag length selected is two, which is determined by Akaike Schwatz criterion.

Table 5
ECM for variable CPI based on cointegrating VAR

Dependent variable is ΔCPI			
Regressor	Coefficient	Standard Error	t value
Zt-1	-0.152365	0.04291	-3.55051*
ΔCPIt-1	-0.111784	0.9805	-1.14001
ΔCPIt-2	-0.298877	0.09974	-2.99644*
ΔM3t-1	-0.000658	0.00049	-1.33331
ΔM3t-2	0.000297	0.00050	0.59019
ΔIPt-1	0.297592	0.08287	3.59106*
ΔIPt-2	0.096401	0.04255	2.26542*
ΔRERt-1	-0.241566	0.14914	-1.61977
ΔRERt-2	-0.177542	0.13901	1.27720

Source : Author's calculations

The ECM equation of CPI is as follows

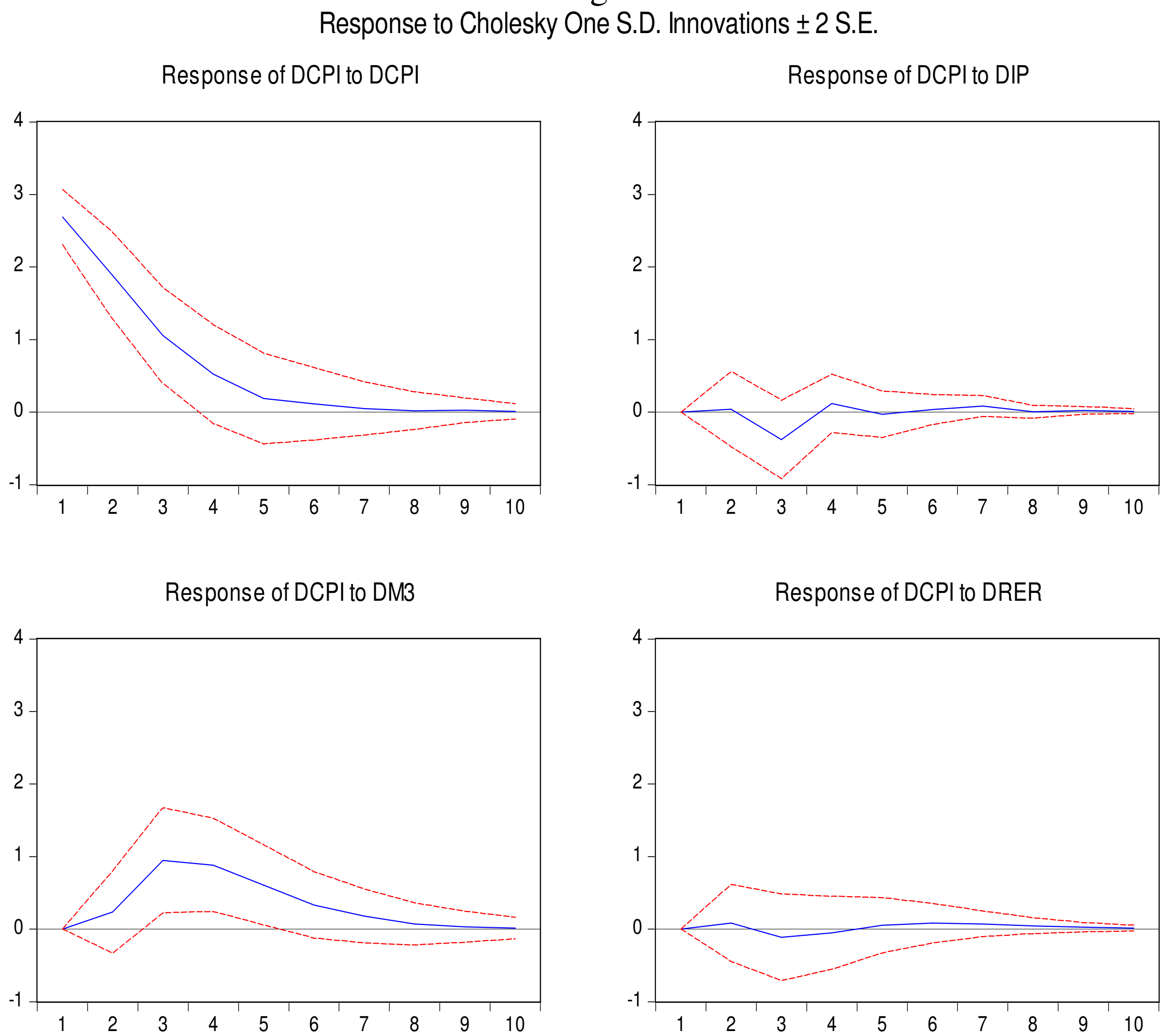
$$\Delta CPI_t = -0.152365\ Z_{t-1} - 0.111784\ \Delta CPI_{t-1} - 0.000658\ \Delta M3_{t-1} + 0.000297 \Delta M3_{t-2} + 0.297592\ \Delta IP_{t-1} + 0.096401\ \Delta IP_{t-2} - 0.241566\ \Delta RER_{t-1} - 0.177542\ \Delta RER_{t-2}.$$

The ECM equation shows the short term and long term relationship among the variables. The coefficient of ECM reflects the self correcting dynamic mechanism. The sign of ECM is negative and significant, which implies that the current changes in CPI adjust to past trends and policy fundamentals. The value of ECM gives the result that 15 percent of correction in disequilibrium takes place in the next time period.

Impulse Response Function (IRF)

The VAR model of selected variables is useful for identifying the relative importance of each variable to others, based on the dynamic interaction among them through IRF. The IRF can be used to produce the time path of the dependent variables in the VAR, to shocks from the explanatory variables.

Fig 3



Source : Author's calculations

Figure three reveals the response time path of CPI variable to the one standard deviation innovation to the variables in the VAR system. The response of CPI to CPI shows that it responds up to five time horizons and subsequently dies out. Impulse response of CPI to IP variable shows that the initial effect is negative and then bouncing back to equilibrium takes place within five horizons. Impulse of one standard deviation to M3 is positively reflected in CPI and this effect remains so up to four time horizons and then subsequently declines and becomes zero by seven time horizons. The response of CPI to RER is minimal. Thus it can be inferred that CPI bears stable relationship with RER, RM and IP. CPI responds positively to money supply and negatively to RER and IP as per the IRF.

Forecast Error Variance Decomposition (FEVD)

The FEVD can also be calculated for the VAR system. Table 6 gives the FEVD of CPI, inflation is explained mostly by its own fluctuations in the initial time periods, but as time passes on, the influence of M3 increases. M3's influence starts only in the third horizon possibly explained by the lags in the effectiveness of Monetary Policy. It can be seen that of all the variables, the influence of M3 is high and remains so even up to the tenth time horizon followed by the influence of IP.

Table 6
Generalised Forecast Error Variance Decomposition for variable CPI

List of variables included in the cointegrating vector				
horizon	CPI	IP	M3	RER
1	100.0000	0.000000	0.000000	0.000000
2	99.41686	0.016423	0.504186	0.062536
3	91.42686	1.097735	7.321802	0.153602
4	86.41680	1.116040	12.30596	0.161198
5	84.22616	1.090289	14.50879	0.174766
6	83.55685	1.088286	15.13856	0.216297
7	83.30851	1.133894	15.30813	0.249466
8	83.27090	1.133412	15.33327	0.262418
9	83.25905	1.137000	15.33733	0.266623
10	83.25652	1.137887	15.33801	0.267586

Source : Author's calculations

6.Conclusion

The study based on monthly data between April 2005 and November 2013 used three variables i.e. industrial production index, broad money supply, and exchange rate to model inflation in India. Since all the variables have unit root at levels, and are stationary after first differencing the study utilizes Engel Granger and Johansen – Juselius cointegration analysis to test for the existence of a long run relationship between the variables. Both tests indicate the existence of a cointegrating vector. The cointegration regression considers only the long run property of the model, and does not deal with the short run dynamics explicitly. For this the error correction model is estimated, which provides the result that current changes in CPI adjust to past trends and policy fundamentals. As per the IRF, inflation bears stable and correcting relationship with is determinants. The study concludes that industrial production has a negative effect on inflation in the long run, whereas money supply has a positive effect.

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