

The Indian Inflation 2006–16: An Econometric Investigation

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ABSTRACT

In recent times, the Reserve Bank of India has adopted several changes in the conduct of monetary policy in India, ranging from focusing on CPI to targeting inflation. However, there are certain curious and unusual features of inflation in the Indian economy that may have some implications on the effectiveness of such measures. This paper tries to explore and analyse the nature of inflation in terms of both WPI and CPI, headline and core and their relationships with certain macroeconomic variables linked to monetary policy. The results are quite interesting and have important policy implications. *First*, the movements of WPI and CPI and their headline and core counterparts are not explained by same set of variables. *Second*, surprisingly, food inflation is not explained by agricultural output. This probably points to the insufficient increase in supply in matching the demand in agriculture, which in turn may imply structural bottlenecks or lack of productivity increase in agriculture. *Third*, the determinants of CPI headline and core inflation are not same. So, it is important to look at both of them while formulating policies. *Fourth*, and the most interesting observation is that the relationship between the different components of inflation implies the possibility of some adjustment in demand from one set of goods to another, i.e. some adjustments in terms of relative prices which needs further exploration.

JEL Classification: E31, E52, C32

1 Introduction

In India, during the past few years, inflation continued to keep policy makers on a roller coaster ride as they had to keep the pace of growth on the right track especially during the recessionary phase. It had posed a serious challenge for policymakers as the different components of inflation were responsible for rise in prices at different points of time. Discussions have also been underway on a number of issues, viz. whether inflation targeting is the appropriate monetary policy; whether the central bank, i.e. Reserve Bank of India (RBI) should target WPI or CPI inflation; or it should look at headline or core inflation etc. For example, in a kind of “regime shift”, the RBI has moved away from tracking WPI and already started targeting CPI inflation from 2014 and subsequently in 2015, the flexible inflation target has also been set. According to this, RBI would look to contain consumer price inflation within 6% by January 2016 and within 4% with a band of 2 percentage points for all subsequent years, as per the monetary policy framework agreement between the central bank and the central government. Recently, in 2016, the Monetary Policy Committee (MPC) has also been formed to decide the target rate of inflation in India. However, the dilemmas about all these play a significant role in policy making, since the monetary policy design and mechanism would depend on whether the price movements are transitory or permanent and the short and long run implications may be different.

This paper draws its motivation from certain curious and unusual features of inflation the Indian economy had experienced during the last decade. First, phasing of inflation and GDP are different. From Figure 1, it may be observed that during 2006 to 2016, while GDP dipped into a recession and then started recovering gradually, WPI and CPI recorded different patterns varying from a cyclical one to highly increasing even when GDP was falling. It is also observed that phasing of WPI and CPI are also not same. When WPI was cyclical in nature, CPI

was high and increasing. There are phases where the gap between WPI and CPI narrowed, even CPI remained lower at times, which is not very common. Second, there is large divergence between WPI headline inflation and CPI headline inflation in terms of variation in prices of various component groups and their weights. From Table 1, it is quite evident that the weights of food and fuel in WPI are different from that of CPI. This implies that adapting CPI or WPI as the target rate will have different implications for the economy.

Since the two competing measures of inflation (Core WPI and Core CPI) followed divergent temporal patterns, which one should be used for policy purposes becomes a choice problem for the policy maker (vide Taylor's rule followed by most monetary authorities for controlling interest rate, keeping eye on the observed rate of inflation and output trend¹), i.e. whether one should look at headline or core inflation and whether one should base the monetary policy decision on the movements of consumer price or wholesale price indexes.

It is also interesting to have a look at the possible linkage between the components of inflation measures (Figures 2.1 and 2.2). It is observed that the movements of headline and core inflation (both WPI and CPI) are similar while those of food and fuel are fluctuating widely. But, while the gap between the food and fuel price inflation is widening in case of wholesale prices in recent times, it is narrowing for CPI.

¹The following relationship, known as Taylor Rule, is used for the purpose:

$$i_t = \pi_t + r_t^* + a_\pi(\pi_t - \pi_t^*) + a_y(y_t - \bar{y}_t)$$

Where i_t ; target short term nominal interest rate; π_t : measured rate of inflation; π_t^* : desired inflation; r_t^* : assumed equilibrium interest rate; y_t : logarithm of real GDP, and \bar{y}_t : logarithm of potential output as determined by a linear trend.

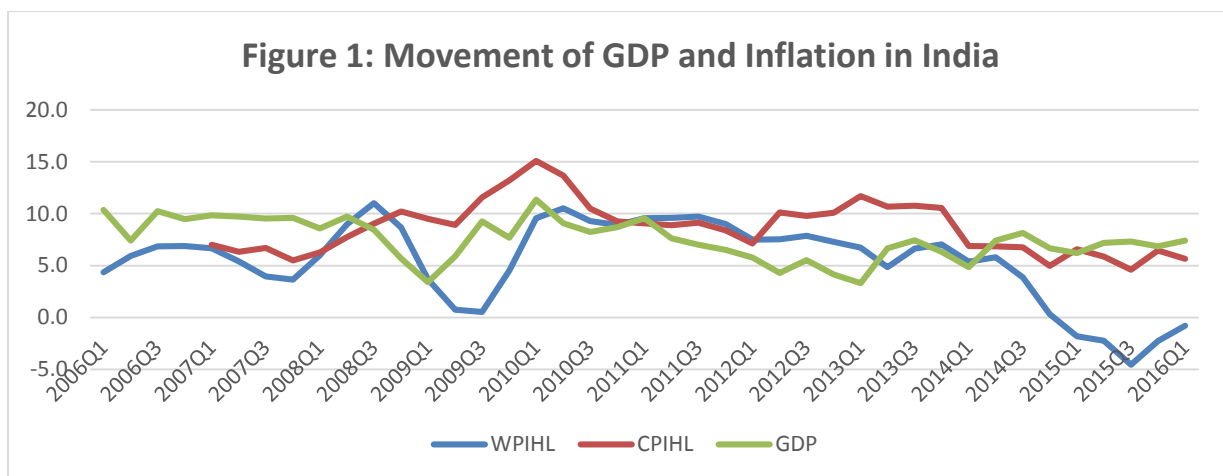
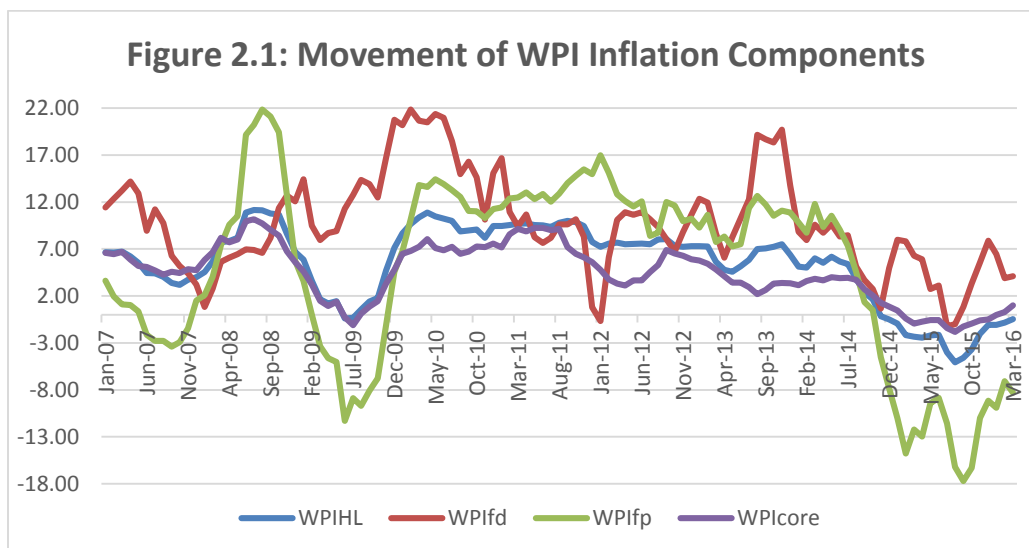
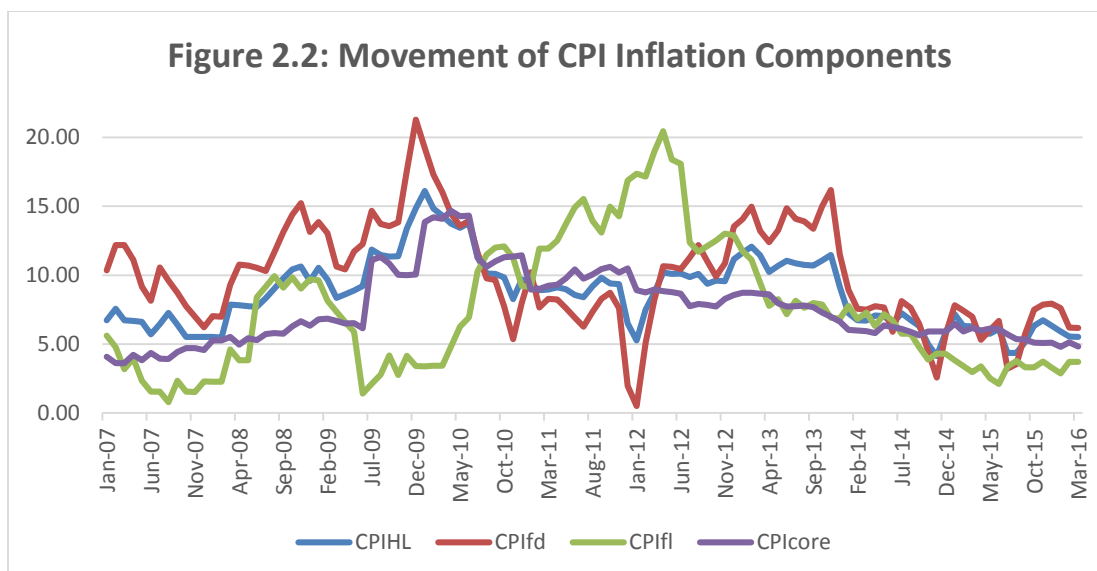


TABLE 1: Weights of Components in Inflation

Weights			
WPI Headline	100	CPI Headline	100
WPI Food	14.3	CPI Food	46.2
WPI Fuel and Power	14.9	CPI Fuel, Light etc.	6.4
WPI Core	70.8	CPI Core	47.5
<i>of which</i>		<i>of which</i>	
WPI Manufacturing	65	PAN, SUPARI, TOBACCO & INTOXICANTS	2.3
WPI Non-food & Minerals	5.8	HOUSING	15.3
		CLOTHING, BEDDING & FOOTWEAR	6.6
		MISCELLANEOUS GROUP	23.3





Rakshit (2011) tries to explore the possible sources of such features. Based on regressions, some of his important observations point out the following: first, inflation was not linked to macroeconomic factors; second, the qualitatively different temporal patterns of WPI and CPI core inflation may be indicative of the presence of a dichotomy between the roles of food and fuel prices in inter-sectoral transmission of inflationary impulses in the Indian economy²; third, CPI food inflation is found to be negatively related to the growth of agricultural GDP, but not related to the growth of non-agricultural GDP. Whereas the former confirms the supply-side story, viz., better agricultural performance abates food price inflation, the latter contradicts the structuralist view, viz., agricultural (food) supply being inelastic in short run, a rise in non-agricultural sector output (which accounts for 80 per cent of Indian GDP) should lead to a food price rise via increased food

²This possible dichotomy is explained as follows: For the Indian economy oil prices are autonomous, governed by international crude prices and government's petro-products pricing policies. Moreover, fuel users are not quantity-constrained. A fuel price shock will raise nominal prices of non-agricultural products, depending on the oil-intensity of the products. With money wages not responding to price increases, the oil price-shock induced inflation have no further consequences for non-agricultural prices. Since short-term supply of farm products are not affected by oil prices and the income and substitution effects of the rise in industrial (including fuel) prices on the demand for agricultural goods operate in the opposite direction, the impact of an oil shock on their prices could in theory be insignificant.

demand due to growth of non-agricultural output. Fourth, exchange rate depreciation is found to produce a significant negative impact on the WPI Core and WPI manufacturing inflation – a result which is considered to be rather curious.

In this paper we try to figure out the nature of inflation in India in the recent past and explore and explain the linkages between the prices in different sectors and the macroeconomic variables. Rakshit (2011) conclusions are based on regressions without any consideration for time series properties of the variables. At the backdrop of the conclusions of Rakshit (2011) from the structuralist viewpoint, we try to perform a time series econometric exercise on whether the conclusions hold empirically, which may help us discover meaningful temporal relationships and discern some definite conclusions about the movement of prices in India that will be beneficial from the point of view of policymakers. The empirical analyses focus on finding out the existence of co-movements among the inflation and macroeconomic variables, explaining the role of components like food and fuel price in driving CPI and WPI.

The paper is organized as follows – the next section presents an overview of the literature. Section 3 describes data and methodology followed by results in Section 4. Section 5 concludes.

2 Literature Review

In the Indian context, the observed divergence between WPI and CPI inflation (both headline and core) poses a serious issue in the context of policy formulation, since the preferred target of the central bank would dictate the appropriate monetary policy to be undertaken. In this section, a review of the existing literature is presented, keeping in view the pertinent debates related to the policy concerned with inflation in a developing country like India. Also, we document here the findings related to inflation in the Indian context.

2.1 Core or Headline Inflation

The first issue relates to whether core or headline inflation should be targeted by the central bank for policy formulation. In his 2007 speech at the Business Cycles, International Transmission and Macroeconomic Policies Conference, Frederic S. Mishkin argues that while it is sensible for central banks to focus on headline inflation when determining the appropriate monetary policy over the medium run, core inflation should be emphasized when deciding on the monetary policy over a longer run. He argues that monetary policy cannot address relative price movements of items such as food and energy arising from temporary supply shocks. Headline inflation is inherently noisy and may not reflect the underlying inflation trend which monetary policy can actually affect. Measures of core inflation, obtained by stripping the headline inflation off the volatile components are likely to be much more stable and thus, better indicators of the underlying trend rate of inflation. Mishkin however warns that central banks should be aware of whether the shocks to the volatile components of headline inflation are permanent in nature, which can put an upward pressure on core prices.

According to Cecchetti (2010), most Emerging Market Economies (EMEs) represented at the 2009 Bank for International Settlements (BIS) meeting of senior officials of central banks (e.g. Brazil, China, Mexico, Phillipines, etc), target the headline inflation for monetary policy, except for Thailand which targets the core CPI inflation. He states that the two main problems facing central banks for short-term policymaking beyond the choice of an inflation target, are transitory shocks or noise (stemming from seasonal patterns, exchange rate changes, etc) which should not affect policy formulation, and biases arising from flawed weighing schemes, sampling techniques and quality adjustments employed.

The most common solution to the problem of noise is excluding certain components from the computation of the index that are believed a priori to exhibit considerable amounts of noise; food and energy being the most commonly excluded items. These ‘core’ measures of inflation should ideally be unbiased and should have lower volatility than the inflation measure including all items. However, there are some problems concerning the core measure. First, these measures are calculated with the assumption that food and energy components contain no information about the long-run inflation trend, an assumption that might not hold. Second, the general public may be more familiar with headline inflation, as observed in countries like the Philippines. Third, in some countries like Brazil, core measures have not been able to forecast the trend in headline inflation. Since headline inflation indicates the cost of living, which affects welfare, most central banks target this measure, using core inflation as a supplementary indicator for internal use. One notable exception is the Bank of Thailand, which targets core inflation. According to Cecchetti, there may be adequate justification for this policy, since in most modern macroeconomic models such as the New Keynesian model, monetary policy affects real variables because of price rigidity and flexible prices such as those of items like food and energy are of no consequence. Contrary to Mishkin’s view, Cecchetti notes that if the target horizon is greater than one or two years, it should not matter whether the central bank targets headline or core inflation.

2.2 True Measures of Inflation

The second issue is related to the question of whether WPI or CPI inflation should be targeted by central banks. This is a pertinent question as, before deciding the target for inflation, one has to ascertain which measure reflects the movement of prices more accurately. Like most of the economies, India shifted from the WPI to CPI as the key measure of inflation in 2014. Patnaik,

Shah and Veronese (2011) consider the advantages and deficiencies of three possible measures of inflation viz. WPI, GDP deflator and CPI. They conclude that despite certain deficiencies, CPI for Industrial Workers (CPI-IW) should be prioritized by the RBI as the inflation target for various reasons; first, it measures the consumption bundle of households and is therefore more relevant than the other sources. Second, it reflects the food-price movements accurately. Third, it includes the prices of services (which is excluded in all other measures) and fourth, it has a large share of non-tradeables, over which monetary policy has significant influence.

In the literature, most of the studies focus on consumer prices and try to find out how much appropriate it is in measuring the movement of general level of prices and whether it is appropriate for central banks to target this measure as the target of their monetary policy. For example, Cecchetti (1996) points out that commonly used index CPI contain both transitory noise and bias. While noise causes short-run changes in measured inflation to inaccurately reflect movements in long-run trends, bias leads to the long-run average change in the CPI to be too high. Sources of noise include varying seasonal patterns, changes in exchange rates and indirect taxes, whereas the biases arise from weighing schemes, sampling techniques and quality adjustments made in calculating the price index. For example, when the relative prices change, expenditure on relatively more costly commodities fall. But since CPI, having weights that do not vary with such relative price changes, will show an increase in the aggregate price level even when not an actual one has occurred. The author proposes a method of noise reduction by average monthly inflation in measures called 'trimmed means' over longer horizons.

2.3 Inflation Targeting

The third strand of literature we discuss here is about the lessons and experiences of inflation targeting as a tool of monetary policy. Inflation targeting (IT) is a policy of the central bank of meeting publicly announced targets for the inflation level. Ball (1999) observes that in an open economy, inflation targeting can be dangerous because of the effects of exchange rates on inflation through import prices. This is the fastest channel from monetary policy to inflation, and inflation targeting implies that this channel is used aggressively. Large shifts in the exchange rate produce large fluctuations in output. However, he also points out that while pure inflation targeting has undesirable effects, a modification of targeting “long-run” inflation produces much better outcomes. This variable is not influenced by the exchange-rate-to-import-price channel, and so targeting it does not induce large exchange rate movements. Targeting long-run inflation is not exactly equivalent to the optimal instrument rule, but it is a close approximation for plausible parameter values.

IT was introduced in New Zealand and Chile in 1990, Canada in 1991 and the United Kingdom in 1992 [Neumann and von Hagen (2002)]. Schaechter, Stone, and Zelmer (2000) have counted 13 countries with IT experience till February 2000, viz. Australia, Brazil, Canada, Chile, the Czech Republic, Finland, Israel, New Zealand, Poland, South Africa, Spain, Sweden, and the United Kingdom. Thailand, Korea, Hungary and Switzerland have subsequently been added to this list. Thus, IT has gained significant popularity among the central banks of countries around the world, and consequently, literature aimed at examining the efficacy of this policy has also expanded rapidly in the past few years. But, the evidences on country experiences are mixed.

Neumann and von Hagen (2002) observe that IT has reduced short-term variability in central bank interest rates and in headline inflation implying that IT has caused central banks to

focus less on short term changes and more on adopting a stable monetary policy. Moreover, in order to describe central bank policies by estimating Taylor rules, they observe that central banks have changed their reaction to output and inflation following the adoption of inflation targeting. In addition to that, using an event study approach to compare the performance of inflation targeting and non-targeting central banks under two similar exogenous shocks, viz. the oil price hikes of 1978 and 1998, they observe that IT countries realized a credibility gain in the second episode compared with the first, allowing them to keep interest rates lower and face these shocks with a much less contractionary monetary policy. They have concluded that adopting this policy has permitted IT countries to reduce inflation to low levels and to curb the volatility of inflation and interest rates. However, they have found no evidence to suggest that IT is superior to strategies that focus on monetary aggregates.

Ball and Sheridan (2004) have examined twenty OECD countries with widely varying economic performances, of which seven had adopted inflation targeting during the 1990s and thirteen had not. On average, they found no evidence to suggest that IT improved economic performance with regard to either persistence of inflation, output growth or interest rate lowering, i.e. while economic performance of these has changed over time, the change is similar for IT and non-IT countries.

Let us now turn to the issue of how the experience with IT may be different for developing countries vis-a-vis advanced economies because of their fundamental differences. Calvo and Mishkin (2003) have outlined ways in which emerging market economies differ from advanced economies, e.g. in terms of the quality of fiscal and financial institutions, credibility of monetary institutions, currency substitution and liability dollarization and vulnerability to sudden stops in capital inflows. While both emerging market economies (EMEs) and advanced economies face

these problems, the degree of these problems is much greater for EMEs. Mishkin (2004) observes that inflation targeting “entails much more than a public announcement of numerical targets for inflation for the year ahead” and it is an institutional commitment to price stability, a strategy where many variables in addition to the monetary aggregates and exchange rates are used for deciding the set of policy instruments, increased transparency of monetary policy strategy and increased accountability of the central bank. Mishkin (2004) argues that IT can be an effective tool for EMEs if they focus on building strong fiscal, financial and monetary institutions. He has particularly focused on the experiences of Chile and Brazil with regard to IT. Chile has experienced tremendous success with IT by achieving rapid economic growth of around 6% per year over the period from 1991 to 2004, as well as lowering inflation level from above 20% to around 2% over this period. However, this achievement has been made possible through a significant improvement in its institutions. Brazil adopted IT in June 1999. Although it did not undertake significant reforms to its financial or monetary institutions, it seemed to benefit from IT. The initial inflation targets were set at 8% for 1999, 6% for 2000 and 4% for 2001, with a tolerance range of 2%. Inflation in 1999 reached 8.9%, but remained within the tolerance range and it fell to 6% in 2000. However, it rose to 7.7% in 2001, exceeding the tolerance range. In the run-up to the presidential election, there was a loss of market confidence and inflation shot up to 12.5%, substantially exceeding the target of 3.5% for 2002. These experiences show the importance of stable and strong institutions for the success of IT in EMEs.

Fraga, Goldfajn and Minella (2003) show that successful implementation of IT in EMEs has been challenging compared to that in developed economies because of the volatility of macroeconomic variables like output, inflation, exchange rate, interest rate and weaker institutions and credibility in these countries. Azad and Das (2014) hold much harsher views regarding the

efficacies of IT in developing countries. They consider five such countries: Bangladesh, India, Nepal, Pakistan and Sri Lanka. They conclude that while IT may be an effective policy instrument in advanced economies, it is not only ineffective in developing economies because of the likeliness of their Phillip's curves to be horizontal (rather than vertical), but it additionally imposes significant difficulties on the working population of these countries.

2.4 Studies on Inflation in India

The existing literature on inflation related to India has been considerably critical of the IT policy proposed and adopted by the RBI recently. In India, inflation targeting was presented by the Urjit Patel Committee set up by the RBI in 2014. It has subsequently been adopted in India by former RBI Governor Raghuram Rajan in 2016 as a means to keep price levels in check while boosting growth. Thus, currently India has targeted inflation at 4% (with an upper and lower limits of 6% and 2% respectively).

Jha (2008) states that given the widespread poverty level, incomplete financial liberalization, strong monopoly elements in the banking sector and high fiscal deficit among other issues, India is not prepared for IT and that monetary policy should focus on higher economic growth at least in the medium term. Kohli (2015) is of the view that the existing adverse domestic and global macroeconomic environment poses a considerable threat to the successful implementation of the transition to IT policies in India. An improved institutional framework is necessary for the effectiveness of IT policies, but possible significant output sacrifices may stand in the way of development of such a framework.

In his 2016 speech at the Tata Institute of Fundamental Research (TIFR), Raghuram Rajan states that given the costs of high inflation, developing countries face a dilemma when setting a

target level of inflation. While double-digit inflation is generally taken to be harmful, there is considerable confusion regarding the optimum level of single-digit inflation as well. While moderate levels of inflation e.g. 7 to 10 percent may not jeopardise overall growth levels, countries still prefer to set their targets at lower levels, since inflation affects different sections of population in different ways.

Nair (2013) identifies the soaring prices of two groups, viz. food and fuel as the major cause for persistence of high inflation in India between December 2009 and August 2013. While the high inflation rate of minerals and mineral oils can be explained by various factors such as volatility of global crude oil prices and domestic supply-side bottlenecks among others, the high food inflation is surprising given the promising domestic food supply situation and low global food prices. Rising domestic demand pressures have been cited as one of the possible reasons for the rising prices of six high-value food commodities, i.e. pulses, milk, egg, fish, meat and edible oil in recent years. Cost escalation has been cited as another possible reason for the high food inflation. This high food inflation rate is of the greatest concern to the masses, considering the existing high levels of poverty, malnutrition and household expenditure on food in India and it has serious detrimental effects on welfare.

Attempts have also been made to address the issue of diverging WPI and CPI inflation observed in India, which poses a problem with regard to policy formulation. According to Lingareddy (2016), the differences in composition between WPI and CPI in terms of products and their weights is responsible for the increase in divergence between them. Plummeting prices of petroleum and metals, which have larger contributions in WPI than CPI, as well as the sluggish transmission of the falling petroleum prices to the consumers, as manifested in the positive inflation rates of petroleum products in CPI, were responsible for the divergence. Moreover,

services with relatively high inflation rates have a weighted contribution of about 25% in CPI but negligible in WPI. While the food products group have exhibited similar positive trends in both indices, non-food manufactured products showed differing trends across the two indices. Finally, due to relatively small sample size in case of the former, it is observed that WPI-based inflation is more volatile than CPI-based inflation. Nadhanael and Pattanaik (2010) point out the scope for possible misleading inferences due to data deficiencies in the Indian context. Also, Raj and Misra (2011), in an attempt to find out an appropriate measure of inflation to be targeted by RBI, observe that non-food manufacturing prices that RBI uses as a measure of demand side pressures, is the only measure which satisfies all the properties of a core measure, a means to achieve low and stable inflation by serving as a short-term operational guide for monetary policy. Mishra and Roy (2011), on the other hand, analysed food price inflation using a disaggregated high-frequency commodity level dataset and find that food price inflation to be consistently higher than non-food, quite persistent, and having a significant pass-through to non-food inflation.

Given the numerous challenges facing economists and policy-makers in India with regard to the current high level of inflation, Rajan argues that a pragmatic rather than a doctrinaire approach is required in order to make a successful transition from high or moderate to low inflation levels. He notes that rather than a hands-off approach, adjustments need to be made in order to build stable institutions that result in sustained low inflation rates and positive real interest rates. This adjustment, while difficult in the short run, need to be continued since we are already making considerable progress as evidenced by the central bank's shift to a CPI based inflation target, and the setting up of an independent monetary policy committee.

At this backdrop, we estimate the relationship between price changes and other relevant macroeconomic variables by employing cointegration and vector auto regression.

3 Data and Methodology

3.1 Data

Since the interesting features of inflation is observed in the recent decade, the study is based on monthly data for the period of January 2006 to March 2016. In this study, keeping in mind the objective, the price index numbers that we have considered are Headline CPI (CPIHL), Core CPI (CPICORE), CPI Food (CPIFD), CPI Fuel (CPIFL), Headline WPI (WPIHL), Core WPI (WPICORE), WPI Food (WPIFD) and WPI Fuel & Power (WPIFP). Core WPI and Core CPI are calculated by stripping off the most volatile food and fuel components. The macroeconomic variables that we incorporate here is Money Supply (M3), GDP³, Agricultural GDP (GDPAG), non-agricultural GDP (GDPNAG), Exchange rate (EXCHRT). The choice of variables like money supply and GDP is quite obvious as they are directly linked to demand, monetary policy and thereby inflation. Exchange rate is included as the fuel price, one of the major fluctuating components of inflation, is closely related to exchange rate. Agricultural GDP and Non-agricultural GDP are taken separately to understand the relationship between the components of inflation, e.g. dual economy theories suggest that an increase in agricultural output has a favourable demand-side impact on the non-agricultural sector both directly and through a rise in the real income of workers. All the macroeconomic variables are then converted into an index with Jan 2006 as the base month with a value of 100. Then the logarithm of those indexed series and other price index series are taken for analysis. The data is sourced from Reserve Bank of India (RBI) Handbook of Statistics on Indian Economy, Office of the Economic Advisor, Government of India and National Informatics Centre (NIC) website.

³The monthly time series data on the three GDP variables have been constructed by repeating every quarterly value three times.

3.2 Methodology

For each of the sets of variables, viz. price-index numbers and macroeconomic variables, first presence of unit root in the data generating process of individual variables are tested by Phillips-Perron test. In this context, Zivot-Andrews test is also performed to detect the presence of any structural break in the data. If there is deterministic trend in the data, the time trend is removed, and then the stationarity of the residuals are checked; these are denoted as rCPIHL, rCPIFD and so on. In case of non-stationarity of these residuals, the first difference of these series are tested and they are denoted by drCPIHL, drCPIFD and so on, which are basically price changes, i.e. inflation for price variables and growth rate for money supply and GDP.

Next we divide the variables in groups to understand the relationship. Following are the 10 groups: (1) CPIHL, GDP, M3; (2) CPICORE, GDP, M3; (3) WPIHL, GDP, M3; (4) WPICORE, GDP, M3; (5) CPIHL, CPIFD, CPIFL, CPICORE; (6) WPIHL, WPIFD, WPIFP, WPICORE; (7) CPIFD, GDPAG, GDPNAG; (8) CPICORE, GDPAG, GDPNAG; (9) WPIHL, WPIFP, EXCHRT; and (10) WPICORE, WPIFP, EXCHRT. The first four groups are meant for exploring the relationship between WPI/CPI headline (core) inflations and the macroeconomic variables. Groups (5) and (6) are constructed to find out the relationship between own components of CPI and WPI separately. Groups (7) and (8) are taken to find out sectoral linkages and (9) and (10) focus on the role of fuel price and exchange rate.

From the figures 1, 2.1 and 2.2, some indication of co-movement may be observed. So, for each group, whether there exists any co-movement among the variables will be tested by employing Johansen cointegration test. If cointegration exists, in order to find out the adjustment process vector error correction models (VEC) will be estimated. If cointegration does not exist, their possible mutual dependence will be explored by vector autoregression model. However, if

the variables are not integrated of same order, Johansen cointegration technique cannot be applied and vector autoregression model (VAR) need to be estimated since price indexes and macroeconomic variables are simultaneously determined and one may influence the other with a few lags.

Table 2 summarizes the stationarity of the variables considered. It is tested with Phillips-Perron unit root test as well as Zivot-Andrews test incorporating the possibility of identification of structural breaks endogenously. It is observed that the order of integration is same for all the variables by both the tests, barring only two, viz. CPIFD and M3. In such cases, we take the results indicated by Zivot-Andrews test. For the variables with order of integration 1, we removed the time trend, if any, and the de-trended series are prefixed by r, i.e. rCPICORE, rCPIFL etc. Even after that, for some variables stochastic trend exists and they are still integrated of order 1 and in such cases, we take the first difference of the variables (e.g. drCPICORE, drCPIFL etc.) which are stationary. It is observed that in almost all the variables, breaks are identified either in 2008-09 or between middle of 2011 to middle of 2013, which means the breaks occur with the worldwide financial crises.

Now we consider the 10 groups of variables mentioned above. Since none of the variable groups are integrated of same order, we cannot go for cointegration. Instead we estimate VAR models for all the pairs.

Table 2: Summary of Stationarity Test Results									
Variable	ZA test statistic	ZA test critical value at 5% los	Order of Integration (ZA test)	Order of Integration (PP test, 5% los)	ZA Test breakpoints	Time-difference variable	Presence of UR (PP test 5%)	Difference of series created	Order of Integration
CPICORE	-4.51	-5.08	I(1)	I(1)	2009 M07	rCPICORE	I(1)	drCPICORE	I(0)
CPIFD	-5.08	-5.08	I(0)	I(1)	2009 M07				
CPIFL	-3.42	-5.08	I(1)	I(1)	2011 M05	rCPIFL	I(1)	drCPIFL	I(0)
CPIHL	-3.73	-5.08	I(1)	I(1)	2013 M06	rCPIHL	I(1)	drCPIHL	I(0)
EXCHRT	-3.36	-5.08	I(1)	I(1)	2012 M03	rEXCHRT	I(0)		
M3	-3.81	-5.08	I(1)	I(0)	2011 M05	rM3	I(1)	drM3	I(0)
WPICORE	-4.00	-5.08	I(1)	I(1)	2013 M07	rWPICORE	I(1)	drWPICORE	I(0)
WPIFD	-4.49	-5.08	I(1)	I(1)	2013 M06	rWPIFD	I(0)		
WPIFP	-3.78	-5.08	I(1)	I(1)	2013 M06	rWPIFP	I(1)	drWPIFP	I(0)
WPIHL	-3.88	-5.08	I(1)	I(1)	2013 M06	rWPIHL	I(1)	drWPIHL	I(0)
GDP	-5.53	-5.08	I(0)	I(0)	2012 M04				
GDPAG	-8.24	-5.08	I(0)	I(0)	2008M04				
GDPNAG	-5.85	-5.08	I(0)	I(0)	2011 M10				

4 Results

It may be noted that the ten sets of variables mentioned above have been specified with the objective of understanding the current inflationary process. In what follows, the results are presented in a somewhat classified manner, based on groups, as mentioned in the previous section. In each case, in the tables, only those variables which are significant in the VAR estimation, are presented.

Relevance of Macroeconomic Factors

Generally inflationary price rise is understood to be a macroeconomic phenomenon and indicators of overall excess demand like growth rates of GDP, narrow money and broad money are taken as its explanatory factors, where a direct linkage with inflation is expected. In the VAR

estimation, we include 3 lags since it is believed that the effect on inflation of money supply and GDP is not immediate, but happens with some lags. We considered a quarter⁴.

The results of the two groups of variables (CPIHL, GDP, M3) and (WPIHL, GDP, M3) are presented in Table 3 and two groups (CPICORE, GDP, M3) and (WPICORE, GDP, M3) are summarized in Table 4. From Table 3, it is observed that both CPI and WPI headline inflation are positively affected by past growth rates of money supply; but, while CPI headline inflation is affected by GDP, WPI headline is not. From Table 4, we observe that both CPI and WPI core inflation are also affected by past growth rates of money supply, but neither are explained by GDP. This indicates that the increase in GDP or income is affecting the CPI headline inflation through food and/or fuel prices. While the negative impact of money supply on core CPI seems interesting suggesting some explanations in terms of relative prices⁵, they have the usual positive influence on core WPI⁶.

TABLE 3: VAR estimation with Macroeconomic factors and Headline Inflation

	DRCPIHL	DRM3	GDP		DRWPIHL	DRM3	GDP
DRCPIHL(-1)	0.179374**	-0.178551*	-0.371633	DRWPIHL(-1)	0.365006***	-0.229684*	-0.601083
DRCPIHL(-3)	0.073421	0.047722	1.267013***	DRM3(-1)	0.160739**	-0.049262	-0.220872
DRM3(-3)	0.161259**	-0.235111***	0.205033	DRM3(-3)	0.131424**	-0.218563**	0.102829
GDP(-1)	-0.051223*	-0.018883	0.928449***	GDP(-1)	-0.012515	-0.017125	0.907516***
GDP(-3)	0.076222***	-0.021605	0.017516				

*** 1% level of significance, ** 5% los, * 10% los

⁴ We have also estimated VARs with more lags, but the results were not widely different in most of the cases.

⁵ This may imply that any increase in money supply leads to demand for food and/or fuel while they reduce demand for goods in non-food non-fuel segments. Or the results may be attributed to the higher weightage of food in CPI compared to WPI.

⁶ However, in Rakshit (2011), these factors fail to explain either headline or core WPI and CPI inflation. This is quite straightforward as WPI core consists of manufactured goods.

TABLE 4: VAR analysis with Macroeconomic factors and Core Inflation

	DRCPICORE	DRM3	GDP		DRWPICORE	DRM3	GDP
DRCPICORE(-3)	-0.11714	0.194733*	0.952157***	DRWPICORE(-1)	0.300477***	-0.111366	-0.895013*
DRM3(-2)	-0.146437*	-0.047656	-0.332133	DRWPICORE(-3)	0.200154**	-0.090687	-1.032787**
DRM3(-3)	0.087148	-0.207939**	0.043254	DRM3(-1)	0.164054***	-0.049963	-0.174826
GDP(-1)	-0.03888	-0.005956	0.937913***	DRM3(-3)	0.059546	-0.254094***	0.115888
				GDP(-1)	0.009462	-0.004669	0.899754***

*** 1% level of significance, ** 5% los, * 10% los

Relationship among Components of Inflation

In Table 5, the relationship between the components of inflation in two groups of variables (CPIHL, CPIFD, CPIFL, CPICORE) and (WPIHL, WPIFD, WPIFP, WPICORE) are estimated. We observe that past values of fuel inflation and food prices affect CPI headline inflation positively, while they do not have any influence on CPI Core which is positively affected by lagged values of headline inflation. CPI food price, on the other hand, depends on core inflation (negatively) and its past values positively. While this may indicate the possibility of some adjustment in demand from one component to the other, the (negative) explanation of fuel inflation in terms of corresponding food price inflation may not be acceptable as fuel prices in India is determined by supply forces and India is a price taker in the international market. prices are not autonomous in the Indian economy. From the right panel, it is observed that, apart from own past values, WPI headline inflation is explained by past values of core inflation positively and past food prices negatively. WPI Core inflation is explained by lagged values of headline inflation positively and by lagged food price and fuel price inflation negatively. The explanation by food price may not be acceptable⁷. Interestingly, WPI food price is not explained by anything other than its own past values; but, WPI fuel price inflation is explained positively by headline inflation and negatively by food prices, like fuel prices.

⁷ Rakshit(2011) observed explanation of CPI core inflation by CPI food inflation to be unacceptable as food prices are not autonomous.

TABLE 5: VAR Estimation on Components of CPI and WPI inflation

	DRCPICORE	DRCPIFL	DRCPIHL	CPIFD		DRWPICORE	DRWPIFP	DRWPIHL	RWPIFD
DRCPICORE(-1)	-0.430822**	0.111038	-0.243081	-0.551186**	DRWPICORE(-1)	-0.123802	-1.306242*	-0.449274	-0.328106
DRCPICORE(-2)	-0.286562*	0.216963	0.104747	0.118481	DRWPICORE(-3)	0.284233**	0.489087	0.280026*	0.261359
DRCPICORE(-3)	-0.258608**	0.160244	0.031395	0.28361	DRWPIFP(-1)	-0.103708*	-0.450105**	-0.132704	0.156454
DRCPIFL(-1)	0.009018	0.161122	0.156881**	0.186445	DRWPIFP(-2)	-0.131898**	-0.026728	-0.075661	0.06164
DRCPIHL(-1)	0.611409*	-0.282096	-0.135409	0.217816	DRWPIHL(-1)	0.66764**	3.305406***	1.187049***	0.311918
DRCPIHL(-3)	0.313032**	-0.209431	0.138543	-0.044921	DRWPIHL(-2)	0.573488*	0.367343	0.328757	-0.72884
CPIFD(-1)	-0.254971	0.142103	0.345646**	1.377933***	RWPIFD(-1)	-0.143708**	-0.627068***	-0.216706***	1.074583***
CPIFD(-2)	0.054043	0.286625	-0.338967**	-0.585352**	RWPIFD(-2)	0.037211	0.622304*	0.134366	-0.106979
CPIFD(-3)	0.201932	-0.427653**	-0.007731	0.202107	RWPIFD(-3)	0.116753*	0.03031	0.061744	-0.111997

*** 1% level of significance, ** 5% los, * 10% los

Relationship between CPI Food Price Inflation and GDP Components

In Table 6, the results of the estimated VAR for two groups of variables (CPIFD, GDPAG, GDPNAG) and (CPICORE, GDPAG, GDPNAG) are presented. The findings are similar to that in Rakshit (2011) in the context of non-agricultural GDP, i.e. it does not have any impact on CPI food prices. However, unlike Rakshit (2011) the findings indicate insignificance of agricultural GDP in explaining CPI food prices. On the other hand, CPI Core inflation is influenced by lagged non-agricultural GDP⁸. This is interesting since non-agricultural GDP cannot explain CPI food inflation, but explains core inflation. Even more interesting is the result that agricultural GDP has a positive impact on CPI Core, but not food and this implies the income from agriculture is spent on non-agricultural goods. The results also indicate a significant positive impact of agricultural GDP on non-agricultural GDP. This is in line with the dual economy theories that suggest that an

⁸ For first and third lags of non-agricultural GDP, the co-efficients of CPI Core inflation are negative and positive, respectively. If the conversion of quarterly GDP into monthly GDP by repeating the same quarterly value for 3 months are kept in mind, probably the third lag of non-agricultural GDP captures the pure effect of last quarter's GDP, while the first two lags consist of values from the contemporary quarter and the last quarter. One should, in that case, look at the positive effect of non-agricultural GDP on CPI Core inflation.

increase in agricultural output has a favourable demand-side impact on the non-agricultural sector both directly and through a rise in the real income of workers⁹.

TABLE 6: VAR Estimation with CPI inflation and Components of GDP

	CPIFD	GDPAG	GDPNAG		DRCPI CORE	GDPAG	GDPNAG
CPIFD(-1)	1.223634***	-2.406389**	0.256821*	DRCPI CORE(-3)	-0.070355	6.417108***	-0.448796**
CPIFD(-2)	-0.485868***	0.286262	0.263686	GDPAG(-1)	-0.003638	0.8545***	0.019173
CPIFD(-3)	0.184709**	2.986026**	-0.355901**	GDPAG(-3)	0.02117***	-0.684754***	0.152145***
GDPAG(-1)	-0.012177	0.622909***	0.011013	GDPNAG(-1)	-0.092498**	2.707773***	0.387978***
GDPAG(-3)	0.01204	-0.766169***	0.166653***	GDPNAG(-3)	0.099067***	-2.27664***	0.522572***
GDPNAG(-1)	-0.045793	1.436024**	0.339461***				
GDPNAG(-3)	0.061269	-2.145626***	0.38203***				

*** 1% level of significance, ** 5% los, * 10% los

Role of Exchange Rate in WPI Inflation

Table 7 presents the estimated VAR model with two groups of variables (WPIH, WPIFP, EXCHRT) and (WPICORE, WPIFP, EXCHRT). It is observed that exchange rate depreciation in previous 1 to 3 months is found to have an influence on WPI fuel price inflation. Here also, for different lags, signs are different; however, while positive relationship makes economic sense, depreciation of exchange rate reducing headline and fuel inflation observed in Table 7 is not justifiable. However, exchange rate depreciation has no impact on core WPI inflation.

⁹ It may be noted that barring the regression on GDPNAG, the signs of the co-efficients concerning GDPAG and GDPNAG with lags 1 and 3 have opposite signs and lag 2 is never significant. This is possibly due to the conversion of quarterly GDP data into monthly data by the adjustment already described. For details, see footnote 8.

TABLE 7: VAR analysis of exchange rate depreciation on WPI headline and core inflation

	DRWPIHL	DRWPIFP	REXCHRT		DRWPICORE	DRWPIFP	REXCHRT
DRWPIHL(-1)	0.349619***	0.653041**	-0.022952	DRWPICORE(-1)	0.318526***	0.869256***	-0.379331
DRWPIHL(-2)	0.127928	0.607641*	0.230369	DRWPICORE(-2)	0.102597	0.725159**	-0.323087
DRWPIHL(-3)	0.218405*	0.344607	-0.112444	DRWPICORE(-3)	0.215944**	0.327632	0.04773
DRWPIFP(-3)	-0.097669**	-0.243983**	-0.109424	DRWPIFP(-2)	-0.037932	0.075676	0.319028***
REXCHRT(-1)	0.024509	0.14183*	1.315839***	DRWPIFP(-3)	-0.029013	-0.188335**	-0.128767
REXCHRT(-2)	-0.097978**	-0.34812***	-0.435876***	REXCHRT(-1)	0.019771	0.225643***	1.288048***
REXCHRT(-3)	0.058233*	0.168682**	0.049895	REXCHRT(-2)	-0.040667	-0.393447***	-0.427168***

*** 1% level of significance, ** 5% los, * 10% los

5 Conclusion

The paper deals with a contemporary debate in the Indian economy regarding the monetary policy targets concerning inflation in the economy. It relates to the measure of price fluctuation to be targeted as well as the relationships among inflation and some macroeconomic variables in order to discern some useful insights for policy makers. The paper is based on monthly data from January, 2006 to March, 2016. The results point out to some significant observations concerning the monetary policy in India. Among the interesting observations, following are the significant ones. *First*, the movements of WPI and CPI and their headline and core counterparts are not explained by same set of variables, e.g. while both CPI and WPI headline and core inflation are influenced by money supply in the economy, the impact of GDP is observed only on CPI Headline inflation. *Second*, surprisingly, in an economy like India where agriculture has a lot of uncertainty, CPI food inflation is not explained by agricultural output. This probably points out to the insufficient increase in supply in matching the demand in agriculture, which in turn may imply the possibility of long run problems like structural bottlenecks or lack of productivity increase in agriculture. Moreover, agricultural GDP has a positive impact on core inflation. *Third*, In light of the fact that India has moved towards tracking CPI rather than WPI as a monetary policy target, it

may be observed that the determinants of CPI headline and core inflation are not same. So, it is important to look at both of them while formulating policies. *Fourth*, and the most interesting observation is that the relationship between the different components of inflation implies the possibility of some adjustment in demand from one set of goods to another, i.e. some adjustments in terms of relative prices which needs further exploration.

India has also moved for inflation targeting recently and whether this will be successful or not, cannot be assessed at this point of time. But, in order to look into the relationships of the prices of various goods in an economy, a possible extension of this paper is to analyse the movement of prices at a more disaggregated level following the theories of relative prices.

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