WORKING PAPER 18/2017

INFLATION IN INDIA: BEHAVIOR OF MAJOR COMPONENTS

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Kuala Lumpur, Malaysia

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February 2017

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Abstract

Understanding the effect of monetary policy (change in interest rate) on several sub-components of inflation, as some of them are believed to be dominated by other than demand-side dynamics, is important to analyze the effectiveness of monetary policy. VAR models, which are widely used to study monetary policy impulse, suffer from degrees of freedom constraints and hence, studying the behavior of several sub-components of inflation for monetary policy innovation using a standard VAR model may not be feasible. Taking advantage of the FAVAR method, in this paper we have extracted the impulse response functions for several important sub-components of wholesale price (WPI) inflation. The results show that even though most of the sub-components of WPI inflation behave as expected, for protein items' inflation and primary non-food articles' inflation, supply-side constraints are not as over-bearing as commonly perceived.

JEL Classification: E5, E31

Key Words: Monetary Policy Transmission, Factor-Augmented Vector Autoregression (FAVAR)

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By
S. Gangadaran

1. Introduction

Monetary policy framework and its operating procedure in India has evolved over time in consonance with the development in the financial sector and has recently moved to a flexible inflation targeting regime.

Under an inflation targeting framework, the expectations channel plays an important role in anchoring inflation. In India, the share of food in total household expenditure is high and inflation expectations are anchored by food inflation (Anand et al., 2014). It is argued that, to prevent inflation expectations, triggered by high food inflation, from getting more entrenched and feeding into an inflationary spiral, RBI should be proactive. The Central Bank, which pursues an activist monetary policy, requires at least an approximate understating of the effectiveness of monetary transmission in the country (Mishra et al., 2016).

Monetary policy measures taken by central banks influence inflation through the aggregate demand channel. However, high and persistent food inflation, due to supply-side constraints, gives rise to the debate on the relevance of monetary policy in influencing inflation in India. Identifying sub-components of inflation, which react to monetary policy and which do not respond to monetary policy, would help understand the monetary policy transmission.

Some components of inflation are driven by demand side factors while others are driven by other factors such administrated price, global factors, supply side constrains, etc. Due to this disparity among the sub-components of inflation, many central banks/literatures use measure of core inflation. While headline represents the general inflation measures such as consumer price index (CPI) or wholesale price index (WPI), core inflation excludes volatile parts, which are assumed to be not controlled by policy action. In the case of India, in general, the food and fuel part of inflation are identified as volatile components and hence excluded from headline inflation in calculating the core inflation. However, some of the sub-components of food and fuel may actually respond to monetary policy innovation while some of the other sub-components of the core parts may be irresponsive. Analyzing the sub-components of inflation for monetary policy shock would help in identifying which of the sub-components should really form part of core inflation.

We have used the vector autoregression (VAR) framework, employed by several literatures to measure the effect of monetary policy shock, to analyze the policy impact on different sub-components of WPI, especially the food component. However, the VAR typically uses a small number of variables to conserve degrees of freedom, which leads to – i) measurement of policy innovations likely to be contaminated; and, ii) impulse response can be observed only for the few included variables (Bernanke, Boivin and Eliasz (BBE), 2005). Analyzing monetary policy impulse of several sub-components of inflation using a standard VAR model may not be feasible. Instead, we have used four VAR models to analyze different sub-components. We have also used factor-augmented vector autoregression (FAVAR), which addresses the abovementioned deficiencies of VAR and compared the results. The value addition of this paper is that it analyzes the monetary policy impact on inflation at sub-components level for India using an FAVAR model. The key findings emerging from the study are that most of the sub-components behave on the expected line to a monetary policy shock. However, inflation of protein items and primary non-food articles which are, in general, believed to be dominated by supply-side constrains shown significant response to the monetary policy shock.

The rest of the paper is organized into four sections. The VAR and FAVAR methodologies are briefly discussed along with data and sample period in Section 2. Using descriptive analysis of WPI inflation and its components, stylized facts are presented in Section 3. Section 4 presents findings from the VAR and FAVAR models while Section 5 provides the conclusion.

2. Methodology, Data and Sample Period

2.1 Methodology

2.1.1 VAR Model

For the base model, we have used a three variables VAR model based on the following simple macroeconomic model in the new Keynesian tradition which consists of three equations.

$$\pi_t = \beta_1 \pi_{t-1} + \beta_2 y_{t-1} + \varepsilon_\pi \quad (1)$$

$$y_t = \delta_1 y_{t-1} + \delta_2 (i - \pi)_{t-i} + \varepsilon_y \quad (2)$$

$$i_t = \gamma_1 i_{t-1} + \gamma_2 y_{t-1} + \gamma_3 \pi_{t-1} + \varepsilon_i \quad (3)$$

where π is inflation, y is the output, i is nominal policy rate and ε_π, ε_y and ε_i are residuals.

In general, for k endogenous variables with p lags, the standard VAR model specification is as follows:

$$Y_t = \gamma 0 + \gamma 1 Y_{t-1} + \gamma 2 Y_{t-2} + \cdots + \gamma p Y_{t-p} + U_t \text{ for t = 1 to T} \qquad (4)$$

where $Y_t = \begin{pmatrix} y1_t \\ y2_t \\ \vdots \\ yk_t \end{pmatrix}, \gamma 0 = \begin{pmatrix} \beta 10 \\ \beta 20 \\ \vdots \\ \beta k0 \end{pmatrix}, \gamma i = \begin{pmatrix} \beta^1 1i & \cdots & \beta^k 1i \\ \vdots & \ddots & \vdots \\ \beta^1 ki & \cdots & \beta^k ki \end{pmatrix} and U_t = \begin{pmatrix} u1_t \\ u2_t \\ \vdots \\ uk_t \end{pmatrix}$

The error terms U_t is uncorrelated with all variables dated (t-1) and earlier.

In our base model, Y_t consists of three variables *viz.* inflation (WPI), output (IIP) and policy rate (weighted average call money rate). Each equation in the system can be estimated using OLS as Y_t is defined as the function of its own lags and lags of other endogenous variables. The impact of monetary policy innovation can be extracted using a Choleski decomposition with appropriate ordering of variables. In our case, we have ordered output first followed by inflation and interest rate.

In addition to above three variables, to get the impact of policy innovation on the sub-components of WPI inflation, we have to add variables on the disaggregated WPI level. However, as the VAR cannot accommodate more than six/seven variables due to the degrees of freedom constrain, we have used three more VAR models. Along with the three variables in the base model, we have taken major components of WPI for the first model, major volatile components of WPI for the second model and important components food inflation for third model.

2.1.2 FAVAR Model

If Y_t in (4) contains some, say k_2, unobserved factors along with k_1 observable variables of primary interest, then the system is known as FAVAR and the equations given in (4) cannot be estimated directly. Unobserved factors can be thought of representing the diffusion index capturing essence of dynamics of other than included variables. Accordingly, let us assume that there are N additional observable variables x_1, x_2, x_3 …x_N (other than k_1 observable variable y_1, y_2 …y_{k1} and N may be more than T, the number of time periods) tracked by policy maker and they are related to the unobservable factors y_{k1+1}, y_{k1+2},…y_{k1+k2} and observable variable y_1, y_2 …y_{k1}as follows:

$$X_t' = \Lambda^f Y^{2'}_t + \Lambda^y Y^{1'}_t + e_t' \text{------(5)}$$

where X_t is T x N matrix of additional observable variable, Λ^f is N x k_2 matrix of factor loading, Y^2_t is T x k_2 matrix of unobservable factors, Λ^y is N x k_1 matrix, Y^1_t is T x k_1 matrix of observable variable of primary interest.

Now one can estimate (4) using Y^2_t estimated from (5). BBE have proposed two approaches for estimating (4) and (5). In this paper, we have adopted the second approach i.e., the single step Bayesian likelihood approach. For more details regarding FAVAR and the Bayesian likelihood approach, please refer to BBE. We have used the Rats Program developed by BBE.

2.2 Data and Sample Period

For this study we use data sourced from the Reserve Bank of India (RBI) article on "Monthly Seasonal Factors of Select Economic Time Series" which analyze seasonal factors of 84 economic/financial time series covering five broad sectors (viz., monetary and banking aggregates, price, industrial production, external trade and services sector). The monthly data used cover the period April 2006 to March 2016. We have used the data series related to price, index of industrial production (proxy for output) and monetary and banking aggregates (as other relevant variables) for the present analysis. The list of the variables included in the analysis is given in Annexure 1. Along with these selected variables, we have taken the following variables also:

1. Back casted monthly CPI index - officially CPI have been adopted as inflation measure for targeting. Even though the objective of this paper is to analyze the sub-components WPI, checking the response of CPI for policy innovation would help in model selection.
2. Weighted average call money rate (WCMR) - used as a proxy for the policy rate as it has tended to trace the effective policy rate - repo rate or reverse repo rate - as the case may be depending upon the liquidity condition (Khundrakpam, 2012).

All the variables are seasonally adjusted, made stationary by calculating the first order difference of the log of the seasonally adjusted variables and then standardized by subtracting the mean and dividing by the standard deviation. In the case of the weighted average call money rate, as it is already in rate form, the first order difference was not taken. In the multiple indicators approach regime, which dominates our sample period, the main price variable was WPI. Hence, we analyze WPI instead of CPI, the current inflation measure targeted by RBI.

3. Stylized Facts

In this section, we present the movement and descriptive statistics of the different components of WPI. For this purpose, we examine the sub-components at the following three levels. At first level, we consider the following major components of WPI which constitute the volatile part and core part of the inflation.

3.1 Volatile Part

1) Primary articles inflation: considered as volatile component, so excluded from core inflation.

3.2 Core Part (Three Measures)

2) Manufactured products inflation: Core inflation 1.
3) Non-food manufactured products inflation: In addition to primary articles, food product which are coming under manufactured product are also considered as volatile, so the same is excluded from core inflation 1 - Core Inflation 2.
4) Non-food non-fuel inflation: WPI inflation excluding food and fuel inflation - Core Inflation 3).

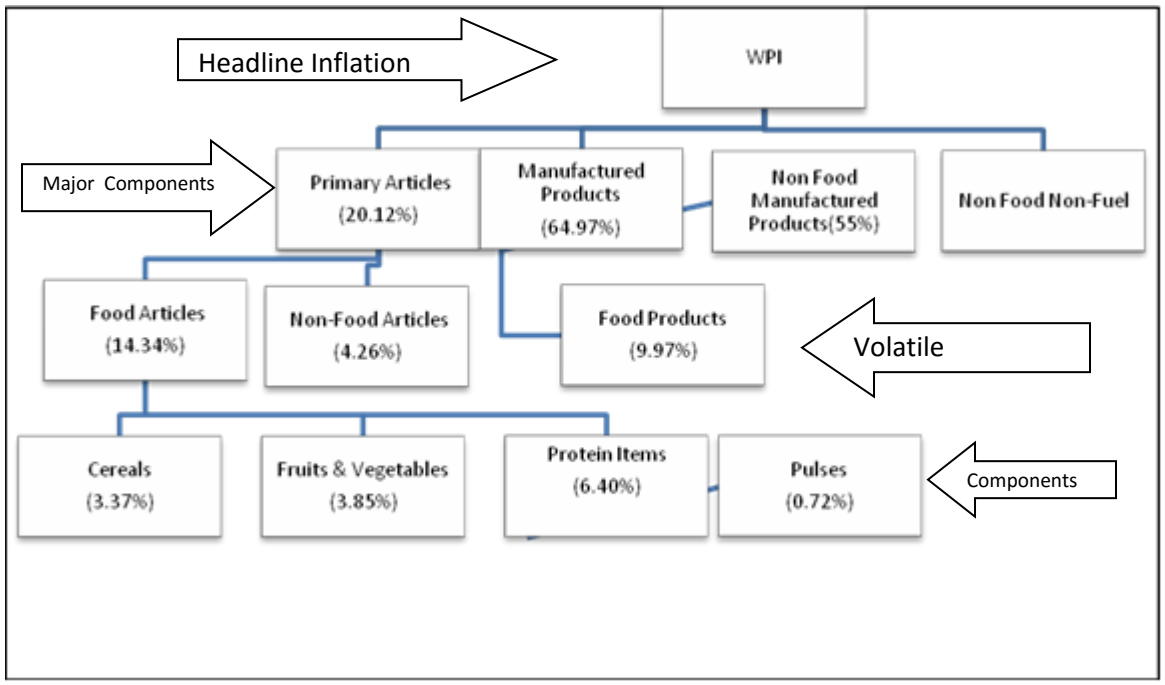
At second level, we consider following major volatile components of WPI which are excluded to calculate core inflation.

1) Primary food articles inflation: First major sub-component of primary articles inflation.
2) Primary non-food articles inflation: Second major sub-component of primary articles inflation.
3) Manufactured food product inflation: Major volatile part of Manufactured Products Inflation.

At third level, we consider following important components of primary food articles inflation.

1) Cereals inflation.
2) Fruits and vegetable inflation.
3) Protein items inflation.
4) Pulses inflation: Even though, this is the part of protein items, we have considered it separately because of its recent high inflation.

The following diagram presents all the WPI components analyzed in this paper, in hierarchical order.



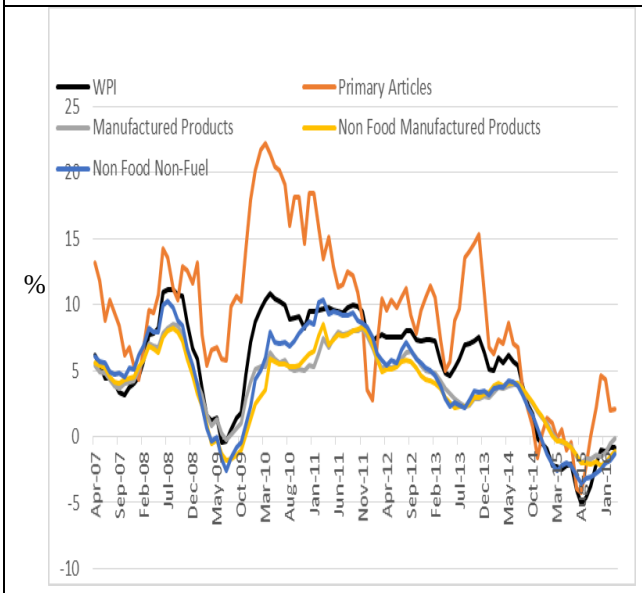
At the major component level, we analyzed the behavior of primary articles inflation vis-à-vis other major core components. Descriptive statistics, such as average, standard deviation and correlation with headline WPI inflation, of major components of inflation during April 2007 to March 2016 given in Table 2, show that both the mean and volatility of primary articles inflation was higher than the other major components. As expected, all the alternative core inflation measures, though a little lower in magnitude, mimic movement in headline WPI and have a high correlation with WPI inflation (Chart 1.a and Table 1). Even though the correlation of primary articles inflation with WPI inflation is high at 0.8, it is lowest among the major components.

At the major component level, primary articles inflation emerges as the most volatile component but its high correlation with WPI inflation gives the indication that some portions of primary articles inflation follow the movement of WPI.

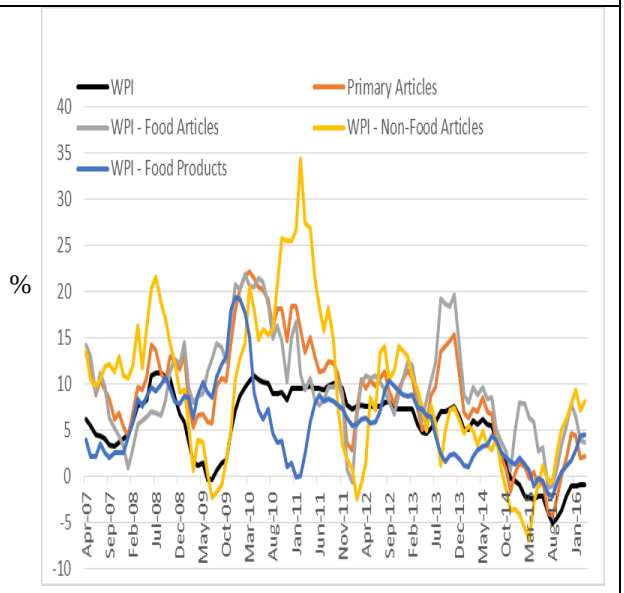
Chart 1

WPI Inflation and its Components (Year on Year)

(a) Major Components



(b) Major Volatile Components



(c) Important Components of Food Inflation

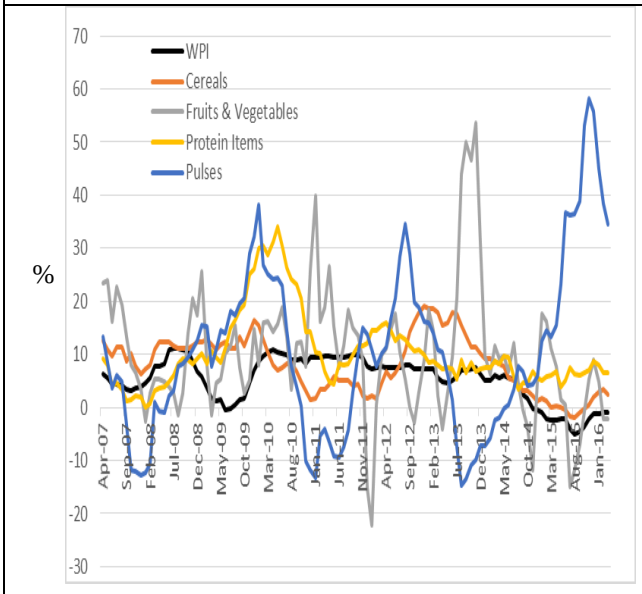


Table 1

Descriptive Statistics of WPI Inflation and its Components

	Mean (in % per annum)	Standard Deviation	Correlation with WPI headline inflation (Descending order)
WPI Headline Inflation	5.35	4.19	1.00
Major Components			
Non-food Non-fuel	4.17	3.88	0.93
Manufactured Products	3.99	2.75	0.93
Non-food Manufactured Products	3.68	3.02	0.88
Major Volatile Components			
Primary Articles	9.22	5.86	0.82
Non-food Articles	9.16	8.20	0.70
Food Articles	9.66	5.30	0.51
Food Products	5.69	4.35	0.45
Important Components of Food inflation			
Cereals	8.22	5.30	0.38
Protein Items Group	10.37	7.18	0.36
Fruits & Vegetables	10.20	12.21	0.35
Pulses	10.54	15.96	-0.44

At the next level, i.e., major volatile components of WPI, the general expectation is that all these components should have high inflation and volatility and low correlation with the WPI inflation. However, only one component i.e., primary food articles inflation has all these on expected lines. Manufactured food product inflation, as it is a part of manufactured products inflation, has low inflation impact and volatility but surprisingly, has very low correlation with headline inflation. On the other hand, primary non-food articles, with high inflation rate and volatility, have very high correlation with WPI inflation (Chart 1.b and Table 1).

Finally, we checked some important components of primary food articles inflation such as cereals, fruit and vegetables and protein items. We have also included pulses, which is a part of protein items, as it is the main driving factor of the recent high food inflation. As expected, all these components have high inflationary impact and volatility and low correlation with WPI inflation. However, cereals inflation and volatility is relatively low among the group (Chart 1.3 and Table 1).

4. Empirical Findings of VAR and FAVAR

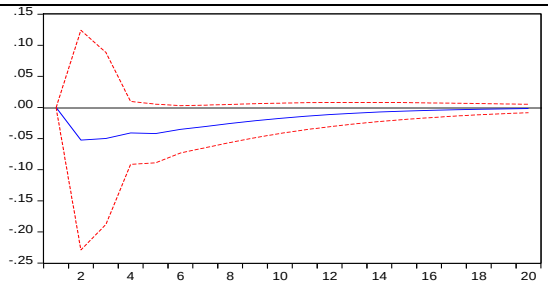
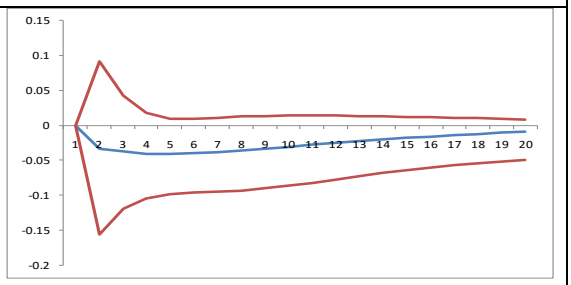
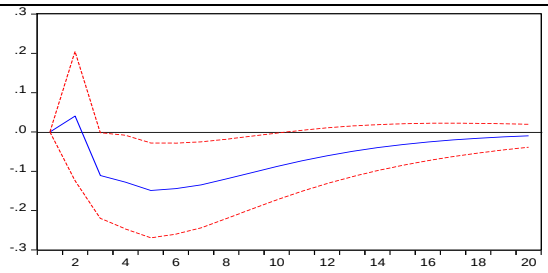
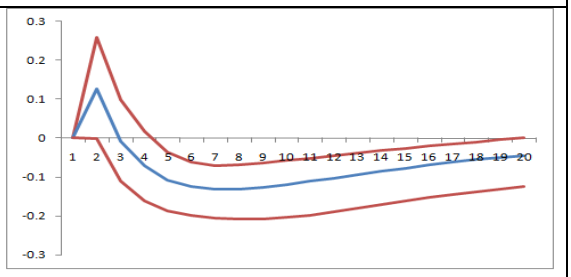
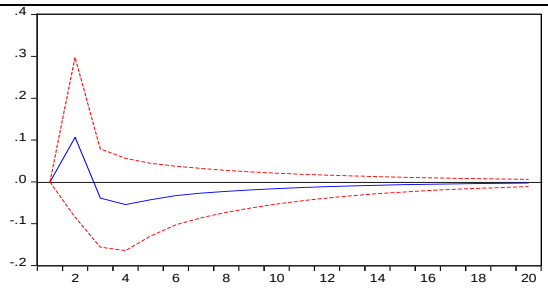
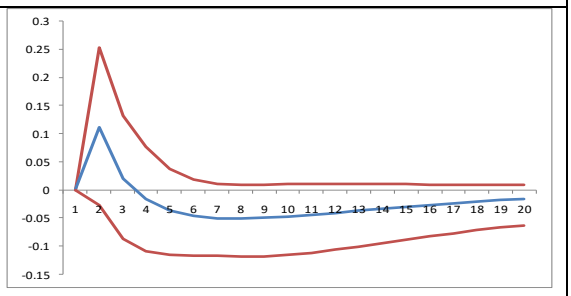
As mentioned in the methodological section, we have used four VAR models along with a FAVAR model. The base VAR model has three variables. Other three VAR models have the three base variables along with the components of WPI at different levels as given in the stylized facts section. Each VAR model was checked for lag length criteria. Almost all criterions in all the four models suggest for one lag. However, for the base model: i) The Lagrange multiplier (LM) test at 1 lag suggests that the residuals are serially correlated; ii) even though the lag exclusion test do not suggest 2 lags, residuals become serially uncorrelated when we use 2 lags; iii) similarly, when we use 2 lags, the impulse response functions (IRF) are smooth and consistent with the literature; iv) the IRFs become more oscillating if we use more than 2 lags. Based on these observations, we use 2 lags for all the four models. For generating the IRFs, we have ordered IIP first followed by WPI and the weighted average call money rate in the base model. For the remaining three models, we have placed the WPI components between IIP and WPI.

In case of FAVAR model, the single step maximum likelihood approach with Gibbs sampling suggested by BBE is used to extract the IRFs of the different sub-components of WPI inflation. For the FAVAR model, we have used one observable variable i.e., the weighted average call money rate and one unobservable factor, derived from 63 time series (given in the Annexure), using one lag in factor loading. Based on the VAR models, for the FAVAR model we have also assumed 2 lags. However, we experimented with several options for the number of lags, number of unobserved factors and lags for factor loading but found that either they generate oscillating IRFs or they do not converge. We assumed that price and IIP variables are slow moving variables following BBE.

First, we compared the IRFs of IIP, WPI and CPI of FAVAR with that of the base VAR model. Chart 2 shows that in both the cases, IRFs of IIP and CPI are not significant and the IRF of WPI is significant. As monetary policy innovation influence inflation through output, in general, it is expected that in India, monetary policy shock affect output with a lag of 2 to 3 months and takes 5 to 6 months to influence inflation. Supporting this expectation, the peak response (decline) in the IRF of WPI of the FAVAR model is observed in the 7^{th} month with significance up to 20 months and cumulative response of 1.4 SD. As these results are broadly on the expected line and are in agreement with the findings of several literatures, we move to the major component level.

Chart 4

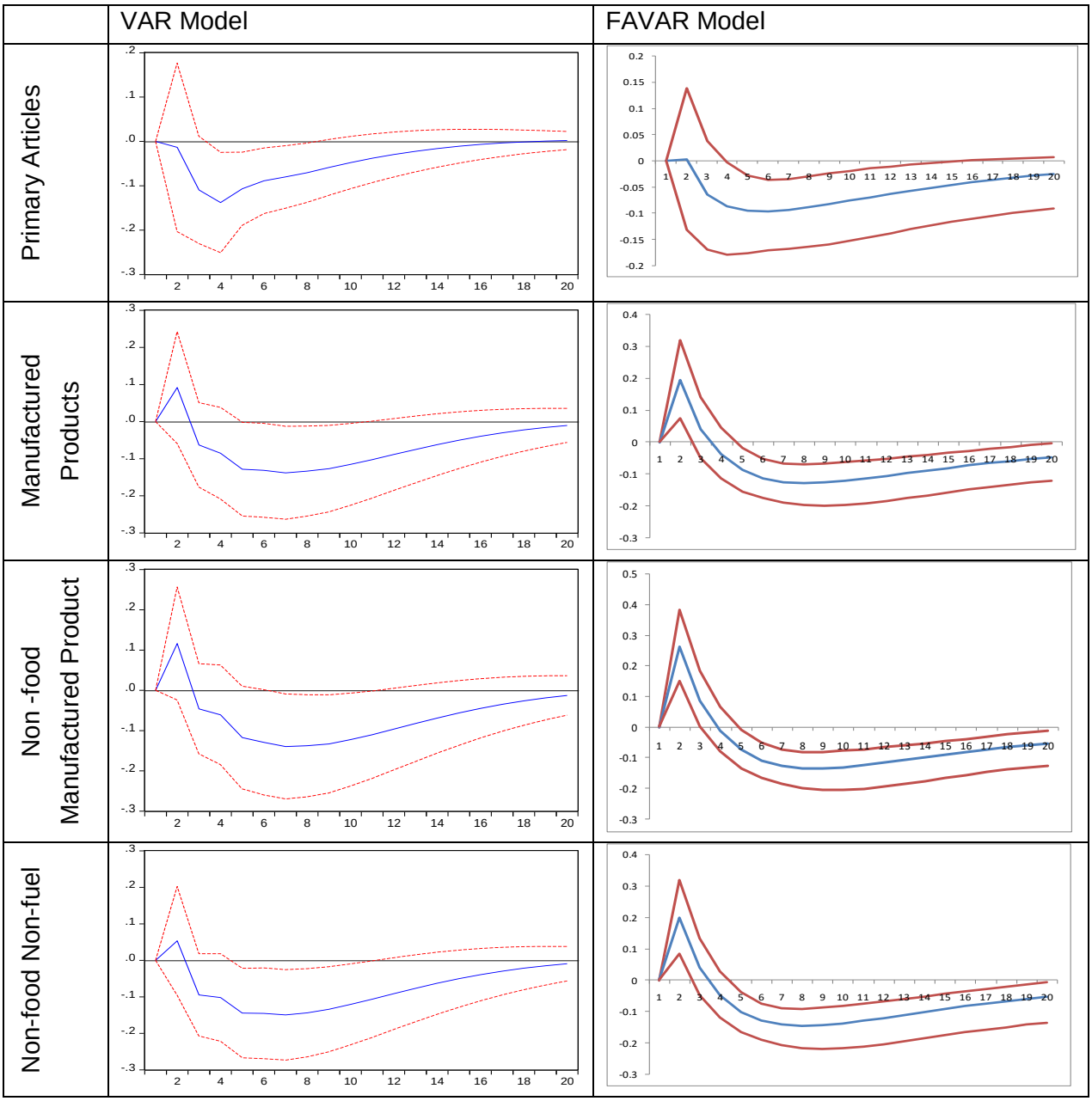
IRFs of IIP, WPI and CPI for 1 SD Shock to Weighted Average Call Money Rate

	VAR Model	FAVAR Model
IIP		
WPI		
CPI		

At the major component level, consistent with theory and general belief, both the models show that all the three alternative core inflation measures respond to a tightening of monetary policy significantly. In case of FAVAR, the impact of 1 SD shock in policy rate was significant for all the three alternative measures of core inflation for more than 20 months with the peak response ranging from 7 to 9 months. The cumulative response of non-food non-fuel inflation to 1 SD shock to policy rate was high at 1.5 followed by manufactured products inflation at 1.28 and non-food manufactured products inflation product at 1.23. Interestingly, primary articles inflation, against the general belief that it does not react to monetary policy due to the domination of supply-side factors, react to monetary policy innovation significantly for about 15 months, with the peak response at the 6th month and cumulative impact of 0.97. This supports our suspicion that some of the sub-components of non-core inflation may respond to monetary policy innovation against the general impression that non-core inflation is volatile and hence do not react to monetary policy shock.

Chart 3

IRFs of Major Components of WPI for 1 SD Shock to Weighted Average Call Money Rate



To understand which component of non-core inflation react to monetary policy shock, we further explore the sub-components of primary articles inflation along with other volatile component of manufactured products inflation.

The results of the major volatile components reveal that among primary articles inflation, which is considered as non-core inflation, primary non-food articles inflation decline to an increase in policy rate significantly up to more than 20 months with the peak response at the 7th

month and cumulative response of 1.09. In line with general expectation, the response of primary food articles inflation and manufactured food product inflation to monetary policy shock is insignificant.

Chart 4

IRFs of Volatile Components of WPI for 1 SD Shock to Weighted Average Call Money Rate

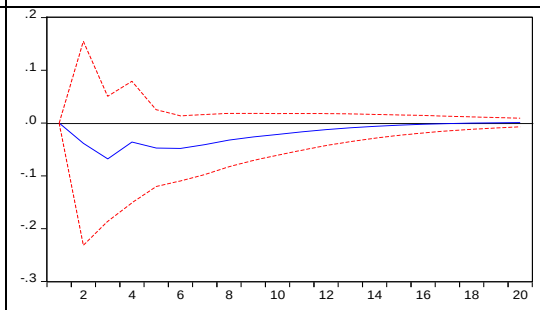
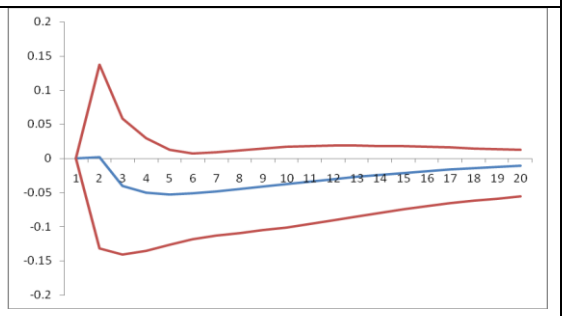
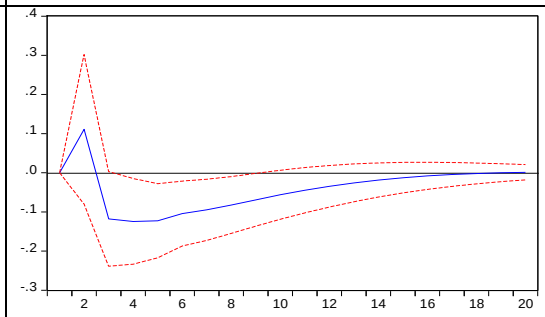
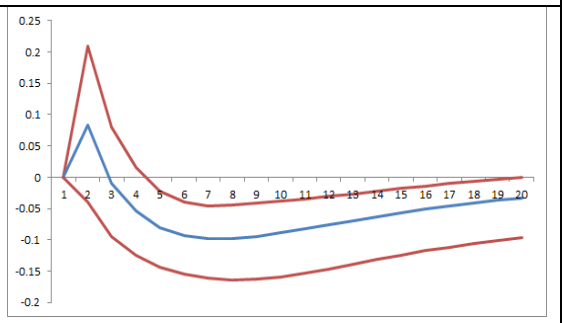
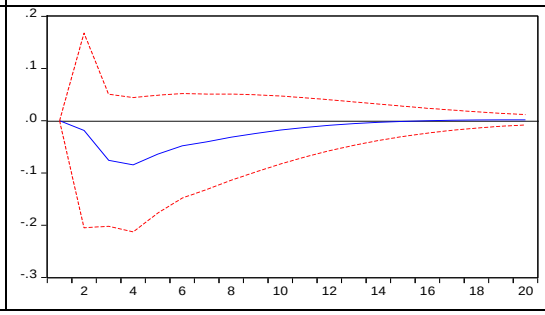
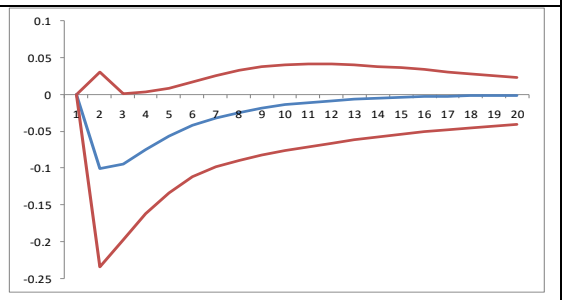
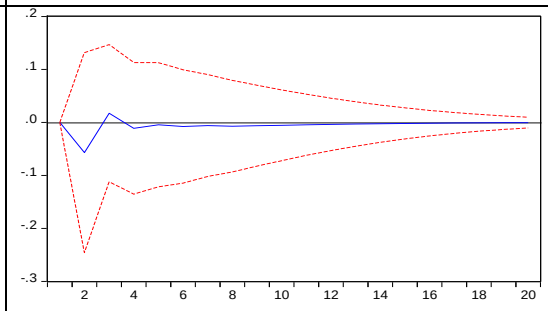
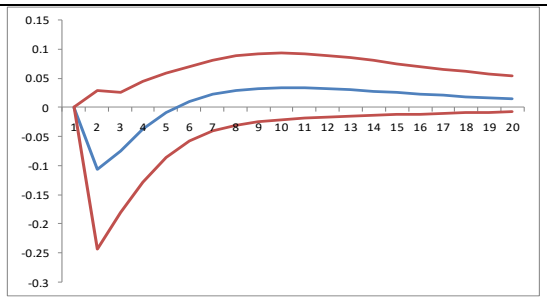
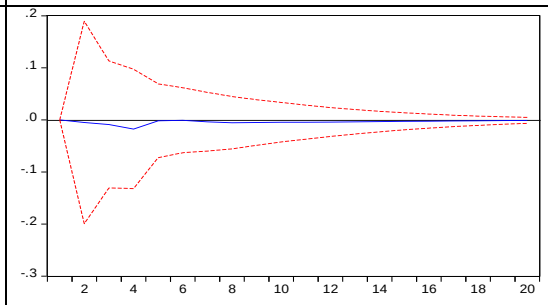
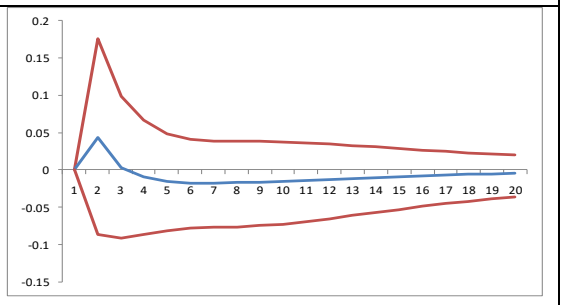
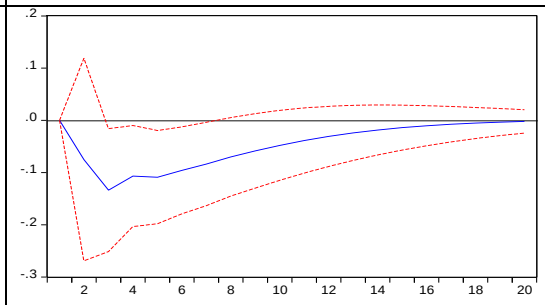
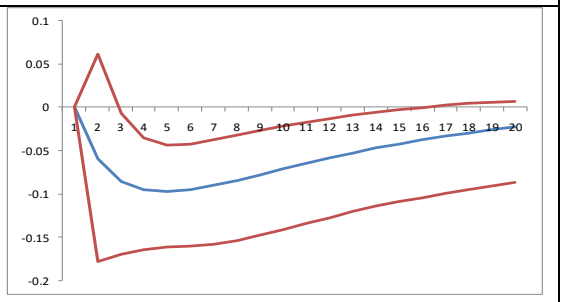
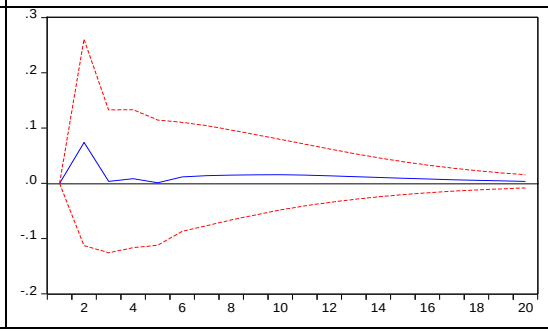
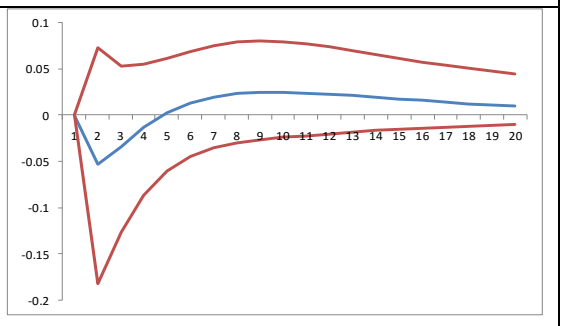
	VAR Model	FAVAR Model
Primary Food Articles		
Primary Non -food Articles		
Manufactured Food Products		

Chart 5

IRFs of Important Components of Food Inflation for 1 SD Shock to Weighted Average Call Money Rate

	VAR Model	FAVAR Model One
Cereals		
Fruits & Vegetables		
Protein Items		
Pulses		

The IRFs of important components of primary food articles inflation ascertain our doubt that not all the components of food inflation are by supply side constrain. Even though, as expected, cereals inflation, fruits and vegetable inflation and pulses inflation do not react significantly to a one SD shock in policy rate, protein items inflation decline significantly up to 16 months with the peak response in the 5th month and cumulative impact of 1.06.

In sum, the IRF of the WPI sub-components for monetary policy innovation show that the behavior of several components is on the expected line. The inflation in the components such as manufactured products, non-food manufactured products and non-food non-fuel are expected to have significant demand-side impact and hence are expected to decline to an increase in the policy rate. On the other hand, primary food articles inflation and its components, cereals inflation and fruits and vegetable inflation are expected to be mostly driven by supply-side constraints and are not expected to be impacted by monetary policy innovation. The IRFs of these components to a shock in policy rate, also suggest the same, as they are not significant.

Surprisingly, some of the sub-components, which are, in general, considered as volatile and hence excluded the construct of the core inflation *viz.* primary non-food articles inflation and protein items inflation, are significantly influenced by monetary policy. Primary non-food articles mostly comprise of intermediate goods used in manufacturing products. The significant impact of the manufactured product inflation, for monetary policy innovation, likely get transmitted to primary non-food articles. Hence, primary non-food articles inflation is more demand driven than supply driven.

Protein items may be considered as substitute goods. When household income increases, people shift to healthy food items and hence, there is an increase in the consumption of protein goods. During the tight monetary policy regime, due to demand side constraint, households may substitute protein items with their original food item, which would lead to a decline in the demand for protein items and result in decline in protein items inflation.

5. Conclusion

To frame an effective monetary policy, understanding the behavior of inflation to monetary policy innovation is vital. Analyzing the behavior of several sub-components of inflation measures in a single model using the VAR is constrained by the problem of the degrees of freedom. The analysis of behavior of the different sub-components of WPI using FAVAR reveals that the sub-components of WPI *viz.,* non-food articles inflation and protein items inflation, which are excluded for calculating the core inflation, show significant influence from monetary policy. These components show prolonged dominance of demand side impact so they have to be ascribed as core inflation rather than volatile components.

Analysis can be improved by including additional macroeconomic variables to address the prize puzzle and taking sub-components of CPI.

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Annexure-I

Sr. no	Series
Price Variables	
1	B. WPI (Base: 2004-05=100) All Commodities
2	B.1 WPI - Primary Articles
3	B.1.1 WPI - Food Articles
4	B.1.1.1 WPI - Food Grains (Cereals+Pulses)
5	B.1.1.1.1 WPI – Cereals
6	B.1.1.1.1.2 WPI – Rice
7	B.1.1.1.1.1 WPI - Wheat
8	B.1.1.1.2 WPI - Pulses
9	B.1.1.2 WPI - Fruits & Vegetables
10	B.1.1.3 WPI – Milk
11	B.1.1.4 WPI - Egg, Meat and Fish
12	B.1.1.4.1 WPI – Egg
13	B.1.1.4.2 WPI – Meat
14	B.1.1.4.3 WPI – Fish
15	B.1.1.5 WPI - Protein Items (viz., Pulses, Milk, Egg, Meat and Fish) Group
16	B.1.2 WPI - Non-food Articles
17	B.1.2.1 WPI – Fibres
18	B.1.2.1.1 WPI - Raw Cotton
19	B.1.2.2 WPI - Oil Seeds
20	B.2 WPI - Manufactured Products
21	B.2.1 WPI - Food Products
22	B.2.1.1 WPI - Grain Mill Products
23	B.2.1.2 WPI - Sugar
24	B.2.1.3 WPI - Edible Oils
25	B.3 WPI – Non-food Manufactured Products
26	B.4 WPI – Non-food Non-fuel
27	C.1 Consumer Price Index for Agricultural Labourers (Base: 1986-87=100)
28	C.2 Consumer Price Index for Rural Labourers (Base: 1986-87=100)

29	C.3 Consumer Price Index for Industrial Workers (Base: 2001=100)
30	C.4 Consumer Price Index – combined (Back casted)
Output Variables	
31	D.2.1 IIP - Mining
32	D.2.2 IIP - Manufacturing
33	D.2.3 IIP - Electricity
34	D. IIP (Base 2004-05 = 100) General Index
35	D.1.1 IIP - Basic Goods Industries
36	D.1.2 IIP - Intermediate Goods Industries
37	D.1.3 IIP - Consumer Goods Industries
38	D.1.3.1 IIP - Consumer Durable Goods Industries
39	D.1.3.2 IIP - Consumer Non-Durable Goods Industries
40	D.2.2.1 IIP - Food products and beverages
41	D.2.2.2 IIP – Textiles
42	D.2.2.3 IIP - Wood and products of wood & cork except furniture; articles of straw & plating materials
43	D.2.2.4 IIP - Paper and paper products
44	D.2.2.5 IIP - Publishing, printing & reproduction of recorded media
45	D.2.2.6 IIP - Coke, refined petroleum products & nuclear fuel
46	D.2.2.7 IIP - Chemicals and chemical products
47	D.2.2.8 IIP - Rubber and plastics products
48	D.2.2.9 IIP - Other non-metallic mineral products
49	D.2.2.10 IIP - Basic metals
50	D.2.2.11 IIP - Fabricated metal products, except machinery & equipment
51	D.2.2.12 IIP - Motor vehicles, trailers & semi-trailers
52	D.2.2.13 IIP - Other transport equipment
53	D.3 Cement Production
54	F.1 Exports
Other variables	
55	Broad Money (M3)
56	Net Bank Credit to Government
57	Bank Credit to Commercial Sector

58	Narrow Money (M1)
59	Currency with Public
60	Notes in Circulation
61	Demand Deposits (SCBs)
Policy Variable	
62	Weighted Average Call Money Rate