WP-2021-011

Effectiveness of Expectations Channel of Monetary Policy Transmission: Evidence from India

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April 2021

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Abstract

We examine the efficacy of expectations channel of monetary policy transmission in India using survey-based expectations of households and professional forecasters in a Structural Vector Auto Regression (SVAR) framework. To analyse the fixed point between inflation and inflation expectations, we estimate how expectations shocks feed into the dynamics of macroeconomic aggregates. Second, we find the shocks affecting these expectations. Third, we estimate shocks influencing core inflation. SPF expectations shocks affect headline and food inflation and RBI projections. Petrol price shocks, RBI projection shocks and supply shocks (headline inflation) affect household inflation expectations. Food inflation affects expectations in the short run while core inflation has long-run influence. 3-month-ahead SPF forecasts are influenced by supply-side shocks, monetary policy shocks and RBI projections. Results are robust to alternative identifications. In the early years of flexible inflation targeting that we cover the main interaction was between SPF forecasts and RBI projections on to core. The fixed point was stable because the response of each variable was less than unity. The evidence indicates the expectations channel of transmission was more effective than the aggregate demand channel.

Keywords: Household Expectations; Survey of Professional Forecasters; Central Bank Communications; Expectations Channel; Structural Vector Auto Regression.

JEL Code: D83; D84; E52; E58

Acknowledgements:

We thank without implicating Mridul Saggar, Michael Debabrata Patra and his team for very useful comments on an earlier draft.

1. Introduction:

Conventionally, monetary policy influences output and inflation through aggregate demand, working through the interest rate, credit, asset prices and exchange rate channels. These channels transmit changes in the policy rate to the final targets (inflation and output). Mishkin (1995) gives a brief overview of the working of these traditional textbook channels. The onslaught of global financial crisis (GFC) in 2007-08 in the United States reduced the effectiveness of these channels, especially in the countries with near zero lower bound (ZLB) interest rates. These testing times led the central banks across the world to lay renewed emphasis on unconventional channels of monetary policy transmission like the expectations channel, cost-push channel and risk-taking channel.

Expectations channel studies how inflation expectations feed into the actual inflation outcomes through firms' price and wage setting (Reid and Siklos, 2020). It is also necessary to understand how expectations formation is influenced by communications. Macroeconomists have emphasized that when everything else fails, communications that influence expectations are able to affect inflation and boost economic activity (Eggertson and Woodford, 2003).

More than one channel of transmission is at work at one point of time. Studies find interest rate channel (Khundrakpam and Jain, 2012; Bhoi et al, 2017) and credit channel via bank lending (Aleem, 2010; Khundrakpam, 2011) to be more successful than the other aggregate demand channels for India. Goyal (2016, 2017) points out there are impediments to standard transmission of monetary policies through traditional channels in emerging markets (EMs), which have large informal sectors and thin financial markets. Since the Indian economy is undergoing growth transition, with large numbers of youthful new entrants into the labour force, structural unemployment is becoming cyclical, flattening the aggregate supply curve. But it is subject to more shocks and cost-push that primarily determine inflation, while policy rates have a larger effect on output. Since inflation expectations affect costs the expectations channel of monetary policy transmission becomes important for influencing inflation.

This study tests these claims and contributes to the literature by examining the functioning of expectations channel of monetary policy transmission for India. Understanding the expectations channel is important also on account of the 2014 de facto adoption of flexible inflation targeting (FIT) in India[1].

We estimate Structural Vector Auto Regressions (SVAR) to test the efficacy of the expectations channel using survey-based inflation expectations of households and professional forecasters. Use of survey-based expectations gives the benefit of independent information on inflation expectations. Imposing restrictions on models to generate those expectations faces economic issues (Leduc et al, 2007). Household expectations are obtained from Inflation Expectations Survey of Households (IESH) and professional forecasters expectations from the Survey of Professional Forecasters (SPF). Both conducted by the Reserve Bank of India (RBI).

In the baseline regressions expectations are relatively exogenous and identification is carefully based on the availability of information. An alternative identification endogenizes expectation. Using recursively identified SVARs, we first investigate the influence of expectations shocks on the macroeconomic aggregates. Second, we identify the influence of various shocks on the expectations formation processes of households and professional forecasters and third, the impact of shocks on core inflation. We define an inflation function and use the estimations to examine convergence to a fixed point.

In our baseline estimates, household expectations shocks (both 3-month-ahead and 1-year-ahead) do not influence any variable significantly. Shocks to 3-month-ahead SPF forecasts influence headline and food inflation contemporaneously and RBI projections with lags. Effects of forecast shocks on all the variables vanish for the model with 1-year-ahead SPF forecasts.

Supply-side shocks (shocks in headline inflation) influence household inflation expectations significantly up to 5 quarters. We find significant positive responses of household expectations to positive communications shocks (shocks in RBI projections). Demand shocks (shocks in output gap) fail to influence household expectations significantly. Household inflation expectations display significant response to the shocks in food-price inflation and petrol prices in the short run (Goyal, 2017), while core-inflation shocks have a larger effect in the long run. 3-month-ahead SPF forecasts are positively driven by supply-side shocks and communications shocks. Monetary policy shocks have desired lagged negative effects. Oil price shocks and

[1] The Monetary Policy Committee (MPC) became the decision-making body of the RBI after the official adoption of FIT in 2016. Communication has a major role in FIT.

demand shocks fail to display a significant influence. Decomposition of headline inflation shocks into food and core components gives a different picture for SPF in comparison to household expectations. While the effect of food inflation shocks is persistent, the influence of core inflation shocks is muted throughout. 1-year-ahead SPF forecasts are influenced by supply-side factors and communications while the demand-side shocks and monetary policy shocks have a muted influence.

To summarize, household inflation expectations do not influence any macroeconomic aggregates. But SPF forecast shocks affect food (headline) and RBI projections. Supply-side variables respond more to the shocks in short-run SPF forecasts than those in their long-run counterparts. Shocks in RBI projections and headline inflation shocks affect household inflation expectations. 3-month-ahead SPF forecasts are influenced by both supply-side and monetary policy shocks. Supply-side shocks dominate 1-year-ahead SPF forecasts. Robustness analysis with alternative identifications largely gives similar results.

Thus in the early years of flexible inflation targeting that we cover the main interaction came through SPF forecasts and RBI projections on to core. The fixed point between inflation and its expectations was stable because the response of each variable was less than unity. The evidence indicates the expectations channel of transmission was more effective than the aggregate demand channel.

The paper is structured as follows: Section 2 gives a brief theoretical overview of the expectations channel followed by data and descriptive statistics in Section 3. Methodology is given in Section 4 and empirical results in Section 5. Section 6 has analysis of various shocks on core inflation. Robustness studies are given in Section 7. Section 8 concludes.

2. Expectations Channel of Monetary Transmission:

The expectations channel of monetary policy transmission claims that the beliefs of economic agents about future economic outcomes and central bank's actions can influence forward-looking macroeconomic variables (Mohan and Patra, 2009). It increases market appreciation of perceptions and expectations of macroeconomic outcomes (Goeltom, 2008). Central bank expectations management is located at the heart of monetary policy (Walsh, 2007; Guler, 2016). Monetary policy succeeds largely through the management of expectations, not just setting overnight interest rates (Blinder, 1999).

Theoretically, formation of inflation expectations of economic agents and their influence on macroeconomic outcomes via consumption, financial and physical investment decisions and wage and price setting forms the core of expectations channel of monetary transmission. Expectations determine the wage-price behavior of economic agents and interest rate spreads. During price determination, firms consider not only the current scenario but also future economic environment, which affects monetary transmission.

Effects of monetary policy appear fastest in the expectations channel. However, this channel operates based on the interpretations of economic agents with regard to the anticipated effects of the central bank's policy on the economy (Guler, 2016). The potency of monetary policy instruments and communication tools in shaping expectations is vital for the effectiveness of expectations channel in an inflation-targeting regime.

The operation of expectations channel depends on central bank credibility, predictability of central bank actions and high degree of commitment. Central bank communications play an important role in enhancing credibility and transparency of the central bank.[2] Communications can be in the form of statements, speeches, reports and forecasts. Credible forecasts can act as a focal point for macroeconomic expectations (Hubert, 2014), especially in the emerging markets where information tends to be thin (Goyal, 2017). Flow charts of the expectations channel are given in the panels below.

1(a) via Policy rate

$$r_t \downarrow \rightarrow \pi^e_{t....t+s} \uparrow \rightarrow \pi_t, i^e_{t....t+s}, W^e_{t....t+s} \uparrow \rightarrow \pi^e_{t+1} \uparrow$$

1(b) via Central Bank Projections

$$\pi^{e,CB}_{t,...t+s} \rightarrow \{\pi^e_{t....t+s}\} \uparrow \rightarrow \pi_t, i^e_{t....t+s}, W^e_{t....t+s} \uparrow \rightarrow \pi^e_{t+1} \uparrow$$

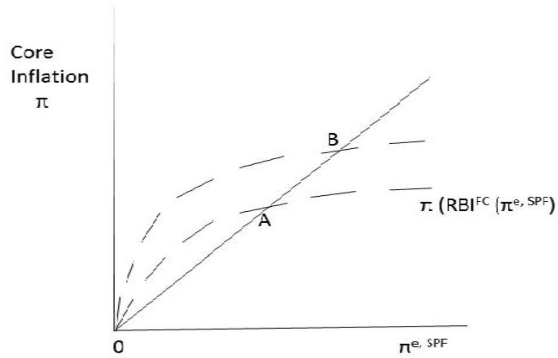
r_t - Policy interest rate (Repo rate for India), $\pi^e_{t,...t+s}$ – Current inflation perceptions over the time period t…t+s, $i^e_{t....t+s}$ – Expectations on interest rate spreads over time period t…t+s, $W^e_{t....t+s}$– Wage

[2] Detailed explanation on various aspects of central bank communications is available in Woodford (2005) and Blinder et al (2008).

expectations over time period t…t+s, π^e_{t+1}– One period ahead inflation expectations, π_t - Current realized inflation, $\pi^{e,CB}_{t.....t+s}$ – Central Bank inflation projections.

Source: Adapted from Goyal (2017)

Figure 1 – The Inflation Expectations Function and Inflation



Policy rate directly affects inflation perceptions. These perceptions influence interest rate spreads, wage setting and then future inflation expectations, which affect other forward-looking macroeconomic variables. Panel 1(b) above shows the same effects via central bank projections of their expected future inflation path.

The standard New Keynesian Phillips curve or aggregate supply curve given below, shows how expected inflation affects current core inflation. The two systemic arguments are one period ahead (t+1) expected inflation and the output gap (x_t), apart from random shocks (u_t).

$$\pi_t = \beta\pi^e_{t+1} + \lambda x_t + u_t$$

Figure 1 graphs core inflation as a function of inflation expectations. The stable fixed point in the Figure occurs where actual inflation equals expectations, assuming the output gap and other shocks are zero. It is stable if the inflation curve cuts the 45-degree line from above—that is, its slope is less than unity.

The slope is shown depending on the impact of RBI inflation projections (RBI^{FC}) on core inflation, multiplied by the impact of SPF forecasts on RBI^{FC}. It could also include the impact of RBI^{FC} on SPF. Household expectations could also be in the loop if they are found to affect other variables. It captures how inflation expectations of different groups interact and coalesce into the core expectations that affect actual inflation.

Our estimations attempt to identify this inflation function for the early years of inflation targeting in India. We use SVAR models to determine the arguments and estimate the slope of the inflation function. The fixed point can be low A or high B values depending on the shift factors, which include the output gap and headline supply shocks.

3. Data:

Inflation expectations are taken from two survey-based datasets named Inflation Expectations Survey of Households (IESH) and Survey of Professional Forecasters (SPF) conducted by the Reserve Bank of India (RBI). IESH is available on a quarterly basis from 2006. However, our analysis is from September 2008 (2008Q3) to March 2019 (2019Q1) since data prior to 2008Q3 is ridden with internal inconsistencies (RBI, 2009). Household surveys are bi-monthly basis since May 2019.

SPF forecasts are available on a quarterly basis from March 2008 to December 2013. Their frequency changed to bi-monthly in line with the changed frequency of RBI monetary policy meetings based on the recommendations by the Patel Committee Report (RBI, 2014). Quarterly SPF forecasts have a limited number of observations (24 observations) and hence, are inadequate for time series analysis. Bi-monthly SPF forecasts have 35 observations. Therefore, we use bi-monthly 3-month-ahead [$\pi^{e,SPF}_{t+3|t}$] and 1-year-ahead [$\pi^{e,SPF}_{t+12|t}$] SPF forecasts from March 2014 to November 2019 for CPI-C inflation. This period coincides with de facto adoption of FIT regime.

We use aggregate quantitative responses on inflation expectations of households for three periods - (current (perceptions) inflation expectations [$\pi^{e,HH}_{t|t}$], 3-month-ahead inflation expectations [$\pi^{e,HH}_{t+3|t}$] and 1-year-ahead inflation expectations [$\pi^{e,HH}_{t+12|t}$]), which are available on the RBI website. These forecasts are called fixed-horizon forecasts.

Bi-monthly forecasts are conducted every two months but they forecast for quarter ends. These forecasts face the risk of being contaminated by varying leads, as they are not fixed-horizon forecasts (Hubert, 2015). Bi-monthly forecasts are provided for every quarter end as well as every financial year-end. Following Dovern et al (2012), we approximate the 1-year-ahead forecasts using weighted averages of financial year-end values and 3-month-ahead forecasts using the forecast values of two quarters. Annual forecasts are approximated as follows:

$$\tilde{\pi}_{t+12|t} = \frac{k}{12}\hat{\pi}_{t+k|t} + \frac{12-k}{12}\hat{\pi}_{t+k+12|t} \qquad (1)$$

Where $k \in \{1,3,\dots,11\}$ gives forecast horizon values at the time of survey. For example, November 2015 1-year-ahead forecasts are approximated using the forecast values for March 2016 and March 2017 by assigning the weights of 5/12 and 7/12 to $\hat{\pi}_{Mar,2016|Nov,2015}$ and $\hat{\pi}_{Mar,2017|Nov,2015}$ respectively. Similarly, we approximate 3-month-ahead forecasts using forecast values of two adjacent quarters. Weights are assigned based on their distance from the month for which forecasts are made. Nearer forecast value is given the weight 2/3 and farther forecast is given the weight 1/3. For example, two of the forecasts in November 2015 are for December 2015 and March 2016. 3-month-ahead forecast are made for February 2016. Weights are assigned based on the proximity to February 2016 forecast value. 2/3rd weight is assigned to the March 2016 forecast ($\hat{\pi}_{March,2016|Nov,2015}$) and 1/3rd is assigned to the December 2015 one ($\hat{\pi}_{Dec,2015|Nov,2015}$).

3.1. Macroeconomic Controls:

Repo rate [R_t] and output gap [y_t^g] affect inflation and have to be used as macroeconomic controls in any analysis of inflation expectations. Repo rate, the policy rate set by the MPC, is taken from RBI DBIE database while the output gap is estimated using Hodrick-Prescott filter on real GDP data.[3] Logarithm of petrol prices [$lnPET_t$] are used as an explanatory variable for households on account of their direct impact on household budgets and incomplete pass-through of international oil prices, which households do not analyze (Goyal and Parab, 2021).[4] International crude oil prices [$lnOIL_t$] (in logarithms) are used as one of the explanatory variables for the SPF forecasts as professional forecasters are expected to gauge the effects of imported inflation.

RBI projections are used as the communications variable. However, the use differs slightly for

[3] Since data on output gap is quarterly frequency parameter λ=1600 is used. Real GDP data is obtained from CSO database.

[4] Petrol prices for major cities are collected from Petroleum Planning and Analysis Cell of the Government of India. Weights are assigned based on the principal component analysis.

the SPF forecasts compared to households. RBI projections appear in the monetary policy statements in two ways. Firstly, they appear in the speeches as follows, *"... the Reserve Bank will endeavor to condition the evolution of inflation to a level of 5.0 per cent by March 2014..."* (RBI May, 2013). Second, these statements also contain fan charts of projected inflation and GDP growth rate for different quarters. Professional forecasters incorporate this information while formulating expectations. While the households have only one anchor point in the form of RBI projections [RBI_t^{FC}], professional forecasters incorporate information from different horizons of RBI projections. We convert RBI projections to fixed-horizon ones using techniques similar to those used for SPF forecasts. 3-month-ahead [$RBI_{t+3|t}^{FC}$] and 1-year-ahead RBI projections [$RBI_{t+12|t}^{FC}$] are used as explanatory variables for [$\pi_{t+3|t}^{e,SPF}$] and [$\pi_{t+12|t}^{e,SPF}$] respectively.[5]

Consumer price index of industrial workers (CPI-IW) based inflation is used as an explanatory variable for household expectations. The newly constructed series on inflation CPI-C (combined) is available from 2011. Inflation based on CPI-IW is a good proxy for the CPI-C as the weights of their components are similar (Goyal, 2015; Goyal and Parab, 2021). However, CPI-C index-based inflation is used for the SPF analysis as CPI-C based headline inflation is the intermediate target of RBI for the period of bi-monthly SPF analysis and hence, professional forecasters provide inflation forecasts for this variable. Headline inflation [π_t] as well as food [π_t^{FOOD}] and core [π_t^{CORE}] inflation are constructed for the respective indices.

Table 1 gives correlations of 3-month-ahead and 1-year-ahead expectations of households and professional forecasters with their respective explanatory variables. SPF forecasts have higher correlation with the aggregate headline inflation as well as with food and core inflation in comparison to their household counterparts. High correlations of SPF forecasts with headline inflation can be attributed to low and stable headline inflation during the period of analysis. RBI projections too display higher correlation with SPF forecasts than with household

[5]Frequency of RBI projections are considered carefully here. Household forecasts are quarterly from 2008Q3 to 2019Q1. RBI projections were changed to a bi-monthly frequency from March 2014. However, they are used in the quarterly SVAR of households by incorporating latest available data. Samanta and Kumari (2021) use the bi-monthly SPF data in a similar manner for their quarterly analysis. Unlike other macroeconomic variables that change with the arrival of new information, RBI projections made at one point of time stay the same until the next set of projections is made two months later. So, in spite of the bi-monthly frequency of the data post 2014, the latest available data on RBI projections is used in quarterly SVAR, which becomes a part of the information set of the households. As a robustness measure, the authors estimated individual OLS regressions for the households and professional forecasters. While households consider only one data point of RBI projections, which appear as news, professional forecasters incorporate more information from the MP statements. Results of OLS estimations are available with the authors and can be provided upon request.

expectations. Repo rate has similar correlations across all the measures. Output gap has lower correlation with household expectations and negative correlation with SPF forecasts. Oil prices display higher correlations with SPF forecasts while the petrol prices show moderate correlations with household expectations.

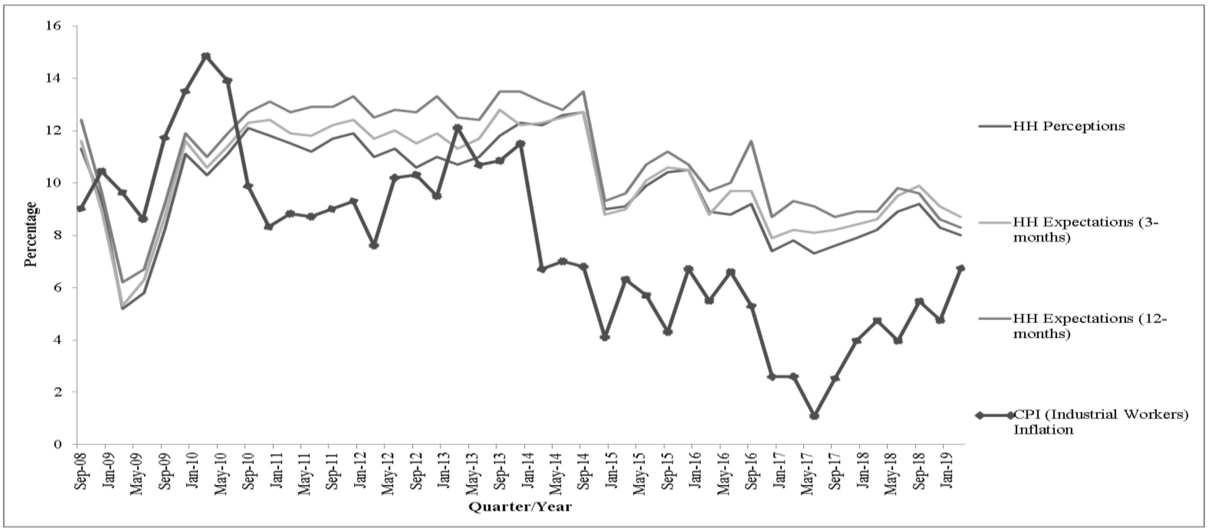
Table 1 – Correlations of Inflation expectations with macroeconomic controls

	HH 3-m expectations	HH 1-y expectations	SPF 3-m forecasts	SPF 1-y forecasts
Headline Inflation	0.46	0.45	0.76	0.49
Food Inflation	0.31	0.32	0.62	0.38
Core Inflation	0.40	0.33	0.50	0.32
RBI Projections	0.73	0.73	0.93	0.93
Output Gap	0.19	0.16	-0.35	-0.30
Repo	0.76	0.77	0.74	0.81
Petrol Prices	0.34	0.34		
Oil Prices			0.51	0.45

Source: Authors' estimates

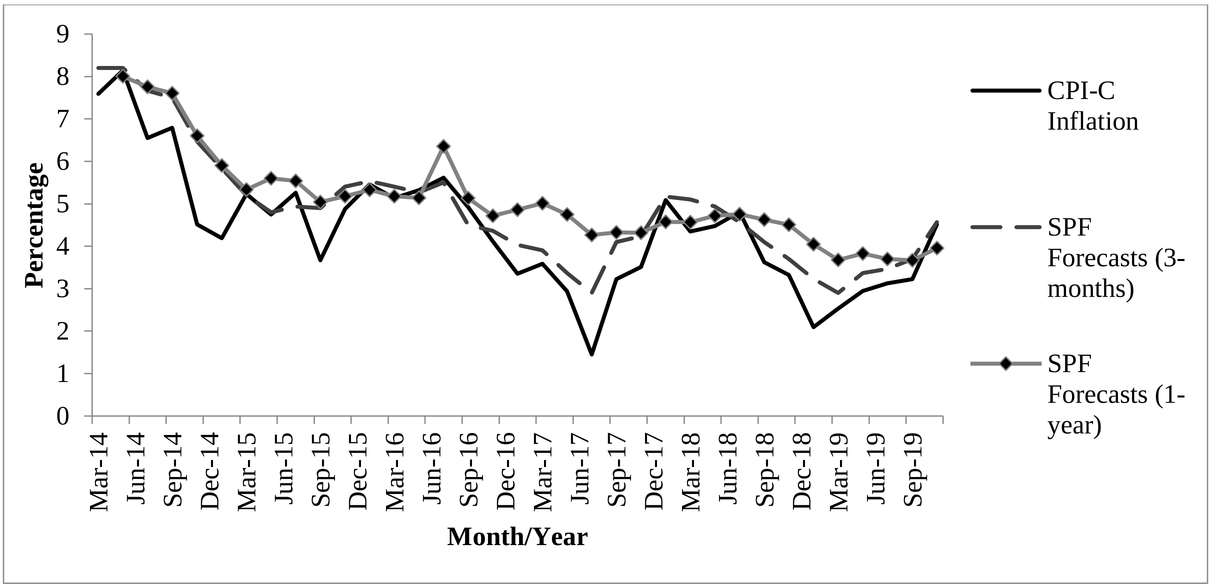
Figure 2 plots household inflation perceptions and expectations along with realized inflation estimated using CPI-IW. Household expectations and perceptions moved in tandem with realized inflation till mid-2014. A reduction in realized inflation in 2013 was accompanied by the decline in household expectations and perceptions, albeit smaller in magnitude. Hence, we observe systematic over-prediction of inflation by households since June 2014. Figure 3 plots 3-month-ahead and 1-year-ahead SPF forecasts along with realized CPI-C headline inflation. SPF forecasts display larger co-movements with realized CPI-C inflation, although SPF forecasts are less volatile. The gap from realized inflation is higher for 1-year-ahead SPF forecasts.

Figure 2 - CPI (Industrial Workers) inflation, household inflation perceptions and expectations



Source: RBI (n.d.) – IESH and DBIE

Figure 3– CPI-C inflation and SPF forecasts



Source: RBI (n.d.) – SPF and DBIE

4. Methodology:

We analyze inflation expectations using a Structural Vector Auto Regressive (SVAR) model. An SVAR model provides structure to an atheoretical VAR model. Let Z_t be an N X 1 vector with p lags of each variable. Then the p^{th} order SVAR model is given as follows:

$$B_0 Z_t = c^* + B_1 Z_{t-1} + B_2 Z_{t-2} + \cdots + B_p Z_{t-p} + u_t$$

Where the B_0 matrix imposes a structure on the reduced form VAR model. 'u_t's' are known as structural disturbances. The underlying assumption is these disturbances are serially and mutually uncorrelated:

$$E(u_t u_\tau') = \begin{cases} D \; for \; t = \tau \\ 0 \; otherwise \end{cases}$$

Where D is a diagonal matrix. The restrictions imposed on the B_0 matrix to obtain the variance-covariance matrix Ω are given below:

$$\Omega = B_0^{-1} E(u_t u_\tau')(B_0^{-1})' = B_0^{-1} D (B_0^{-1})'$$

Ω has N(N+1)/2 free parameters out of which N belong to the diagonal matrix D. Hence, N(N-1)/2 restrictions should be imposed on the B_0 matrix for just identification. Restrictions greater than N(N-1)/2 would imply the model is over-identified. Orthogonality of structural identification restrictions distinguishes SVAR from other dynamic structural identification models.[6]

To test the influence of expectations shocks on macroeconomic aggregates, we estimate a six-variable SVAR with identifying restrictions imposed using a lower triangular recursive matrix. Initial period recursive restrictions imposed on the variables are based on presence/absence of contemporaneous effects on one another. The data vector used for analysis is $[lnPET_t, \pi_t^{e,HH}, RBI_t^{FC},\ R_t,\ y_t^g, \pi_t]$. Our benchmark identification takes expectations as exogenous of contemporaneous macroeconomic variables. The short-run identification matrix is over-identified as given by the equation $u_t = B_0 e_t$, expanded in (2) below:

[6]Gottschalk (2001) provides detailed non-technical insights on the advantages of SVAR over other structural identification models used in the macroeconomics literature.

$$\begin{pmatrix} u^{PET} \\ u^{\pi^{e,HH}} \\ u^{RBI^{FC}} \\ u^{R} \\ u^{y^g} \\ u^{\pi} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b1 & 1 & 0 & 0 & 0 & 0 \\ b2 & 0 & 1 & 0 & 0 & 0 \\ b3 & b6 & b9 & 1 & 0 & 0 \\ b4 & b7 & b10 & b12 & 1 & 0 \\ b5 & b8 & b11 & b13 & b14 & 1 \end{pmatrix} \begin{pmatrix} e^{PET} \\ e^{\pi^{e,HH}} \\ e^{RBI^{FC}} \\ e^{R} \\ e^{y^g} \\ e^{\pi} \end{pmatrix} \qquad (2)$$

Where $u^{PET}, u^{\pi^{e,HH}}, u^{RBI^{FC}}, u^{R}, u^{y^g}\, and\, u^{\pi}$ are structural shocks and $e^{PET}, e^{\pi^{e,HH}}$, $e^{RBI^{FC}}, e^{R}, e^{y^g}\, and\, e^{\pi}$ are residuals of reduced form equations. They represent unanticipated movements in each variable. Recursive ordering of the variables is based on the information available at a point in time and the level of endogeneity.

To understand the timeline, consider an IESH conducted in March. Petrol prices are assumed to be most exogenous in the model with no contemporaneous influence from domestic macroeconomic factors. March values are taken for the same. The second equation shows a contemporaneous effect of petrol prices on the household expectations and a lagged effect of the remaining variables. RBI projections released in April first week but conducted in March follow the household forecasts in the identification scheme. However, since RBI forecasts are made independently of survey expectation data, that coefficient is put as zero, so they are not affected contemporaneously by the household expectations. Communication shocks (shocks in RBI projections) influence the Repo rate setting in the month of April. Output Gap is taken for April-June quarter. Headline inflation for April (obtained in May) follows output gap in the order of endogeneity.

Analysis of bi-monthly SPF forecasts is similar. Petrol prices are replaced with the international crude oil prices since we expect professional forecasters to gauge the effect of imported inflation through oil prices. A similar set of over-identification restrictions imposed on the data vector $[lnOIL_t,\ \pi_t^{e,SPF}, RBI_t^{FC}, R_t, y_t^g, \pi_t\ ]$ is given below.

$$\begin{pmatrix} u^{OIL} \\ u^{\pi^{e,SPF}} \\ u^{RBI^{FC}} \\ u^{R} \\ u^{y^g} \\ u^{\pi} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b1 & 1 & 0 & 0 & 0 & 0 \\ b2 & 0 & 1 & 0 & 0 & 0 \\ b3 & b6 & b9 & 1 & 0 & 0 \\ b4 & b7 & b10 & b12 & 1 & 0 \\ b5 & b8 & b11 & b13 & b14 & 1 \end{pmatrix} \begin{pmatrix} e^{OIL} \\ e^{\pi^{e,SPF}} \\ e^{RBI^{FC}} \\ e^{R} \\ e^{y^g} \\ e^{\pi} \end{pmatrix} \qquad (3)$$

Ordering of the variables is similar to the one in equation (2). For an SPF forecast conducted and compiled by the end of January, oil prices are taken from the month of January, keeping them at the top of the identification vector followed by the SPF forecasts. RBI forecasts conducted in January and released in the first week of February, are made independently of SPF forecasts, therefore there is no contemporaneous effect of SPF forecasts on them. However, the Monetary Policy Committee considers all available information in setting the Repo rate. So the Repo set in February is contemporaneously affected by oil prices, SPF forecasts and RBI projections. Output gap for January-March quarter and headline inflation for the month of February follow Repo rate in the order of endogeneity.[7]

Following Goyal and Parab (2021), we extend equations (2) and (3) to seven-variable SVAR by decomposing headline inflation into food and core components.[8] Identification restrictions for households and professional forecasters are given below:

$$\begin{pmatrix} u^{PET} \\ u^{\pi^{e,HH}} \\ u^{RBI^{FC}} \\ u^{R} \\ u^{\pi^{FOOD}} \\ u^{y^g} \\ u^{\pi^{CORE}} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b1 & 1 & 0 & 0 & 0 & 0 & 0 \\ b2 & 0 & 1 & 0 & 0 & 0 & 0 \\ b3 & b7 & b11 & 1 & 0 & 0 & 0 \\ b4 & b8 & b12 & b15 & 1 & 0 & 0 \\ b5 & b9 & b13 & b16 & b18 & 1 & 0 \\ b6 & b10 & b14 & b17 & b19 & b20 & 1 \end{pmatrix} \begin{pmatrix} e^{PET} \\ e^{\pi^{e,HH}} \\ e^{RBI^{FC}} \\ e^{R} \\ e^{\pi^{FOOD}} \\ e^{y^g} \\ e^{\pi^{CORE}} \end{pmatrix} \tag{4}$$

$$\begin{pmatrix} u^{OIL} \\ u^{\pi^{e,SPF}} \\ u^{RBI^{FC}} \\ u^{R} \\ u^{\pi^{FOOD}} \\ u^{y^g} \\ u^{\pi^{CORE}} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b1 & 1 & 0 & 0 & 0 & 0 & 0 \\ b2 & 0 & 1 & 0 & 0 & 0 & 0 \\ b3 & b7 & b11 & 1 & 0 & 0 & 0 \\ b4 & b8 & b12 & b15 & 1 & 0 & 0 \\ b5 & b9 & b13 & b16 & b18 & 1 & 0 \\ b6 & b10 & b14 & b17 & b19 & b20 & 1 \end{pmatrix} \begin{pmatrix} u^{OIL} \\ u^{\pi^{e,SPF}} \\ u^{RBI^{FC}} \\ u^{R} \\ u^{\pi^{FOOD}} \\ u^{y^g} \\ u^{\pi^{CORE}} \end{pmatrix} \tag{5}$$

This ordering differs from the six-variable SVAR as food inflation is placed before RBI projections due to its contemporaneous effect on the latter. Demand-driven core inflation is placed last as it is contemporaneously influenced by the output gap.

Mehra and Herrington (2008) follow a similar approach for the analysis of the shocks influencing household inflation expectations of the US. Availability of long time-series data allows them to conduct analysis across time and discover the evolution of expectations pre- and post-Volcker era. They analyze both the aspects mentioned here: The effects of the shocks

[7] Given the bi-monthly nature of survey and quarterly frequency of output data, we take weighted averages of the output gaps for the months where the quarter end data is not available.
[8] Core inflation is estimated as the weighted average of all the components excluding food, fuel and pan, tobacco and other intoxicants (Goyal and Parab, 2021).

in macroeconomic variables on expectations formation and the movements in macroeconomic aggregates in response to the expectations shocks.

5. Empirical Results:

Output gap, inflation (headline, food and core), petrol prices and oil prices are seasonally adjusted using Census X-13 in the E-views software. Results of unit root tests conducted using the Augmented Dickey Fuller (ADF) test are given in Table A1 in the appendix. Barring output gap, all the variables used for the analysis of household inflation expectations are I(1) whereas all the variables used for the SPF analysis are I(1) at 5 percent level of significance, except for core inflation which is I(0).

5.1. Impulse Response Functions of Shocks to Inflation Expectations:

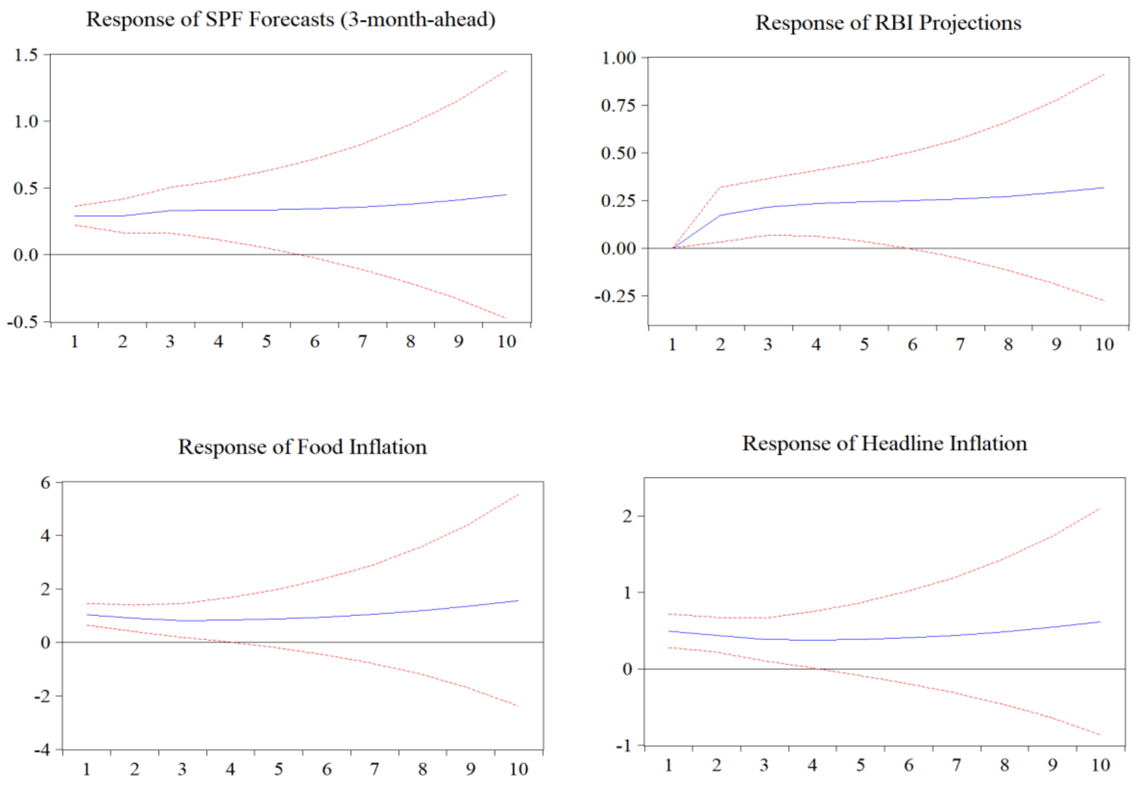
Indian household inflation expectation shocks are naïve and show large departures from actual inflation (Figure 2). Hence they are unlikely to affect other variables. Effects of household expectation shocks on all the macroeconomic aggregates are estimated, however, to examine the working of the expectations channel of monetary policy transmission. Results show only household expectations are significantly influenced by their own unanticipated shocks. Their effects on petrol prices, headline inflation, output gap and RBI projections are insignificant indicating a lack of response on the part of macroeconomic aggregates. The influence of expectations shocks on Repo rate is positive but insignificant. Similar story follows for the seven-variable SVAR with food and core inflation.[9]

Figure 4 gives responses of all the variables, which respond significantly to the shocks in 3-month-ahead SPF forecasts.[10] SPF forecasts respond significantly to their own shock till the 6th period. RBI projections react to the forecast shocks with lags, from 2nd to 6th period. Forecast shocks have a significant and positive influence on headline inflation for the first 4 periods, which is primarily observed on food inflation. This may be capturing the inflation expectations component affecting food pricing. The effects on output gap are muted throughout. Repo rate

[9] Results of the IRFs of all the variables in response to the shocks in household inflation expectations (3-month-ahead and 1-year-ahead) are available with the authors and can be provided upon request.
[10] Impulse responses of the variables common in both six-variable and seven-variable SVAR (output gap, RBI projections, Repo rate and expectations/forecasts) are similar unless stated otherwise. Hence, all the IRFs contain the responses to common shocks only from the six-variable SVAR.

and core inflation respond positively to the forecast shocks but the effects are insignificant at 5 percent.

Figure 4- Impulse response functions of all variables to shocks in 3-month-ahead SPF forecasts



Source: Authors' estimates

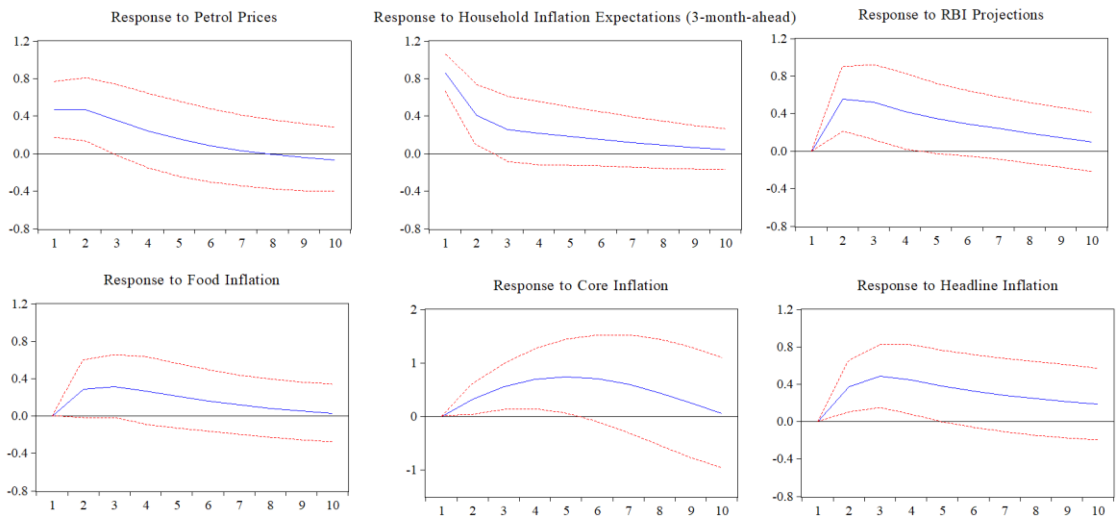
Results for 1-year-ahead SPF forecasts show insignificant responses of all the other variables for both six-variable and seven-variable SVARs.[11] This is intuitive, since Figure 3 shows larger deviations for longer-run forecasts from realized inflation. The first leg of the expectation channel shows a significant influence of shorter-horizon SPF forecasts on RBI projections and on inflation. We go on to see the variables that affect expectations.

[11] Results of responses of all the variables to forecast shocks (3-month-ahead and 1-year-ahead) are available with the authors and can be provided upon request.

5.2. Impulse Response Functions and Variance Decompositions of Inflation Expectations to Shocks in all other variables:

Figure 5 gives significant responses of 3-month-ahead household inflation expectations to shocks in all the macroeconomic variables given in equations (2) and (4). Petrol price shocks display significant effects for the first three quarters. Household expectations respond significantly to their own shocks for the first two quarters. Communications shocks affect expectations from the end of 1st quarter to the 4th quarter, while monetary policy shocks (Repo rate) display insignificant (but positive) effects throughout. Supply-side shocks (headline inflation) display persistent positive influence, which dies down by the 5th quarter. Demand shocks (output gap) have insignificant effects on household expectations. Decomposition of headline inflation into food and core components shows significant short-run influence of food-price shocks till the end of first quarter and persistent influence of core inflation shocks from 2nd to 5th quarter. Results of 1-year-ahead household expectations mimic their 3-month-ahead counterparts, with the effects of food inflation shocks persisting till the 3rd quarter.[12]

Figure 5- Impulse response functions of household inflation expectations (3-month-ahead) to shocks in other variables



Source: Authors' estimates

Forecast error variance decomposition (FEVD) results for 3-month-ahead household expectations are given in Tables 2 and 3. Around 90 percent of the variations in household

[12] The IRFs and FEVDs for 1-year-ahead household expectations are provided in Figure A1 in the appendix.

expectations in the six-variable SVAR are explained by own shocks, shocks to petrol prices and communication shocks in the second quarter. Communication shocks contribute around 18 to 19 percent of the variations from the 3rd quarter. Supply-side shocks (headline inflation) account for more than one-fifth of the variations since the 4th quarter. Demand shocks and monetary policy shocks fail to display any significant influence on the variations in household expectations. Food inflation shocks contribute around 2 to 6 percent of the total variation while core inflation shocks contribute more than 25 percent since the 4th quarter.[13] Results for the variance decomposition of 1-year-ahead household expectations are qualitatively similar (provided in Tables A2 and A3 in the appendix).

Table 2 - Variance decomposition of household inflation expectations (3-month-ahead) to shocks in other variables

Forecast Horizon	Petrol	HH 3-m Expectations	RBI Projections	Repo Rate	Output Gap	Headline Inflation
1	22.86	77.14	0.00	0.00	0.00	0.00
2	24.43	50.76	14.61	0.15	2.26	7.80
3	23.08	39.83	17.71	0.27	3.85	15.27
4	21.68	35.44	18.15	0.34	4.61	19.79
5	20.48	33.34	18.40	0.38	4.90	22.50
6	19.51	32.11	18.72	0.40	4.96	24.30
7	18.78	31.26	19.07	0.41	4.90	25.59
8	18.26	30.62	19.37	0.40	4.81	26.54
9	17.94	30.11	19.61	0.40	4.71	27.23
10	17.77	29.69	19.79	0.39	4.64	27.72

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

[13] These results differ slightly from the ones obtained by Goyal and Parab (2021). In their Cholesky factorization scheme, household expectations appear at the bottom of the vector. They obtain significant short-run effects of food-price shocks and long-run influence of core inflation shocks on household expectations. We conduct robustness analysis by incorporating 2 lags and check the FEVDs for household expectations. These results support the findings of Goyal and Parab (2021) in the form of higher short-run effects of food-price shocks and long-run effects of core inflation shocks, indicating the results are robust. FEVDs for 3-month-ahead expectations with 2 lags are provided in Table A4 in the appendix.

Table 3 - Variance decomposition of household inflation expectations (3-month-ahead) to shocks in other variables (with food and core inflation)

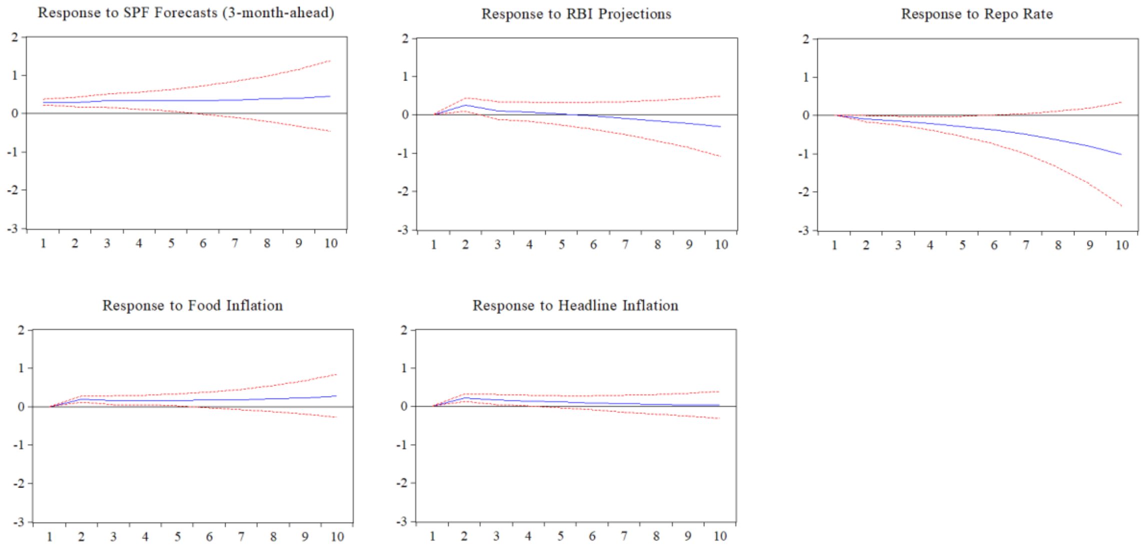
Forecast Horizon	Petrol	HH 3-m Expectations	RBI Projections	Repo Rate	Food Inflation	Output Gap	Core Inflation
1	21.02	78.98	0.00	0.00	0.00	0.00	0.00
2	23.52	51.96	15.15	0.00	2.41	0.96	6.00
3	23.29	37.70	18.47	0.01	2.61	0.70	17.22
4	22.16	28.63	17.58	0.01	1.98	1.20	28.43
5	20.67	22.77	15.66	0.02	1.93	2.96	36.00
6	19.26	19.54	13.71	0.08	2.47	5.34	39.60
7	18.08	18.22	12.07	0.21	3.33	7.75	40.34
8	17.14	18.07	10.89	0.38	4.29	9.84	39.40
9	16.39	18.46	10.23	0.58	5.21	11.37	37.75
10	15.81	18.95	10.10	0.76	5.96	12.23	36.19

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

Figure 6 gives significant responses of 3-month-ahead SPF forecasts to one standard deviation shocks in all the variables. SPF forecasts respond positively to their own shocks till the 5th period. Impact of communication shocks in the form of RBI projections dies down after the significant influence in the second period. Monetary policy shocks (Repo rate) display lagged negative influence on the SPF forecasts. Unlike household expectations, SPF forecasts respond to the monetary policy shocks in concurrence to theory. While the effect of food inflation shocks lasts till the 5th period, the influence of headline inflation shocks (supply shocks) dies down by the end of the 3rd period. Core inflation fails to have significant influence on the SPF forecasts. Results for the responses of 1-year-ahead SPF forecasts are qualitatively similar to their 3-month-ahead counterparts.[14]

[14] The influence of monetary policy shocks diminishes for 1-year-ahead SPF forecasts. Results are provided in the appendix.

Figure 6- Impulse response functions of SPF forecasts (3-month-ahead) to shocks in other variables



Source: Authors' estimates

Variance Decompositions of 3-month-ahead SPF forecasts for six-variable and seven-variable SVARs are given in Tables 4 and 5 respectively. Supply-side shocks contribute significantly to the variance of SPF forecasts from 2nd period till the 4th period. Communications shocks explain around 11 percent of the variations in the SPF forecasts for the 2nd period. Demand-side shocks as well as monetary policy shocks have a large influence since the sixth period. SPF forecasts' own shocks explain more than 50 percent of the variations till the 5th period. Food-price shocks have large persistent effects from the second to the fifth period. Incorporating food and core inflation increases the role of monetary policy shocks in explaining the variations over the long run. Results are largely similar for the 1-year-ahead SPF forecasts. The influence of supply-side shocks and communications shocks increase significantly compared to the 3-month-ahead counterparts. Food-price shocks emerge as the major contributor of variations in 1-year-ahead SPF forecasts followed by communication shocks. While forecasts are significantly influenced by shocks in headline inflation and RBI projections; output gap and Repo rate fail to display similar contribution to the variations in 1-year-ahead SPF forecasts.[15]

[15] IRFs and FEVDs of 1-year-ahead SPF forecasts are provided in the appendix in Figure A2 and Tables A5 and A6.

Table 4 - Variance decomposition of SPF forecasts (3-month-ahead) to shocks in other variables

Forecast Horizon	Oil Prices	SPF 3-m Forecasts	RBI Projections	Repo Rate	Output Gap	Headline Inflation
1	3.17	96.83	0.00	0.00	0.00	0.00
2	1.71	73.61	11.25	0.90	0.09	12.44
3	7.04	69.72	8.03	2.43	0.50	12.27
4	13.93	62.70	5.79	4.88	2.05	10.65
5	20.27	54.15	4.16	8.07	4.75	8.60
6	24.62	45.43	3.08	11.88	8.28	6.71
7	26.67	37.27	2.51	16.15	12.26	5.13
8	26.70	30.00	2.34	20.74	16.34	3.87
9	25.24	23.73	2.50	25.42	20.23	2.89
10	22.85	18.47	2.88	29.98	23.69	2.13

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

Table 5 - Variance decomposition of SPF forecasts (3-month-ahead) to shocks in other variables (with food and core inflation)

Forecast Horizon	Oil Prices	SPF 3-m Forecasts	RBI Projections	Repo Rate	Food Inflation	Output Gap	Core Inflation
1	0.33	99.67	0.00	0.00	0.00	0.00	0.00
2	1.39	74.89	10.76	2.42	10.04	0.36	0.14
3	1.08	74.46	7.84	5.03	11.01	0.34	0.24
4	2.11	70.05	6.01	8.79	11.05	1.33	0.66
5	3.87	62.64	4.44	13.49	10.40	3.73	1.42
6	5.55	53.21	3.24	18.86	9.41	7.49	2.24
7	6.69	43.05	2.45	24.49	8.27	12.17	2.88
8	7.13	33.37	2.09	29.96	7.14	17.11	3.21
9	6.97	24.96	2.09	34.94	6.12	21.69	3.23
10	6.43	18.16	2.37	39.25	5.26	25.52	3.02

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

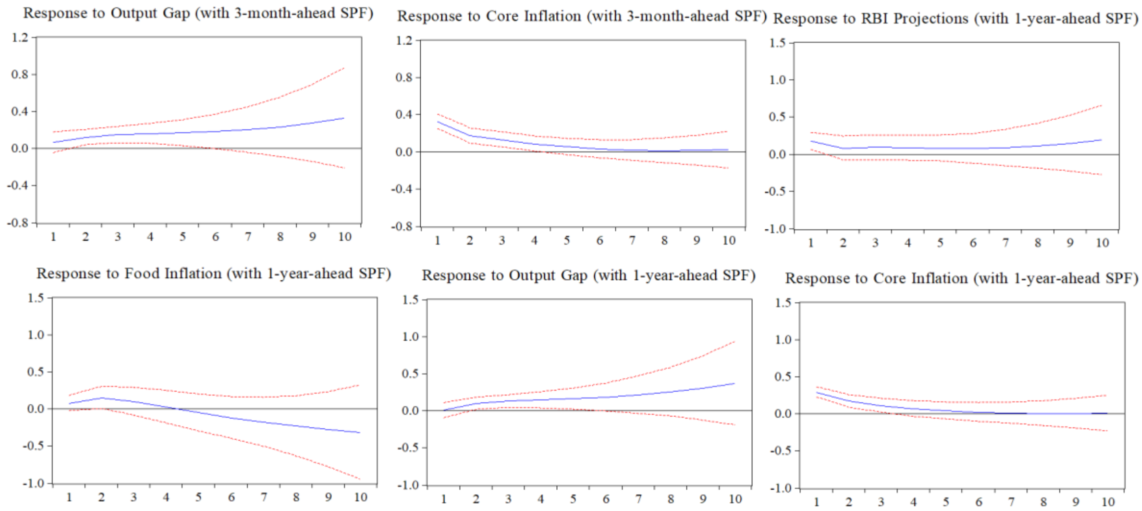
6. How does core inflation react to the shocks?

Since in normal times a volatile headline reverts to a more stable core (Goyal and Parab, 2020) and it explains 40 percent of variance in household inflation expectations in 2 years, analysis of shocks driving core inflation is important. Moreover, the results will allow us to derive the slope of the inflation expectations function we had hypothesized for India in Section 2.

In the SVARs with household inflation expectations, core inflation is influenced by its own shocks and demand shocks. Shocks to all other variables fail to significantly influence core inflation.[16] Therefore we do not consider these SVARs for the inflation expectations function.

Responses of core inflation to all the (significant) shocks using 3-month-ahead and 1-year-ahead SPF forecasts are given in Figure 7. For the model with 3-month-ahead SPF forecasts, core inflation responds to its own shocks till the third period. Demand shocks (output gap) have significant persistent effects on core inflation from second to fifth period in the model with both 3-month-ahead and 1-year-ahead SPF forecasts. As for the model with 1-year-ahead SPF forecasts, apart from its own shocks, core inflation responds to the shocks in RBI projections, output gap and food inflation while the forecast shocks fail to have a significant influence.

Figure 7- Impulse response functions of core inflation to shocks in other variables (with 3-month-ahead and 1-year-ahead SPF forecasts)



Source: Authors' estimates

The SPF SVAR estimations imply that the inflation expectations function slope is stable at less than unity[17]. It is calculated as the impact of RBI^{FC} on core inflation, multiplied by the impact

[16] This finding holds for both 3-month-ahead and 1-year-ahead household expectations. Results are not reported to save space and can be made available upon request.

[17] For 3-month-ahead SPF, the coefficient of SPF on RBI^{FC} is 0.19(0.23), RBI^{FC} on core inflation is -0.24(0.13)*. For 1-year-ahead SPF, the coefficient of SPF on RBI^{FC} is -0.04(0.17) and that of RBI^{FC} on core inflation is -0.16(0.16).

of SPF forecasts on RBI^{FC}[18]. Similarly, the impact of SPF forecasts on core inflation, multiplied by the impact of RBI^{FC} on SPF forecasts is stable and less than unity.[19] The interaction of the inflation expectations of different groups is convergent. Convergence can be improved as forecasts become more precise. For example, over our data period March 2014 to November 2019 the average deviation of 3-month-ahead and 1-year-ahead SPF forecasts from realized CPI-C was 0.62 and that for RBI forecasts 0.73. Both overestimated inflation, RBI more than SPF.

7. Robustness with Alternative Identification:

A common robustness check in the SVAR literature is to change in the order of identification restrictions. Following Mehra and Herrington (2008), we change the order by allowing expectations to be the most endogenous variable and carry out a similar set of exercises as for the baseline models. The dating and availability of data is not so important in this ordering since agents are assumed to be able to pick up leading indicators of current variables although data on the variable may not yet be released. The ordering is also the standard ordering used in SVARs to identify monetary policy shocks, on the assumption that current output and inflation affect the policy rate, while the policy rate affects these variables with a lag (Christiano et al 1999). The ordering of six-variable SVAR with household expectations is [$lnPET_t$, $y_t^g, \pi_t, RBI_t^{FC},\ R_t, \pi_t^{e,HH}$].

$$\begin{pmatrix} u^{PET} \\ u^{y^g} \\ u^{\pi} \\ u^{RBI^{FC}} \\ u^{R} \\ u^{\pi^{e,HH}} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b1 & 1 & 0 & 0 & 0 & 0 \\ b2 & b6 & 1 & 0 & 0 & 0 \\ b3 & b7 & b10 & 1 & 0 & 0 \\ b4 & b8 & b11 & b13 & 1 & 0 \\ b5 & b9 & b12 & b14 & b15 & 1 \end{pmatrix} \begin{pmatrix} e^{PET} \\ e^{y^g} \\ e^{\pi} \\ e^{RBI^{FC}} \\ e^{R} \\ e^{\pi^{e,HH}} \end{pmatrix} \tag{6}$$

For the March IESH, January to March average of petrol prices is taken as the most exogenous variable. Output gap for January-March is placed after petrol prices. Headline inflation for

[18] Wald Chi2 test to compare the two coefficients are: 2.47(0.12) (3-month), 0.21(0.64) (1-year), indicating that the effects of SPF on RBI^{FC} are not significantly different from those of RBI^{FC} on core inflation.

[19] For 3-month-ahead SPF, the coefficient of RBI^{FC} on SPF forecasts is 0.31(0.11)***, and that of SPF forecasts on core inflation is 0.21(0.15). In the case of 1-year-ahead SPF forecasts, the coefficient of RBI^{FC} on SPF forecasts is 0.28(0.13)**, and that of SPF forecasts on core inflation is -0.21(0.15). Wald Chi2 test gave significant results for 1-year-ahead SPF forecasts: 0.26(0.61) for 3-month-ahead SPF forecasts and 6.41(0.01)** for 1-year-ahead forecasts, indicating the effects of RBI^{FC} on 1-year-ahead SPF forecasts are significantly different from the effects of 1-year-ahead SPF forecasts on core inflation.

January, obtained in February is placed third in the order of exogeneity after petrol prices and output gap. RBI projections made in January and released in January end or February first week follow the headline inflation. Repo rate comes after the RBI projections and is placed before the household expectations conducted in March. Household expectations, the most endogenous component for this analysis, are placed at the bottom of the vector. Decomposition of headline inflation into food and core components changes the ordering by placing food inflation before and core inflation after the output gap. Unlike the baseline estimates, this SVAR is just-identified.

SVAR identification restrictions for SPF forecasts follow a similar procedure. The data vector used for robustness checks is $[lnOIL_t,\ y_t^g, \pi_t, RBI_t^{FC},\ R_t, \pi_t^{e,SPF}]$. For a bi-monthly structure of the time series, SPF forecasts conducted in March are placed at the bottom of the identification vector. February oil prices are taken as the most exogenous variable followed by the January-March output gap in a six-variable SVAR and food inflation in a seven-variable one. Output gap is succeeded by February headline inflation (core inflation) in the six-variable (seven-variable) SVAR. RBI projections from January end appear next in the order of endogeneity followed by the Repo rate set in the first week of February.

$$\begin{pmatrix} u^{OIL} \\ u^{y^g} \\ u^{\pi} \\ u^{RBI^{FC}} \\ u^{R} \\ u^{\pi^{e,SPF}} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b1 & 1 & 0 & 0 & 0 & 0 \\ b2 & b6 & 1 & 0 & 0 & 0 \\ b3 & b7 & b10 & 1 & 0 & 0 \\ b4 & b8 & b11 & b13 & 1 & 0 \\ b5 & b9 & b12 & b14 & b15 & 1 \end{pmatrix} \begin{pmatrix} e^{OIL} \\ e^{y^g} \\ e^{\pi} \\ e^{RBI^{FC}} \\ e^{R} \\ e^{\pi^{e,SPF}} \end{pmatrix} \tag{7}$$

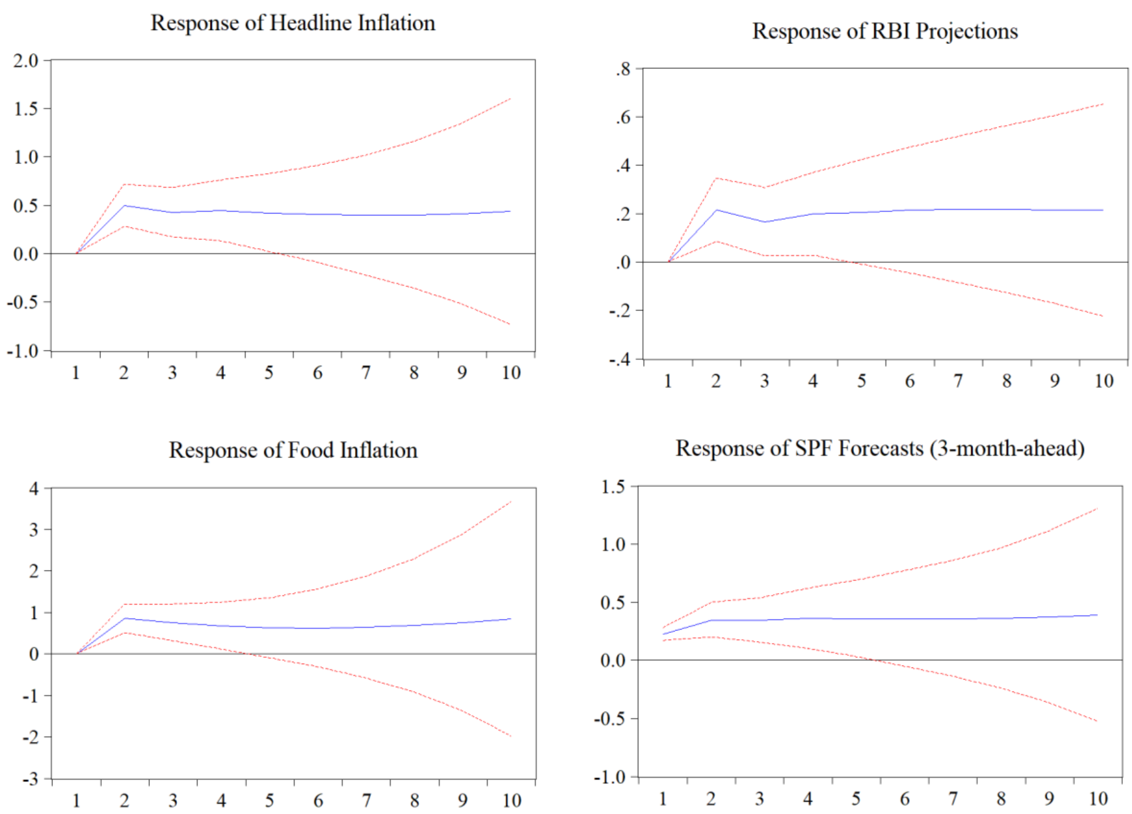
We run robustness checks for all the baseline estimates. We first analyze the effects of expectations shocks on all the other variables, followed by the analysis of the response of expectations to all the shocks. Finally, we check the impulse response functions of core inflation to the shocks in all the variables.

7.1. Impulse Response Functions of Shocks to Inflation Expectations:

Unlike the baseline model, 3-month-ahead household expectations shocks significantly influence RBI projections for 2 quarters. Household expectations respond significantly to their own shocks till the 4th quarter. All other variables show insignificant response to 3-month-ahead expectation shocks. The slight difference in results indicates household inflation expectations are yet to stabilize, but do have some effect. On the other hand, 1-year-ahead household expectations shocks fail to influence any other variable. This result resembles the baseline estimates.[20]

Significant responses of all the variables to 3-month-ahead SPF forecast shocks are given in Figure 8. Headline inflation responds positively till the fifth period and RBI projections till the fourth. While the effects on food inflation persist till the fourth period, SPF forecasts respond to their own shocks till the fifth period. Unlike their 3-month-ahead counterparts, 1-year-ahead SPF forecast shocks do not have a significant influence on any other variable.[21]

Figure 8- Impulse response functions of all variables to shocks in 3-month-ahead SPF forecasts



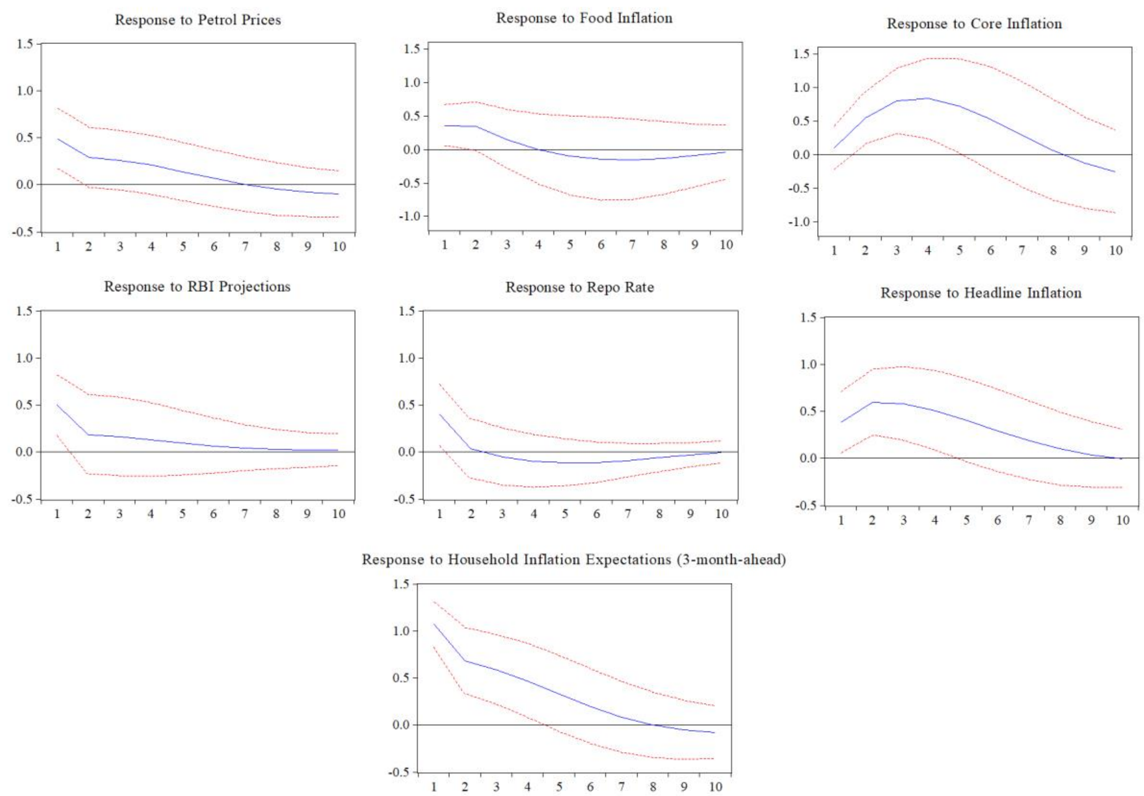
Source: Authors' estimates

[20] Results for responses of all the variables to 3-month-ahead and 1-year-ahead expectations shocks are available with the authors and can be provided upon request.
[21] Results for 1-year-ahead SPF forecasts are available with the authors and can be provided upon request.

7.2. Impulse Response Functions of Inflation Expectations to Shocks in all the variables:

Figure 9 gives significant responses of 3-month-ahead household inflation expectations to all the shocks. These results mimic the findings of Goyal and Parab (2021), since the identification is similar. Petrol price shocks have a positive significant influence only for the first quarter. Household inflation expectations respond significantly to their own shocks till the 5th quarter. While food inflation shocks have a significant short-run effect, core inflation shocks dominate in the long run. Communication shocks and monetary policy shocks display significant positive short-run influence. Positive effects of monetary policy shocks can be related to the cost of borrowing channel.[22] Supply shock effects (headline inflation) persist till the 5th quarter.[23]

Figure 9- Impulse response functions of household inflation expectations (3-month-ahead) to the shocks in all the variables



Source: Authors' estimates

[22] Goyal and Parab (2021) give detailed explanation of the possible reasons for the positive effects of monetary policy shocks on household expectations.

[23] Results are similar for 1-year-ahead household expectations. They are available with the authors and can be provided upon request.

Forecast error variance decompositions of 3-month-ahead household expectations are given in Tables 6 and 7. Demand shocks and monetary policy shocks fail to explain the variations in household expectations significantly. One-fifth of the variations are explained by petrol prices in the first quarter and one-sixth by headline inflation. RBI projections explain 11 percent of the variations in the first quarter. Headline inflation explains more than 40 percent of the changes from the 3rd quarter. Decomposing headline inflation into food and core components shows the dominance of food inflation in explaining the variations in the first 2 quarters while core inflation has larger effects from the 3rd quarter.

Table 6 - Variance decomposition of household inflation expectations (3-month-ahead) to shocks in other variables

Forecast Horizon	Petrol	Output Gap	Headline Inflation	RBI Projections	Repo Rate	HH 3-m Expectations
1	20.95	0.56	16.17	11.03	2.48	48.81
2	16.97	4.84	34.79	6.62	1.69	35.09
3	15.47	5.00	43.15	5.02	1.39	29.97
4	14.67	4.44	46.96	4.34	1.69	27.90
5	14.09	4.10	48.55	4.06	2.24	26.96
6	13.66	4.18	48.97	3.96	2.76	26.48
7	13.41	4.60	48.81	3.91	3.10	26.18
8	13.34	5.17	48.43	3.87	3.25	25.94
9	13.42	5.70	48.04	3.84	3.27	25.73
10	13.59	6.10	47.70	3.82	3.25	25.54

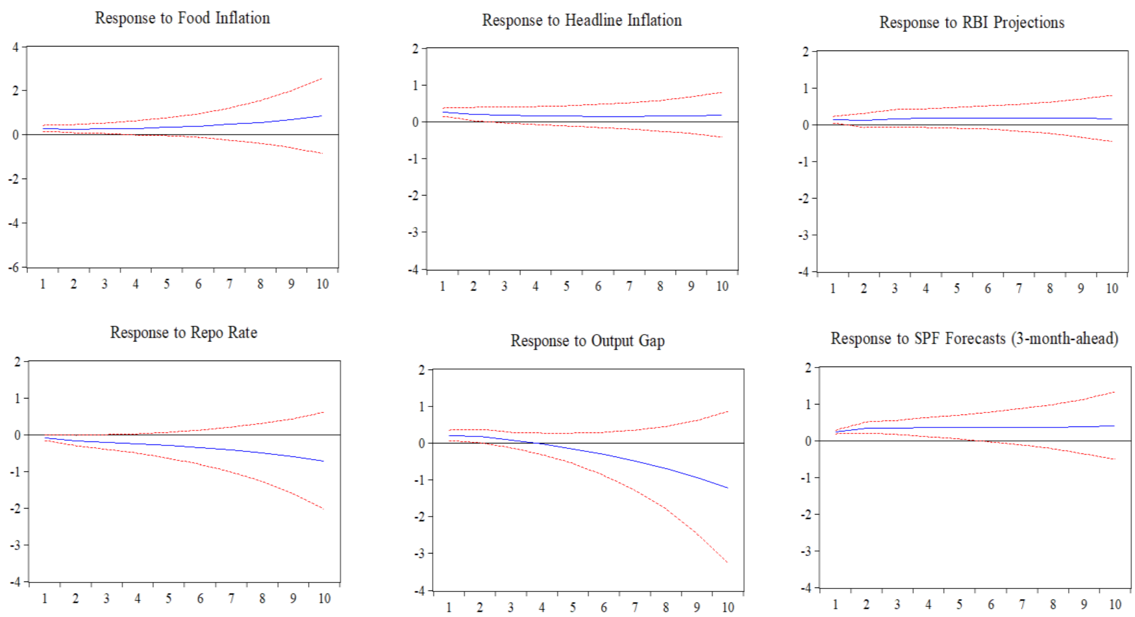
Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

Table 7 - Variance decomposition of household inflation expectations (3-month-ahead) to shocks in other variables (with food and core inflation)

Forecast Horizon	Petrol	Food Inflation	Output Gap	Core Inflation	RBI Projections	Repo Rate	HH 3-m Expectations
1	19.98	15.94	0.34	0.00	15.51	1.29	46.93
2	18.83	19.32	0.29	15.61	10.08	1.01	34.86
3	17.98	14.36	3.23	31.82	6.87	1.23	24.51
4	16.82	10.36	8.15	38.83	5.19	2.60	18.05
5	15.70	8.43	12.27	40.33	4.35	4.30	14.62
6	14.77	7.76	15.11	39.63	3.94	5.86	12.93
7	14.13	7.73	16.78	38.40	3.74	7.04	12.19
8	13.81	7.90	17.45	37.54	3.66	7.71	11.94
9	13.79	8.00	17.44	37.41	3.61	7.90	11.85
10	13.98	7.92	17.12	37.93	3.56	7.78	11.70

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

Figure 10- Impulse response functions of SPF forecasts (3-month-ahead) to the shocks in all the variables



Source: Authors' estimates

Figure 10 gives significant responses of 3-month-ahead SPF forecasts to shocks in all the variables. While the effects of communication shocks die down after the first period, the positive effects of supply shocks (headline inflation) and demand shocks (output gap) last for two periods. Food inflation shocks have persistent effects till the 4th period. Monetary policy shocks display significant negative effects till the 3rd period, in concurrence to the theory. SPF forecasts respond significantly to their own shocks till the end of fifth period. 1-year-ahead SPF forecasts, on the other hand, respond significantly to oil price shocks, supply shocks (headline and food inflation) and to their own shocks.[24]

Tables 8 and 9 give FEVDs of 3-month-ahead SPF forecasts. Both demand shocks and supply shocks explain more than 50 percent of the variations in the first period, dominated by the headline inflation (35 percent). The contribution of headline inflation diminishes with the widening of forecast horizons while that of output gap increases. Repo rate explains significant amount of variations since the 3rd period. RBI projections explain around 8 percent of the variations. Decomposition of headline inflation shows larger influence of food inflation while core inflation explains less than 10 percent of the total variations. These results resemble the baseline estimates.[25] While there are differences, there are sufficient similarities, especially with regard to the effect of communication variables, to consider the results as robust.

Table 8 - Variance decomposition of SPF forecasts (3-month-ahead) to shocks in other variables

Forecast Horizon	Oil Prices	Output Gap	Headline Inflation	RBI Projections	Repo Rate	SPF 3-m Forecasts
1	6.05	19.50	34.67	8.31	4.81	26.65
2	2.77	16.01	25.20	6.37	9.14	40.52
3	3.02	11.00	21.12	8.04	12.81	44.01
4	4.22	7.91	17.82	8.83	16.23	44.99
5	5.29	7.90	15.04	9.06	19.27	43.43
6	5.72	11.49	12.49	8.63	21.80	39.88
7	5.42	18.46	10.11	7.65	23.58	34.78
8	4.60	27.71	7.95	6.36	24.51	28.86
9	3.58	37.71	6.10	5.00	24.67	22.95
10	2.59	47.10	4.60	3.75	24.27	17.68

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

[24] Results for 1-year-ahead SPF forecasts are available with the authors and can be provided upon request.
[25] FEVDs for 1-year-ahead SPF forecasts are available with the authors and can be provided upon request.

Table 9 - Variance decomposition of SPF forecasts (3-month-ahead) to shocks in other variables (with food and core inflation)

Forecast Horizon	Oil Prices	Food Inflation	Output Gap	Core Inflation	RBI Projections	Repo Rate	SPF 3-m Forecasts
1	7.97	40.91	24.58	0.07	4.70	3.25	18.52
2	3.66	33.14	22.37	1.62	3.16	7.03	29.02
3	2.40	31.65	16.54	3.41	4.51	10.26	31.23
4	1.73	31.66	11.87	5.78	5.14	13.02	30.81
5	1.27	31.83	10.24	7.88	5.06	15.30	28.41
6	0.93	31.30	12.94	9.09	4.41	16.91	24.41
7	0.68	29.74	19.74	9.17	3.47	17.68	19.52
8	0.54	27.39	28.93	8.31	2.49	17.67	14.66
9	0.47	24.75	38.42	6.99	1.67	17.17	10.53
10	0.47	22.25	46.78	5.60	1.06	16.47	7.37

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

7.3. Impulse Response Functions of Core Inflation to Shocks in all the variables:

Impulse response analysis based on the ordering with expectations as the most endogenous variable gives significant positive response of core inflation to its own shocks in the models with 3-month-ahead and 1-year-ahead household expectations. Demand shocks (output gap) and monetary policy shocks (Repo rate), however, display significant negative effects till the 3rd quarter. In the model with SPF forecasts (both 3-month-ahead and 1-year-ahead), core inflation responds positively to its own shocks and demand shocks. [26]

Similar to our baseline estimates, we analyze the difference between the effects of RBI^{FC} on core inflation and that of SPF forecasts on RBI^{FC}. Multiplicative effects in these cases as well are less than unity.[27] In a similar manner, the effects of SPF forecasts on core inflation and RBI^{FC} on SPF forecasts too are less than unity.[28]

[26] IRFs of core inflation with 3-month-ahead and 1-year-ahead household expectations and SPF forecasts are available with the authors and can be provided upon request.
[27] For 3-month-ahead SPF the coefficient of SPF on RBI^{FC} is 0.84(0.25)***, RBI^{FC} on core inflation is -0.21(0.18). For 1-year-ahead SPF, coefficient of SPF on RBI^{FC} is 0.23(0.22) and that of RBI^{FC} on core inflation is -0.18(0.16). Wald Chi2 test to compare the two coefficients gave significant results for 3-month-ahead SPF forecasts: 11.18(0.00)*** (3-month), 1.93(0.17) (1-year), indicating that the effects of SPF on RBI^{FC} are significantly different from the effects of RBI^{FC} on core inflation for 3-month-ahead SPF forecasts.
[28] For 3-month-ahead SPF, the coefficient of RBI^{FC} on SPF forecasts is -0.22(0.17), and that of SPF forecasts on core inflation is 0.43(0.26)*. In the case of 1-year-ahead SPF forecasts, the coefficient of RBI^{FC} on SPF forecasts is 0.28(0.18), and that of SPF forecasts on core inflation is -0.29(0.20). Wald Chi2 test gave the following results: 3.89(0.04)** for 3-month-ahead SPF forecasts and 4.28(0.04)** for 1-year-ahead forecasts, indicating that effects

7.4. Sign-Restricted Vector Auto Regression (SRVAR):

In the field of monetary economics dynamic simultaneous equation models are primarily used for policy simulation, whereas SVAR models are used for the analysis of the monetary transmission mechanism (Gottschalk, 2001), where well-accepted intuitive identification restrictions (Christiano et al 1999), compatible with a wide range of theories, are imposed.

However, one criticism is that SVAR models impose hard, informal and arbitrary restrictions on the model, which under certain circumstances, may allow data mining. Hence, some studies like Faust (1998), Uhlig (2005), Rubio-Ramirez et al (2010) and Arias et al (2019) propose sign restrictions for the impulse responses to various shocks in an SVAR model. These models impose relatively weak prior beliefs on the variables. Other alternative identifications, for example Bayesian SVARs, also require strong priors.

Therefore, we continue robustness analysis using sign-restricted VAR (SRVAR) models (Rubio-Ramirez et al (2010)). Rejection method based on Uhlig (2005) paper is the most commonly used SRVAR in the literature. The Rubio-Ramirez et al (2010) [RWZ algorithm] algorithm is a generalized version of Uhlig's algorithm. It differs on two grounds: First, all the posterior draws are kept in practice and second, the orthogonal matrix is a simple draw from the uniform distribution with a single operation of QR decomposition (Rubio-Ramirez et al, 2010).

We undertake impulse response analysis by examining the influence of expectations shocks (household expectations) and forecast shocks (SPF forecasts) on all the variables following the baseline ordering. We impose sign restrictions on the expectations (forecasts) and the Repo rate which responds positively to the shocks, for the first four periods. Results are qualitatively similar to the baseline estimates. None of the variables respond significantly to the household expectations shocks (3-month-ahead and 1-year-ahead). In the case of 3-month-ahead SPF forecasts, RBI projections respond to the forecast shocks with a two-period lag and the effects die down by the fourth period. SRVAR delivers directionally similar results to the baseline estimates for both household expectations and SPF forecasts, again pointing to the robustness of the results.[29]

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of RBI^{FC} on SPF forecasts are significantly different from the effects of SPF forecasts on core inflation for both 3-month-ahead and 1-year-ahead SPF forecasts.

[29] IRFs for household expectations and SPF forecasts (3-month-ahead and 1-year-ahead) are available with the authors and can be provided upon request.

8. Conclusions:

Central bank communication is both challenging and important for an emerging market (EM). Reid and Siklos (2020) point out the difficulties that face EM monetary policy makers while using central bank communications as a policy instrument: a historic lack of monetary policy credibility; the fragile condition of central bank autonomy; the amplified importance of external shocks to domestic inflation; and the potential contrast between headline inflation and the relatively greater sensitivity to volatile food and energy prices. But as Goyal and Parab (2021) point out, more respect for hierarchy and absence of other credible sources of information can give greater impact to central bank communication in EMs.

This paper provides original evidence for the effectiveness of the expectations channel of monetary policy transmission in India using survey-based expectations of households and professional forecasters, with a special emphasis on central bank communications in the form of RBI projections. Using recursive SVAR models, we first examine if expectations shocks affect other variables. We then observe the effects of macroeconomic aggregates on the expectations formation processes of households and professional forecasters. In order to derive the slope of the inflation expectations function and since volatile headline inflation tends to converge to a more stable core, and core inflation affects household inflation expectations in the long run, we finally estimate shocks influencing core inflation.

Household expectations do not feed into any macroeconomic aggregates. 3-month-ahead SPF forecast shocks influence RBI projections, headline and food inflation. Analyzing the expectations formation processes, we find household inflation expectations are primarily influenced by communications shocks and supply-side shocks. Decomposition of headline inflation into food and core components shows significant short-run effects of food-price shocks and long-run influence of core inflation shocks. Monetary policy shocks have a positive but insignificant influence on household expectations. SPF forecasts are significantly influenced by all kinds of shocks barring oil price shocks and demand shocks. However, a significant difference from the household expectations is the negative influence of monetary policy shocks.

Core inflation in the model with household expectations (3-month-ahead and 1-year-ahead) does not respond significantly to any other shocks apart from its own shocks and demand shocks (output gap). In the model with 3-month-ahead SPF forecasts, core inflation responds positively to its own shocks and demand shocks. On the other hand, in the model with 1-year-ahead SPF forecasts, significant movements in core inflation are observed on account of the shocks in RBI projections, output gap and food inflation.

Robustness analysis conducted by changing the order of identification for both household expectations and SPF forecasts gives results similar to the baseline estimates. Monetary policy shocks have positive and significant influence on household expectations in the short run, highlighting the limitations of the aggregate demand channel. Another set of robustness estimations conducted using sign-restricted VAR (SRVAR) gives results similar to the benchmark estimations.

Role of RBI projections as a measure of central bank communications stands out in this analysis. Central bank communications matter in monetary policy decision-making for anchoring inflation expectations by “creating news” or “reducing noise” (Blinder et al., 2008). Policy makers use communications as a monetary policy tool for the following reasons: (1) Build central bank credibility to protect monetary policy institutions; (2) Persuade the price setters to behave in a manner that is consistent with the price stability goal of central banks, thereby improving the effectiveness of monetary policy (Reid and Siklos, 2020).

The fixed point between inflation and its expectations was stable because the response of each variable was less than unity. The interaction between RBI projections and SPF forecasts and the response of core inflation to RBI projections played a key role in this. Core had a major impact on long-run household inflation expectations. The estimations imply core inflation is a stable function of inflation expectations, and can converge faster if supply shocks are contained and the forecasts are made more precise.

Using the expectations channel of monetary policy transmission requires strategic use of central bank communications (Goyal, 2017). Supply-side factors play a decisive role in the Indian scenario. Removal of supply-side bottlenecks to keep food inflation in check, with improved RBI communications can further enhance the effectiveness of expectations channel in India.

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Appendix:

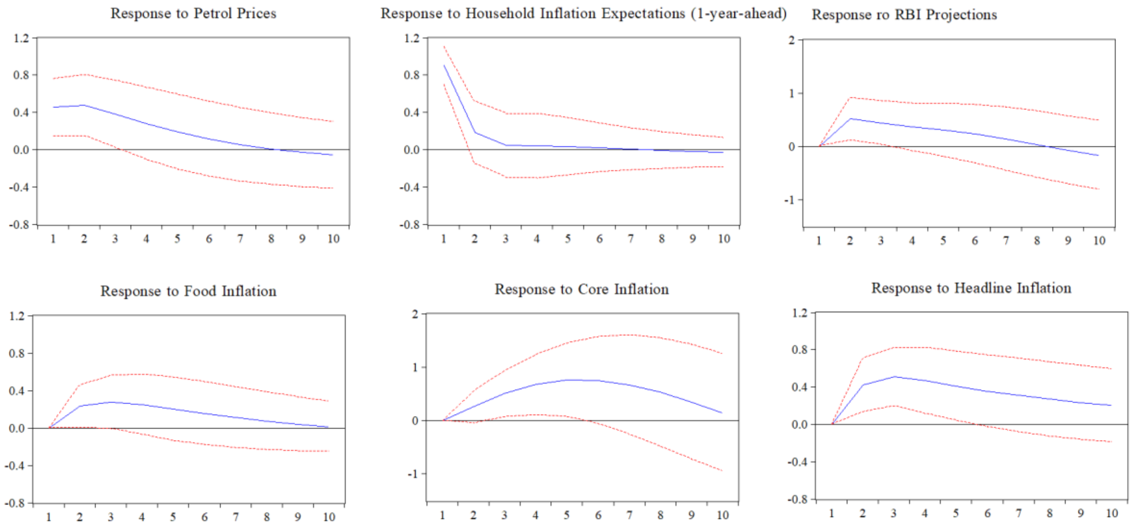
Table A1 – Augmented Dickey Fuller Unit Root Tests

Null Hypothesis: Series contains unit root				
	HH Quarterly (Sep-2008 to Mar-2019)		SPF Bi-monthly (Mar-2014 to Nov-2019)	
Variables	**Level (p-values)**	**First Difference (p-values)**	**Level (p-values)**	**First Difference (p-values)**
Inflation Expectations (3-months)	0.19	0.00***	0.7*	0.01***
Inflation Expectations (1-year)	0.25	0.00***	0.08*	0.00***
Inflation (Headline)	0.26	0.00***	0.06*	0.00***
Food Inflation	0.11	0.00***	0.40	0.00***
Core Inflation	0.71	0.02**	0.01***	
Output Gap	0.01***		0.99	0.04**
Repo Rate	0.42	0.00***	0.09*	0.00***
Oil Price			0.21	0.00***
Petrol	0.90	0.00***		
RBI Projections (for HH)	0.07*	0.00***		
RBI Projections (3-m for SPF)			0.16	0.00***
RBI Projections (1-y for SPF)			0.21	0.00***

Note: Level of Significance- *** - 1%, ** - 5%, * - 10%

Source: Authors' estimates

Figure A1- Responses of 1-year-ahead household inflation expectations to shocks in other variables (baseline estimates)



Source: Authors' estimates

Table A2 - Variance decomposition of 1-year-ahead household inflation expectations to shocks in other variables (baseline estimates of six-variable SVAR)

Forecast Horizon	Petrol	HH 1-y Expectations	RBI Projections	Repo Rate	Output Gap	Headline Inflation
1	20.30	79.70	0.00	0.00	0.00	0.00
2	23.78	50.16	13.46	0.02	2.92	9.66
3	22.94	37.25	17.28	0.07	5.14	17.32
4	21.69	31.63	18.46	0.13	6.33	21.76
5	20.49	28.73	19.20	0.18	6.90	24.49
6	19.47	27.01	19.85	0.21	7.11	26.35
7	18.66	25.90	20.42	0.23	7.11	27.68
8	18.07	25.13	20.90	0.24	7.02	28.65
9	17.68	24.57	21.27	0.24	6.90	29.34
10	17.45	24.16	21.55	0.23	6.78	29.83

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

Table A3 - Variance decomposition of 1-year-ahead household inflation expectations to shocks in other variables (with food and core inflation) [baseline estimates of seven-variable SVAR]

Forecast Horizon	Petrol	HH 1-y Expectations	RBI Projections	Repo Rate	Food Inflation	Output Gap	Core Inflation
1	21.16	78.84	0.00	0.00	0.00	0.00	0.00
2	23.38	51.92	13.99	0.00	4.86	2.06	3.79
3	23.43	38.44	17.62	0.05	5.32	1.77	13.37
4	22.61	29.48	17.35	0.10	4.14	1.63	24.69
5	21.25	23.31	15.70	0.09	3.46	2.76	33.43
6	19.79	19.64	13.71	0.07	3.61	4.85	38.31
7	18.49	17.84	11.90	0.09	4.39	7.31	39.98
8	17.40	17.22	10.54	0.16	5.50	9.66	39.52
9	16.52	17.22	9.74	0.27	6.73	11.58	37.95
10	15.80	17.41	9.55	0.39	7.86	12.86	36.13

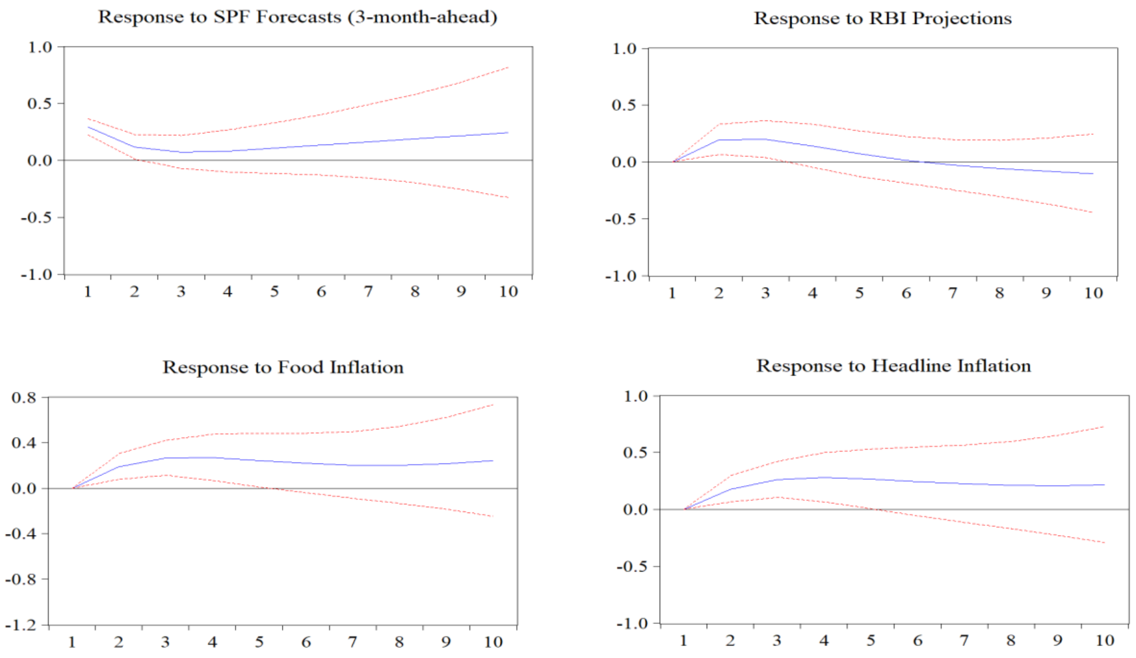
Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

Table A4 - Variance decomposition of 3-month-ahead household inflation expectations to shocks in other variables (with food and core inflation) [baseline estimates of seven-variable SVAR with 2 lags]

Forecast Horizon	Petrol	HH 3-m Expectations	RBI Projections	Repo Rate	Food Inflation	Output Gap	Core Inflation
1	18.82	81.18	0.00	0.00	0.00	0.00	0.00
2	20.93	60.98	7.01	0.96	9.16	0.11	0.84
3	18.57	44.90	9.29	2.21	14.74	0.75	9.54
4	15.66	35.74	8.73	3.12	12.86	8.75	15.15
5	12.14	27.57	6.55	2.72	9.49	20.26	21.26
6	8.74	22.66	4.81	2.16	7.35	28.67	25.61
7	5.92	20.68	3.31	1.66	7.18	33.27	27.98
8	3.98	19.69	2.22	1.33	8.50	36.00	28.29
9	2.73	19.10	1.52	1.06	10.94	37.45	27.19
10	1.92	18.81	1.16	0.85	13.73	37.79	25.74

Notes: Maximum lags 2
Source: Authors' estimates

Figure A2- Responses of 1-year-ahead SPF forecasts to shocks in other variables (baseline estimates)



Source: Authors' estimates

Table A5 - Variance decomposition of 1-year-ahead SPF forecasts to shocks in other variables (baseline estimates of six-variable SVAR)

Forecast Horizon	Oil Prices	SPF 1-y Forecasts	RBI Projections	Repo Rate	Output Gap	Headline Inflation
1	3.22	96.78	0.00	0.00	0.00	0.00
2	1.82	61.13	19.50	0.00	0.40	17.16
3	1.68	41.51	23.81	0.02	0.31	32.66
4	3.55	32.87	21.37	0.02	0.28	41.90
5	6.25	28.85	17.79	0.02	0.73	46.35
6	8.70	26.95	14.80	0.13	1.82	47.61
7	10.32	26.08	12.64	0.52	3.56	46.88
8	10.99	25.64	11.12	1.42	5.89	44.93
9	10.82	25.30	10.00	3.03	8.68	42.18
10	10.03	24.81	9.11	5.46	11.77	38.82

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates

Table A6 - Variance decomposition of 1-year-ahead SPF forecasts to shocks in other variables (with food and core inflation) [baseline estimates of seven-variable SVAR]

Forecast Horizon	Oil Prices	SPF 1-y Forecasts	RBI Projections	Repo Rate	Food Inflation	Output Gap	Core Inflation
1	5.19	94.81	0.00	0.00	0.00	0.00	0.00
2	5.63	54.54	18.24	0.03	20.60	0.74	0.21
3	4.05	35.76	21.57	0.05	37.54	0.89	0.15
4	3.06	28.43	19.89	0.04	47.68	0.71	0.19
5	2.86	25.47	17.35	0.12	53.05	0.69	0.47
6	3.14	24.38	14.97	0.53	54.83	1.24	0.91
7	3.53	24.11	12.97	1.56	53.87	2.62	1.34
8	3.71	24.03	11.33	3.45	50.98	4.89	1.61
9	3.58	23.74	9.99	6.29	46.89	7.84	1.67
10	3.19	23.03	8.91	9.99	42.21	11.11	1.56

Notes: Maximum lags 1 – chosen using the Bayesian Information Criterion.
Source: Authors' estimates