

The dynamics of survey-based household inflation expectations in India

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Abstract

Purpose – The author analyzes households' inflation expectations data for India, collected quarterly by the RBI for more than a decade. The contribution of this paper lies in two folds. First, this study examines the relationship between relatively recent inflation expectations survey of households (IESH) and the actual inflation for India. Secondly, the author employs a structural VAR with the time period 2006 Q2 to 2020 Q2 on inflation expectation survey data of India. A short-term non-recursive restriction is imposed in the model in order to capture the simultaneous co-dependence causal effect of inflation expectation and realized inflation.

Design/methodology/approach – This paper studies the dynamic behavior of inflation expectations survey data in two folds. First, the author analyzes the time series property of the survey data. The author begins with testing the stationarity property of the series, followed by the casual relationship between the expected and actual inflation. The author further examines the short-run and long-run behavior of the IESH with actual inflation. Employing autoregressive distributed lag and Johansen co-integration, the author tested if a long-run relationship exists between the variables. In the second approach, the author investigates the determinants of inflation expectations by employing a non-recursive SVAR model.

Findings – The preliminary explanatory test reveals that inflation expectation is a policy variable and should be used in monetary policy as an instrument variable. The model identifies the price puzzle for India. The author finds that the response of inflation to a monetary policy shock is neutral. The results also indicate that the expectations of the general public are self-fulfilling.

Originality/value – IESH has only commenced from September 2005, hence is relatively new as compared to other survey in developed countries. Being a new data set so far, the author could not locate any study devoted in analyzing the behavior of the data with other macroeconomic variables.

Keywords Inflation expectations, Monetary policy, India, ARDL, VECM, Impulse response function

Paper type Research paper

1. Introduction

Every central bank faces the challenge of keeping the inflation rate within reasonable limits. One of the main factors that determine the rate of inflation is the inflation expectations of various macroeconomic agents in an economy. Thus, central banks try to keep the inflation expectations “well-anchored” primarily by making their policy for targeting inflation public and by sharing the data on the inflation expectations of professional forecasters and the general public. While these policies have been an inherent part of the central banks in developed countries, it is only recently that India has begun following a similar path.

JEL Classification — C22, E31, E52

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Inflation expectations can influence the behavior of economic agents. The inter-temporal decisions like savings, investments, wage negotiations, etc., made by economic agents are highly dependent on their expectations about future inflation. These inter-temporal decisions, in turn, affect economic activity, which further influences actual inflation. If the current inflation rate creates expectations for future inflation, which itself is induced by the expectations of the economic agents, it leads to the creation of an “inflation expectations spiral” in the economy. The effect of the “inflation expectations spiral” can cause high and persistent inflation, thereby reducing the effectiveness of monetary policy for controlling inflation.

In order to control inflation and to avoid the trap of “inflation expectations spiral,” the monetary policymakers must know the pattern and behavior of expected inflation. [Berk \(2002\)](#) indicates that any effect of monetary policy on inflation expectations depends upon the direction and intensity of the causality between the inflation expectations and actual inflation. [Ball *et al.* \(2005\)](#) point out that the dynamic correlation between inflation expectations and realized inflation will help anchor inflation expectations and strengthen the credibility of central banks. In other words, a strong co-relationship between the realized and expected inflation will allow monetary policy to achieve price stability for the economy.

Several studies have presented different conclusions on the relationship between inflation expectations and actual inflation. Among those finding inflation expectations to be self-fulfilling, [Leduc *et al.* \(2007\)](#) prove inflation expectations to be the cause of the high and persistent US inflation rate of the 1970s. [Mavroeidis *et al.* \(2014\)](#) study shows that inflation expectations could cause inflation in a self-fulfilling spiral. Other studies, on the other hand, conclude that actual inflation has significant effects on inflation expectations. The expectations-augmented Phillips Curve predicts that actual and expected inflation would move in a coordinated and balanced relationship ([Phelps, 1967](#)). Furthermore, studies like [Chen \(2008\)](#) demonstrate a significant positive correlation between the expectations of future inflation and current actual inflation. [Feng and Zhu \(2012\)](#) study document a causal relationship from expected inflation to actual inflation.

In addition to the unidirectional nexus indicated by the above literature, other studies support a bi-directional relationship between inflation expectations and actual inflation. [Patra and Ray \(2010\)](#) certify bidirectional causality between the inflation expectations and the actual inflation. They state that the increase in inflation may cause an increase in inflation expectations, which will further drive up inflation. [Reid \(2015\)](#) finds a causal relationship between realized inflation and inflation expectations in South Africa. The change in inflation occurs first, followed by a similarly adjusted change in expectations. Using impulse responses, [Kim and Lee \(2013\)](#) illustrate the dynamic effects on actual inflation due to the shocks of the inflation expectation for Asian countries.

Previous research provides evidence of opposing and supporting the lead-lag relationship between expected and actual inflation and even supporting the bi-directional linkages. The existence of such vivid literature indicates the importance of the studies. Our study, highly intertwined with the existing literature, attempts to identify the relationship between actual and expected inflation for India.

The contribution of this paper to the existing literature is as follows. First, this study examines the relationship between relatively recent inflation expectations survey of households (IESH) and the actual inflation for India. The survey has only commenced from September 2005; hence it is relatively new than other surveys in developed countries. Being a new data set so far, we could not locate any study devoted to analyzing the behavior of the data with other macroeconomic variables. Second, like other developed countries, India recently (June 2016) has formally adopted inflation targeting as its framework. With inflation targeting as its framework, analyzing the dynamic behavior of inflation expectations becomes of paramount importance.

This paper studies the dynamic behavior of inflation expectations survey data in two folds. First, we analyze the time series property of the survey data. We begin with testing the stationarity property of the series, followed by the casual relationship between the expected and actual inflation. Our study reveals inflation expectations survey data to be stationary at the first difference and indicates a causal relationship between actual consumer price index (CPI) and wholesale price index (WPI) inflation and the expected inflation. Second, we proceed further by examining the short-run and long-run behavior of the IESH with actual inflation. Employing autoregressive distributed lag (ARDL) and Johansen co-integration, we test if a long-run relationship exists between actual CPI and WPI inflation and households' inflation expectations survey data.

Further, use structural vector auto regressive (SVAR) model to study the various determinants of inflation expectation and their effects on economic variables and inflation. We construct a four-variable VAR with the output gap, nominal interest rate, inflation and inflation expectation as our endogenous variable. We impose a non-recursive restriction in our VAR, as inflation expectation attributes simultaneous co-dependence causal effect with realized inflation.

Inflation in India is measured by the WPI and CPI. WPI measures the inflation from the producer side as its basket constitutes wholesale goods. The CPI is mainly considered as consumer side inflation as the basket consists of consumer goods. In our analysis for both the dynamic nature of inflation expectations and the SVAR, we use CPI as our realized inflation. Since inflation expectations collected by RBI are household survey data, we believe that a lot of general public expectations must be based on the price of their day-to-day consumption. Hence CPI comes into play. Secondly, we find a long-run correlation of survey data with CPI and not WPI inflation. Moreover, the lagged CPI inflation shows a better correlation with survey data than the lagged WPI.

This paper is organized in the following manner: [Section 2](#) explains the data set used for the analyses. Next, [Section 3](#) reports on the unit root test results for analyzing the stationarity of the data and the Granger causality results. Further, [Section 4](#) explains the long-run relationship between realized inflation and the IESH. [Section 5](#) provides the genesis of structural vector autoregressive (SVAR), [Section 6](#) presents the results, and [Section 7](#) concludes.

2. Data

2.1 Inflation expectations survey of households [\[1\]](#)

Reserve Bank of India (RBI) initiated a survey of the inflation expectations of the general public (IESH) since September 2005. The survey has both qualitative and quantitative responses regarding the changes in price levels and the rate of inflation for three months and one year ahead.

The survey data has been published in the public domain since September 2006. Recently, the 63rd round of the survey concluded, collecting responses from around 6,000 households. A visual representation of survey-based inflation expectations variable and actual inflation gives us a quick idea about how these series move over time.

[Figure 1](#) reveals the relationship between household inflation expectations and actual inflation: CPI and WPI. In the initial period, [Figure 1](#) depicts a lag relationship of inflation expectations with the CPI inflation. It could be said; initially, the inflation CPI is leading the public perception in a very early stage of the survey. This pattern of households' inflation expectations and actual CPI inflation can only be witnessed till the 2008 financial crisis. During the global recession of 2007–08, the public expectations about inflation were higher than the actual CPI inflation.

Similarly, the highest peak in actual inflation was witnessed in the second quarter of 2009 (15.2%), whereas the expectations were at their highest four-quarters earlier, i.e. in the second

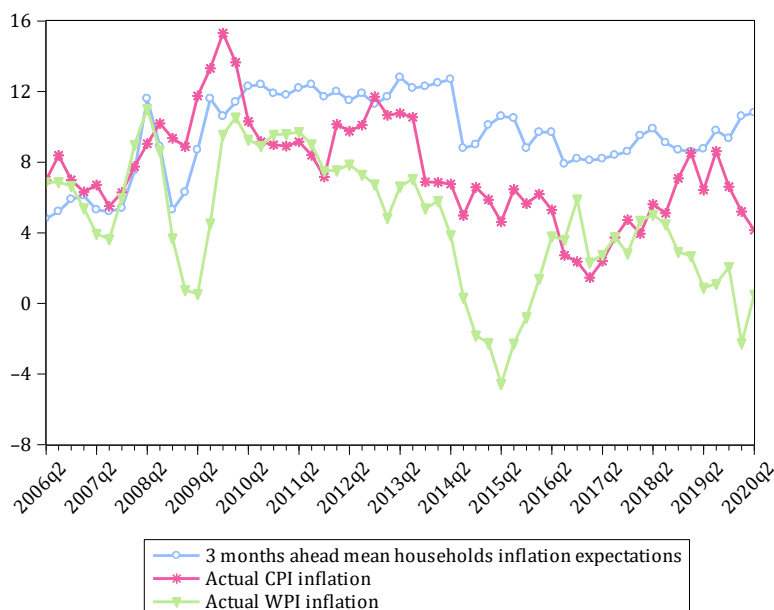


Figure 1.
Households inflation
expectations and
actual inflation

quarter of 2008 (13.5%). Since that time, the expectations have always responded to the CPI with lags. The trend that is clear from the figure is that the expectations, no matter the situation in the economy, have always remained higher than the actual CPI inflation.

Unlike the CPI inflation, the earlier observations show that expectations are in line with the WPI inflation. Until the second quarter of 2008, the general public's expectations followed the WPI inflation, i.e. during the same period the highest peak was obtained for all of the variables. The divergence in the data is seen after this, i.e. when the WPI inflation drops, the expectations fall in response, but then they rise again. One reason for this rise in inflation expectations may be CPI inflation. The CPI inflation increased to 15.3% in quarter two of 2009. Hence, this may have pulled the inflation expectations up. Looking at the data, we believe that since WPI has been the policy variable in India for a long time, people's expectations in the starting quarters were based on it. Gradually, as the survey proceeded, the public began relating their expectations to the prices of the basket of goods consumed by them rather than WPI. Hence, we find that expectations started to connect more to CPI rather than WPI, despite the latter being the policy variable until 2016.

Table 1 contains the statistical summaries of the variables of our interest. Both CPI and WPI are positively and significantly correlated with the three-month-ahead inflation expectations. A quick observation of the results shows inflation CPI (mean = 7.49 and std. dev. = 2.89) to be closely associated with the three-months ahead mean households' inflation expectations (mean = 9.60 and std. dev. = 2.31) than the WPI inflation (mean = 4.58 and std. dev. = 3.71).

2.2 Output gap

To generate the output gap, we collect the Gross Domestic Product (GDP) at factor cost from the RBI database on the Indian economy. The output gap is the difference between the seasonally adjusted real GDP series using the X-11 ARIMA method and the trend computed through the HP filter.

All the other data like CPI inflation, WPI inflation and repo rate is obtained from the database of the Indian economy (DBIE), RBI. The analysis runs from the second quarter of 2006 until the second quarter of 2020. The survey data on inflation expectations is available in the public domain from the second quarter of 2006 onward; hence, we commence our analysis from this period.

3. Empirical analysis

This part of our study is an attempt to better understand the survey-based inflation expectations of the general public. We begin by exploring the economic relation of inflation expectations with actual or realized inflation by investigating the time-series properties of the former. We start by testing the stationarity property for both CPI and WPI of inflation, with a particular focus on the tests meant for small samples; then we analyze the causality relation between the two series on realized and survey-based inflation expectations, and, finally, examine the existence of a long-run relationship between the series.

3.1 Stationarity property

As a first step in determining the time-series properties of survey-based inflation expectations, we investigate its stationarity property. A stationary time series has a constant mean and variance over time. We check the hypothesis that IESH has no systematic trend, no systematic change in the variance and no periodicity or seasonality to the series.

We investigate the presence of a unit root with the following four tests – augmented Dickey–Fuller (ADF), Phillips Perron (PP), Dickey–Fuller generalized least square (DF-GLS), and Ng-Perron. The reason for using all four tests is as follows. The ADF and PP tests are widely used in the unit root literature, though they suffer from drawbacks. The ADF test is known to have low power, and the PP test does not perform well with small samples (Davidson and Mackinnon, 2004).

Perron and Ng (1996), Elliot *et al.* (1996) and Ng and Perron (2001) have modified the traditional ADF and PP tests to mitigate the size distortion and to increase the power of each test for every persistent alternative. We incorporate these tests for our time series data since the sample size is small and provides the robustness check.

Elliot *et al.* (1996) proposed an efficient test modifying the Dickey–Fuller test statistic using a generalized least square (GLS) method. They demonstrate that the modified test has the best overall performance in small sample size and power tests, conclusively dominating the standard Dickey–Fuller test. In particular, Elliott *et al.* (1996) find that their “DF-GLS” test “has substantially improved power when an unknown mean or trend is present.”(1996, p. 813).

Therefore, the DF-GLS and NG-Perron [2] unit root tests are also conducted, as they perform better with small samples. All these tests deliver robust results, suggesting that the series is stationary.

Table 2 indicates that all the variables are stationary at first difference.

Table 1.
Statistical summary of realized inflation and survey-based inflation expectations in India

Variables	Mean	SD	Correlation with three-months-ahead inflation expectations
Inflation CPI	7.49	2.89	0.37*** (2.94)
Inflation WPI	4.58	3.71	0.25*** (1.93)
3-months-ahead inflation expectations	9.60	2.32	–

Note(s): *t*-statistics are reported in brackets. The time period covered is between 2006Q2 and 2020Q2

3.2 Pairwise Granger causality

As outlined in the Introduction section, inflation expectations are an essential variable for policymakers since this variable might both affect and get affected by actual or realized inflation. Therefore, a two-way causal relationship is suspected between these two variables. We investigate whether such a relationship prevails between survey-based inflation expectations and actual CPI and WPI inflations in India. The results of the Granger causality tests are presented in Table 3.

Results from Table 3 support the hypothesis that a causal relationship exists between the CPI inflation and inflation expectations. CPI inflation comprises the prices of consumer goods and services; a two-way relationship between CPI inflation and inflation expectations of the general public is justified. For WPI inflation, we find a mixed result. Table 3 first row indicates a weak acceptance of the null hypothesis of inflation expectations with WPI inflation. At the same time, the vice-versa does hold. One of the reasons for such a discrepancy could be that the general public relates more to the prices of the goods they regularly consume rather than the wholesale prices relevant to the producers. This was perhaps the primary reason why the Urjit Patel Committee Report in 2014 recommended that CPI inflation be the official measure of inflation instead of the WPI inflation. It was formally accepted as an official measure of inflation in 2016 by RBI.

On identifying the causal relationship between the actual and expected inflation, we try to identify the short- and long-run relationship between them. The two econometric approaches widely used to determine the short and long-run relationship are the ARDL – ECM and vector error correcting method (VECM) approach.

Both approaches mentioned above have their specifications like ARDL – ECM can only be used when anyone series is stationary at $I(0)$. In contrast, VECM is used when series are integrated at $I(1)$ and are co-integrated in the long run. In our case, all our series are stationary at $I(1)$ (as depicted in Table 2). However, in the literature, there is debate regarding the stationarity of the inflation series. Juselius (2006) mentions that inflation series can be stationary at a level if the series is considered for more extended periods; otherwise, the series remains non-stationary. Since the time period of survey-based inflation data is limited in the Indian context, it is not surprising that the data series is stationary at the first difference and

Table 2.
Unit root tests for
survey-based inflation
expectations and
actual inflation

Variables	ADF	Unit root tests PP	DF-GLS
<i>At first difference</i>			
3-months ahead mean inflation expectations	−6.81***	−7.33***	−6.79***
CPI inflation	−3.47**	−7.44***	−6.34**
WPI inflation	−5.53***	−5.23***	−5.53***

Note(s): ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The time period covered is between 2006Q2 and 2020Q2

Table 3.
Granger Causality test

Null hypothesis	Probability (lag 2)
Inflation expectations does not Granger cause WPI inflation	0.10
WPI inflation does not Granger cause inflation expectations	0.94
Inflation expectations does not Granger cause CPI inflation	0.39
CPI inflation does not Granger cause inflation expectations	0.17

Note(s): The lag for the test is chosen based on the Schwarz Bayesian information criterion

not at levels. However, [Reid \(2015\)](#) estimates the ARDL –ECM (error correction model) and VECM model for measuring the stickiness of survey-based inflation expectations for South Africa for 40 observations. The study considers inflation to be stationary at both levels and the first difference. Following the same line, we also analyze the long-run relationship of households' survey-based inflation expectations with actual inflation using the ARDL and VECM approach.

3.3 ARDL bound testing approach

Considering that the actual inflation can also be stationary at the level, we examine the long-run relationship between inflation expectations and realized inflation following the ARDL bound test approach to co-integration developed by [Pesaran et al. \(2001\)](#). ARDL is considered a better way of testing a long-run relationship. Firstly, it can be used for series that are not stationary at the same level, i.e. it can be applied to the series irrespective of I(0) or I(1). Secondly, it can simultaneously estimate short-run and long-run parameters. Thirdly, it has better small sample properties ([Smyth and Narayan, 2006](#)). The following unrestricted error correction model is estimated for ARDL:

$$\begin{aligned} \Delta IESH_t = & \alpha_{01} + \alpha_{12} IESH_{t-1} + \alpha_{21} \text{InfCPI}_{t-1} \\ & + \sum_{i=0}^p \alpha_{1i} \Delta IESH_{t-i} + \sum_{j=0}^q \alpha_{1j} \Delta \text{InfCPI}_{t-j} + \varepsilon_t \end{aligned} \quad (1)$$

$$\begin{aligned} \Delta IESH_t = & \alpha_{02} + \alpha_{12} IESH_{t-1} + \alpha_{22} \text{InfWPI}_{t-1} \\ & + \sum_{i=0}^p \alpha_{1i} \Delta IESH_{t-i} + \sum_{j=0}^q \alpha_{1j} \Delta \text{InfWPI}_{t-j} + \mu_t \end{aligned} \quad (2)$$

Where, Δ is the first difference operator, α_{01} is the constant, α_{12} and α_{21} are the long-run coefficients and α_i and α_j represents the short-run coefficients. The ε_t is the white noise error term. The optimal lag structure for the ARDL approach is determined by Schwarz Bayesian information criterion. We estimate [equation 2](#) to determine the long-run relation of IESH with inflation WPI.

To determine the long-run relationship between the variables, two separate bound tests are performed: a Wald or F -test for the joint null hypothesis $H_0: \alpha_{12} = \alpha_{21} = 0$ and a t -test on lagged dependent variable. The asymptotic distribution of the F -test is non-standard; one can use the value of the critical bound provided by [Pesaran et al. \(2001\)](#). There are two asymptotic critical values computed by [Pesaran et al. \(2001\)](#); one at I(0), that variables are considered not to be co-integrated, and second at I(1) when variables are co-integrated. The I(0) is regarded as lower critical bound (LCB) and I(1) as upper critical bound (UCB). If the test statistic exceeds the UCB, then the variables are co-integrated in the long run. Additionally, if the test statistic is below the LCB, the null hypothesis of no co-integration is not rejected. On the other hand, if test statistics lie between LCB and UCB, the results are inconclusive. [equation \(1\)](#) and [equation \(2\)](#) in the ARDL version of the error correction model can be expressed as [equation \(3\)](#) and (4), respectively below.

$$\Delta IESH_t = \alpha_{01} + \sum_{i=0}^p \alpha_{1i} \Delta IESH_{t-i} + \sum_{j=0}^q \alpha_{1j} \Delta \text{InfCPI}_{t-j} + \lambda \text{ECM}_{t-1} + \varepsilon_t \quad (3)$$

$$\Delta IESH_t = \alpha_{02} + \sum_{i=0}^p \alpha_{1i} \Delta IESH_{t-i} + \sum_{j=0}^q \alpha_{1j} \Delta \text{InfWPI}_{t-j} + \lambda \text{ECM}_{t-1} + \varepsilon_t \quad (4)$$

Where, λ is the speed of adjustment parameter, and ECM is the residuals obtained from the estimated co-integration model of equations (1) and (2). The α_{1i} and α_{1j} if significant, provides evidence on the direction of the short-run causation while a significant t -statistic for the ECM depicts the presence of significant long-run causation.

Table 4 presents the bound test result. The calculated F -statistics (5.53) is greater than the UCB at a 10% significance level for CPI inflation. Whereas for WPI inflation, the F -statistics is lower than UCB for all the significance levels. Hence we conclude based on the results that there exists no co-integration relation between IESH and WPI inflation. This inspection of IESH with CPI and WPI inflation separately provides us with some insight, but because the results obtained are not significant at a higher degree as well as the unit root result proves the actual inflation series to be stationary at I(1), we avoid the ARDL regression. In order to establish the long-run relationship, we run a VECM. The result of which is present in the next section.

4. Long-run co-integration between inflation expectations and realized inflation

The causality test above indicates the actual CPI and WPI inflation cause households' inflation expectation. The linear relationship between the two variables can be expressed as equation 5.

$$\pi_t^e = \alpha + \beta\pi_t + e_t \quad (5)$$

Where, π_t^e is the inflation expectations and π_t is the actual inflation. The econometric analysis of equation 5 is possible only when the relationship as established is stable. For a stable relationship, the variables should be stationary. Our unit root test suggests that the households' inflation expectations and actual inflation are non-stationary at levels, thereby stationary at I(1). Being non-stationary, there is a high tendency that these variables may not converge to equilibrium in the long run.

Moreover, the deviations from the equilibrium will not be eliminated in the long run. However, if the series are co-integrated, linked up in the long run, then the linear combination of the two series shall be stationary. Solving for the error term, we can rewrite equation 5 as equation 6 below.

$$e_t = \pi_t^e - \beta\pi_t \quad (6)$$

Since the error term is stationary, the linear term of the right-hand side variable of equation 6 must also be stationary. Thus the time path of two non-stationary variables must be linked, that is, they must be co-integrated.

Panel I: bound test to co-integration

Estimated model	$F_{\text{cpi}}(\text{IESH}/\text{InfCPI})$	$F_{\text{wpi}}(\text{IESH}/\text{InfWPI})$
Optimal lag length	[4,0]	[4,1]
F -statistics	5.53*	3.57
Significance level	Lower bound I(0)	Upper bound I(1)
1%	6.84	7.84
5%	4.94	5.73
10%	4.04	4.78

Panel II: Diagnostic test

R square	0.76	0.78
Adjusted R square	0.73	0.75
SE.E.	1.09	1.05

Note(s): ***, ** and * indicate significance at 1%, 5 and 10% levels respectively

Table 4.
Results of co-
integration test

A characteristic of co-integrated variables is that their time path depends upon the extent of deviations from equilibrium, for if such deviations are temporary, at least one of the variables has to move to restore the equilibrium. From the following system of equations, equilibrium can restore at period t either by a decline in expected inflation, an increase in actual inflation, or a combination of both.

$$\begin{aligned}\Delta\pi_t^e &= \delta_{\pi^e}(\pi_{t-1}^e - \beta\pi_{t-1}) + \varepsilon_{t\pi^e}, & \delta_{\pi^e} &> 0 \\ \Delta\pi_t &= \delta_{\pi}(\pi_{t-1}^e - \beta\pi_{t-1}) + \varepsilon_{t\pi}, & \delta_{\pi} &< 0\end{aligned}\quad (7)$$

Equation 7 above represents the ECM. In an ECM, the deviations from the equilibrium influence the short-term dynamics of the variables. The inflation expectations and actual inflation change in response to the stochastic shocks ($\varepsilon_{t\pi^e}$ and $\varepsilon_{t\pi}$) and to previous period deviations from the long-run equilibrium. If the long-run deviation ($\pi_{t-1}^e - \beta\pi_{t-1} > 0$) is positive, then the inflation expectations would rise, and actual inflation would fall to equilibrium. We further incorporate the lagged term of each variable in both the above equations.

$$\begin{aligned}\Delta\pi_t^e &= \alpha_{10} + \alpha_{\pi^e}(\pi_{t-1}^e - \beta\pi_{t-1}) + \sum \alpha_{11}(i)\Delta\pi_{t-i}^e + \sum \alpha_{12}(i)\Delta\pi_{t-i} + \varepsilon_{t\pi^e} \\ \Delta\pi_t &= \alpha_{20} - \alpha_{\pi}(\pi_{t-1}^e - \beta\pi_{t-1}) + \sum \alpha_{21}(i)\Delta\pi_{t-i}^e + \sum \alpha_{22}(i)\Delta\pi_{t-i} + \varepsilon_{t\pi}\end{aligned}$$

The two variable error correction equations above is a bivariate VAR in first difference augmented by error correction terms $\alpha_{\pi^e}(\pi_{t-1}^e - \beta\pi_{t-1})$ and $\alpha_{\pi}(\pi_{t-1}^e - \beta\pi_{t-1})$ coined as a vector error correction model (VECM). The parameters α_{π^e} and α_{π} is termed as the speed of adjustment parameters. The larger the α_{π^e} , the greater the response of inflation expectations to the previous period deviations from long-run equilibrium. At the opposite extreme, a very small value of α_{π^e} indicate that the inflation expectations are unresponsive to long-run deviations.

We test the co-integration between the series using Johansen co-integration. The lag length for each series is based on Schwartz–Bayes lag selection criterion. The chosen lag structure for CPI and WPI inflation is 1 lag each. The results of Johansen co-integration identify both the actual inflation to be co-integrated with households' inflation expectations in the long run. In order to understand the short-run and long-run dynamics of the variables, we estimate a VECM model. Table 5 presents the result of the model.

The first and second column of Table 5 presents the VECM results of households' inflation expectations with CPI inflation and WPI inflation. The first panel of the table indicates the long-run dynamics. When interpreted in terms of long-run elasticity, the results indicate a 0.40% change in CPI inflation and 0.51% changes in WPI inflation in response to a 1% change in inflation expectations.

The second panel of Table 5 reports the short-run dynamics of the model. The lagged coefficient of the inflation expectations and actual inflation is not significant but are of correct signs. The “speed of adjustment” coefficient, which depicts the speed at which the deviation is adjusted in the long run, is statistically significant at the 1% significance level. The sign of the speed of adjustment is in accord with the convergence to the long-run equilibrium. The previous period deviation from the long-run equilibrium is corrected in the current period at the speed of 28 and 14% for CPI and WPI inflation, respectively.

The last panel of Table 5 describes the diagnostic test of the model. The null hypothesis of no serial correlation fails to reject as the p -value of chi-square is higher than the 5% level. Hence there is a presence of no serial correlation in residuals of the model. The residuals are all free from heteroskedasticity as the null hypothesis of the presence is rejected with a p -value of 0.16% for CPI inflation, whereas for WPI inflation, the null is not rejected (0.05).

Dependent variable: IESH

Variable	3-months ahead inflation expectations CPI inflation	3-months ahead inflation expectations WPI inflation
<i>Long-run results</i>		
Constant	-6.65	-12.04
InfCPI(-1)	-0.40*	NA
InfWPI(-1)	NA	0.51
<i>Short-run results</i>		
Constant	0.08	0.10
D(IESH(-1))	0.18	0.10
D(InfCPI(-1))	-0.16	NA
D(InfWPI(-1))	NA	0.05
Speed of adjustment	-0.29***	-0.14**
<i>Diagnostic tests</i>		
LM stat (AC)	0.12	0.11
χ^2 stat _{W,HS}	0.16	0.05
Q stat Portmanteau	0.47	0.27

Note(s): ***, ** and * indicate significance at 1, 5 and 10% levels respectively. Values reported in the last row of the table are the p -value of the diagnostic tests

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Table 5.
The VECM long-run
and short-run results

The model diagnostic test in the last row of the table notes the p -value of the test. The LM test is done for the presence of serial correlation in the residual of the model. The null of the test states absence of serial correlation. p -value is greater than 5% indicates acceptance of the null hypothesis. Hence our model is free from serial correlation. Further, the p -value of the chi-square for the absence of heteroskedasticity is done in the last row. The p -value greater than and equal to 5% indicates that the residuals are all homoscedasticity.

5. SVAR methodology

We use a SVAR methodology to examine the determinants of inflation expectations of households in India. We write the SVAR model in the following way for p order:

$$A_0 X_t = A_1 X_{t-1} + A_2 X_{t-2} + \dots + A_p X_{t-p} + e_t \quad (8)$$

Where, X_t is a vector of n endogenous variables at time period t . The structured shock in the model is given by e_t , is assumed to follow white noise innovation, i.e. uncorrelated, and the variance and covariance matrix are of the $n \times n$ identity matrix. The A_0 is defined by

$$A_0 = \begin{bmatrix} 1 & -a_{12}^0 & \dots & -a_{n1}^0 \\ \vdots & \vdots & \dots & \vdots \\ \vdots & \vdots & \dots & \vdots \\ -a_{n1}^0 & -a_{n2}^0 & \dots & 1 \end{bmatrix}$$

Where, A_0 is $n \times n$ matrix whose row i and column j element is a_{ij}^s for $s = 1, 2, 3 \dots p$.

Now, if each side of the equation is pre-multiplied by A_0^{-1} , the result will be:

$$x_t = \gamma_1 x_{t-1} + \gamma_2 x_{t-2} + \dots + \gamma_p x_{t-p} + v_t \quad (9)$$

Where, $\gamma_s = A_0^{-1}A_s$, for $s = 1, 2, 3, \dots, p$

$$v_t = A_0^{-1}e_t.$$

Thus [equation 9](#) above is the reduced form of dynamic SVAR of [equation 8](#). The structural form error e_t term and the reduced form residuals v_t are related as follows:

$$e_t = A_0v_t$$

To estimate the parameters from the structural form of the model, the models must be exactly or over-identified. A restriction is now imposed to identify the mutually independent structural shocks that will cause the independent variable to fluctuate. The number of restrictions that are imposed for any VAR model is $n(n-1)/2$.

The literature widely supports the imposition of recursive restriction on the VAR model, especially in monetary policy [[3](#)]. [Leduc et al. \(2007\)](#) use the recursive model restriction to identify the structural shocks. [Mishra and Mishra \(2010\)](#) use the recursive VAR model to identify and measure the monetary policy shock on the real side of the economy with respect to India.

A recursive model has all casual effects in a unidirectional framework; hence there lacks the bidirectional impact of the variable. In a non-recursive model, the causal effect can be represented as both unidirectional and reciprocal. [Sims \(1986\)](#) employs the VAR model for policy analysis. He argues that the policy-making decision consists of some identifying assumptions, and these assumptions in the econometric policy-making model may not be certain. Hence, a VAR model can be used as it can incorporate the uncertainty in the identification issue. Other works that include non-recursive restrictions in SVAR are [Gordon and Leeper \(1994\)](#), [Sims and Zha \(1998\)](#) and [Leeper et al. \(1996\)](#). [Ueda \(2010\)](#) employs a non-recursive restriction on the reduced form of the SVAR model for understanding the determinants of inflation expectation. He emphasizes using non-recursive restrictions as inflation expectation has a dual casual effect, i.e. it is affected by and affects inflation. Hence we too employ a non-recursive limitation in our model.

We estimate a VAR model with four endogenous variables. The output gap (y_t), the short-term nominal interest rate (i_t), the past inflation rate (π_t) and the inflation expectation rate at time period t (π_t^e). We consider the repo rate to be our short-term nominal interest rate. The inflation rate is the CPI, which constitutes the consumer basket. Also, CPI does show a long-run correlation with household expectations. The real GDP at factor cost is taken for computing the output gap. The output gap is the difference between the actual and potential GDP. So for our analysis, we compute the output gap by differencing the real GDP (seasonally adjusted) by its trend obtained by the HP filter. For de-seasoning, we use the X-11 algorithm from the US Commerce Department. The inflation expectations are three months mean household expectation survey data that RBI quarterly collects for 18 cities presently. The sample period for our analysis is 2006Q2 to 2020Q2.

The zero restriction imposed on our model is described below. The four variables that are represented by $X_t = \{y_t, \pi_{t-1}, i_t, \pi_t^e\}$, the A_0 the coefficient matrix in the equation is:

$$A_0 = \begin{bmatrix} X & 0 & 0 & 0 \\ 0 & X & 0 & X \\ X & 0 & X & X \\ X & X & X & X \end{bmatrix}$$

The number of restrictions that we impose is equal to $n(n-1)/2$. So as we have four variables, the restrictions imposed in the model are $4(4-1)/2 = 6$ zero restrictions. By imposing these restrictions, the equation yields:

$$\begin{aligned}
y_t &= A_1(L)X_{t-1} + e_t^y \\
i_t &= \beta_1 \pi_t^e + A_2(L)X_{t-1} + e_t^i \\
\pi_{t-1} &= \beta_2 y_t + \beta_3 \pi_t^e + A_3(L)X_{t-1} + e_t^p \\
\pi_t^e &= \beta_4 y_t - \beta_5 i_t + \beta_6 \pi_{t-1} + A_4(L)X_{t-1} + e_t^{pe}
\end{aligned}$$

These restrictions imply the following rationale:

The output gap response only to the lagged variable and does not affect any of the contemporaneous variables. The shock associated with the equation implies the demand shock. The second equation represents the interest rate equation. The central bank sets the interest rate. Since the other economic variables like output gap and inflation rate affect the economy with a lag, only inflation expectations are a proxy for their own expectation (Ueda, 2010). The inclusion of the expectations variable in the equation determines the forward-looking behavior of the policymakers. Kim (1999) and Sims and Zha (2006) assume this to be an essential non-recursive restriction. The corresponding shock is the interest rate or monetary policy shock by the central bank. The coefficient of β_1 is expected to be positive. The third equation, past inflation CPI, is not contemporaneously related to interest rate because of lagged effect of monetary policy. This equation is comparable to new Keynesian Phillips Curve. The coefficient of β_2 and β_3 are expected to be positive, and in the case of purely forward-looking NKPC the β_3 is expected to be less than or close to unity. The corresponding shock is interpreted as an unexpected shock in the Phillips Curve. There is no restriction imposed in the fourth equation. Inflation expectation is an unobserved component; hence what effect more is indecisive. Moreover, the model's objective is to understand the determinants of inflation expectation; hence there was no restriction imposed. Also, while making expectation general public do consider all information past or in contemporaneous form. The corresponding shock is interpreted as inflation expectation shock.

Figure 2 represents the non-recursive restriction that is imposed in the model.

6. Estimated results

6.1 Variance decomposition

Table 6 presents the variance decomposition results for all the four endogenous variables at the horizon of 1, 2, 3, 4, 8 and 12 quarters.

The contribution of the monetary policy shock to the expected inflation is about 30% in the short run. Its contribution to realized inflation is relatively negligible, primarily due to price stickiness. Secondly, the contribution of the demand shock to the realized inflation is

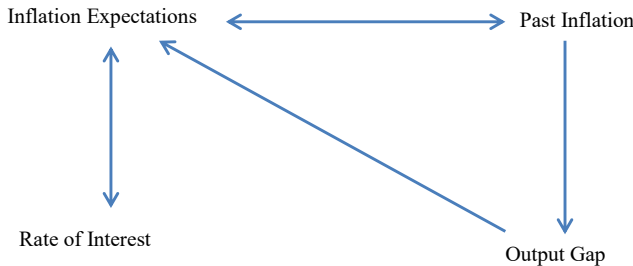


Figure 2.
Non recursive
restriction for
SVAR model

Table 6.
Variance
decomposition (in
percentage)

Horizon	Shocks in output gap	Shocks in monetary policy	Shocks in inflation	Shocks in inflation expectations
<i>Variance decomposition of output</i>				
1	100.00	0.00	0.00	0.00
2	99.61	0.06	0.15	0.18
3	99.15	0.10	0.38	0.38
4	98.78	0.10	0.61	0.51
8	97.98	0.14	1.23	0.64
12	97.63	0.27	1.45	0.64
<i>Variance decomposition of monetary policy</i>				
1	7.19	92.81	0.00	0.00
2	8.20	91.68	0.11	0.02
3	8.84	90.80	0.33	0.04
4	9.31	90.02	0.63	0.05
8	10.53	87.15	2.24	0.08
12	11.37	84.64	3.93	0.06
<i>Variance decomposition of inflation</i>				
1	0.74	0.81	98.45	0.00
2	2.73	0.92	96.20	0.15
3	4.11	0.98	94.46	0.46
4	5.09	0.97	93.08	0.87
8	7.51	0.79	89.08	2.62
12	9.07	1.81	85.47	3.65
<i>Variance decomposition of inflation expectations</i>				
1	1.26	29.69	9.49	59.56
2	0.90	25.69	12.88	60.54
3	0.75	22.40	16.23	60.61
4	0.69	20.04	19.29	59.97
8	0.66	19.00	26.30	54.03
12	0.76	23.60	26.84	48.80
Note(s): Cholesky Ordering: Output Gap, Repo rate, Actual CPI inflation, Inflation Expectations				

less than 6% up to four quarters but close to 10% up to the 12 quarters. The immediate impact of the demand shock on inflation expectations is large, which slowly mitigates in the long run. Thirdly, the contribution of inflation shocks to the inflation expectations is huge and is close to 30% in the long run. These findings indicate that realized and expected inflation changes are mainly caused by the monetary policy and the output in the long run.

6.2 Robust analysis

6.2.1 Impulse response function. Figure 3 illustrates the impulse responses of four endogenous variables to four structural shocks. Each column represents a structural shock of one-standard-error magnitude, and each row represents the responses of the endogenous variable.

The first column shows the positive demand shock (e_y) lowers the output gap, does not affect the interest rate and increases the inflation and inflation expectation. The demand shock is expected to increase the output gap when hitting the economy, which is not proven in this Figure. However, the demand shock does increase inflation and, therefore, inflation expectations on the shock, which reduces down the horizon. These features also indicate that the effect of a demand shock on inflation is not persistent in the long run.

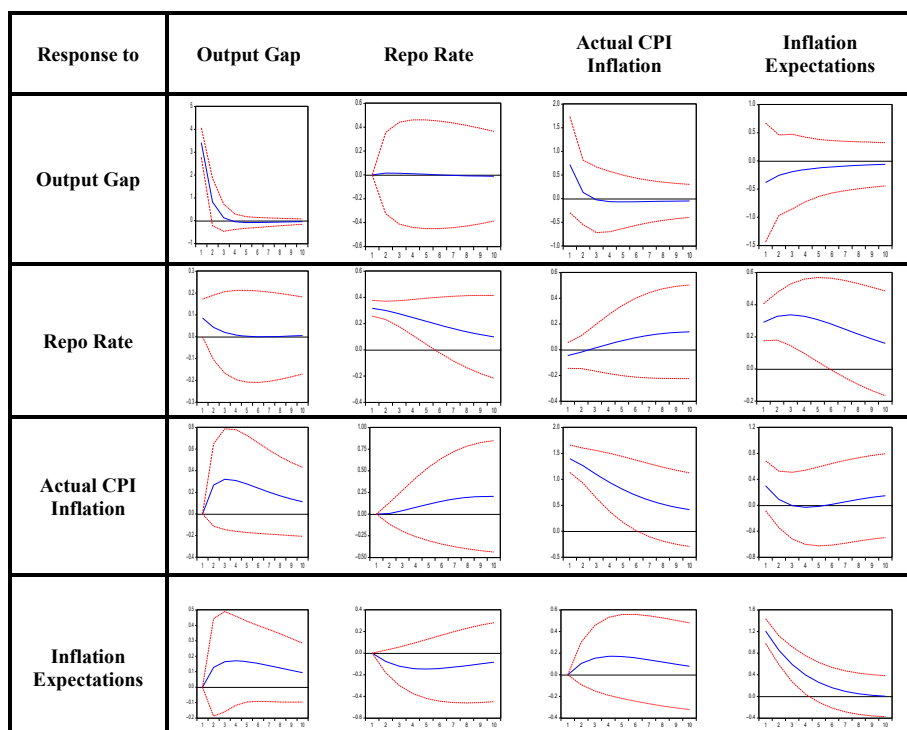


Figure 3.
Impulse response
function

The second column represents the monetary policy (interest rate) shock. The positive monetary policy shock does not impact the output gap, whereas it decreases the interest rate. A tightened monetary policy shock does not have an immediate impact on actual inflation. However, an increase in inflation is witnessed from the 4th period onward. With inflation expectations, the shock creates an outward hump shape impact. The “price puzzle” theory, which indicates an increase in interest rate, is witnessed in the analysis here. Thereby, it could be stated here that the price puzzle for the Indian economy even holds in the presence of inflation expectations.

The third column represents that the positive inflation shock lowers the inflation and output gap; however, the shock to output dies quickly. The inflation shock increases the interest rate. For inflation expectations, the shocks firstly increase the inflation expectations, which lowers down and converges to equilibrium in the long run.

The fourth column represents positive inflation expectation shock to the four variables. The shock lowers the interest rate, inflation and inflation expectation immediately, increasing the output gap.

6.2.2 Model diagnostic test. As the last exercise, we run the diagnostic test to prove the stability of the VAR model. We run our SVAR model on lag 1 based on the Akaike information criterion (AIC). To check the stability of the model, we check the stability condition by checking the inverse root. Table 7 provides the result of the inverse root.

The results of the inverse root have the module less than and lie inside the unit circle; hence the VAR model is stable. We then check for the presence of autocorrelation in the residuals. We perform the LM test up to lag 4. Table 8 presents the result of the LM test.

The null hypothesis of the LM test indicates the absence of serial correlation among the residuals. The probability of the test value should lie above 5% to accept the null hypothesis. As shown in Table 8, our result proves the absence of serial correlation up to lag 6, indicating the estimated VAR model free from autocorrelation.

At last, we check if the residuals are normally distributed. We run the Cholskey orthogonalization, normality test. Table 9 presents the results of the Jarque–Bera test. The null hypothesis of the test considers the residuals to be multivariate normal. We reject the null hypothesis if the *p*-value lies below 5% and do not reject it if it lies above 5%.

7. Conclusion

We analyze households’ inflation expectation data for India, collected quarterly by the RBI for more than a decade. In this work, we explore the time-series properties of the survey data and investigate further the determinants of inflation expectation. The preliminary explanatory test reveals that inflation expectation is a policy variable and should be used in monetary policy as an instrument variable. The realized CPI inflation exhibits both short- and long-run relationships with the inflation expectations, indicating a strong co-relationship between the realized and expected inflation. This established relationship will further help policymakers in anchoring inflation expectations, which will enhance the central bank’s credibility. To investigate the determinants of inflation expectations, we employ the SVAR model. We impose non-recursive restrictions on the model, considering the reciprocal relation between inflation and inflation expectations. Inflation expectation adjusts to the change in response to interest rate, inflation and the output gap. Hence while framing the monetary policy, inflation expectations do become an important variable to consider.

Table 7.
Inverse root test

Root	Modulus
0.980120	0.980120
0.839332 – 0.081320i	0.843263
0.839332 + 0.081320i	0.843263
0.283327	0.283327

Table 8.
Autocorrelation test

Lags	LM – stat	Prob
1	22.73	0.1211
2	28.33	0.0289
3	12.007	0.7435
4	16.662	0.4077

Table 9.
Residual normality test

Component	Jarque–Bera	df	Prob
1	0.006	2	0.937
2	2.113	2	0.146
3	0.413	2	0.8134
4	2.691	2	0.2603
Joint	5.223	8	0.1236

Notes

1. A detail discussion of this could be traced from [Saakshi \(2019\)](#).
2. The results of the Ng–Perron test are available upon request.
3. For example: [Sims \(1980, 1992\)](#), [Bernanke and Mihov \(1998\)](#), [Christiano *et al.* \(1999\)](#), and [Leduc *et al.* \(2007\)](#).

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