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EconomiA 19 (2018) 74–89

ECONOMIA

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The properties of inflation expectations: Evidence for India

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Received 18 November 2016; received in revised form 7 December 2017; accepted 26 December 2017
Available online 2 January 2018

Abstract

Empirical inferences about particular forms of agents' inflation expectations are crucial for the conduct of monetary policy. This paper is an attempt to explore the properties of the Reserve Bank of India's survey data of households' inflation expectations. The paper shows that survey respondents do not form expectations rationally, regardless of the reference measures of inflation used. Further, results indicate that inflation expectations are formed purely in backward-looking manner, suggesting that the Reserve Bank of India (RBI) has a low degree of credibility within the survey respondents. The study then formulates a model to identify individual elements of the backward-looking expectations in the data. The results suggest that the respondents' short term expectations for WPI inflation are purely naïve type of expectations, only influenced by respondents earlier period expectations. In the case of CPIIW inflation, the results however suggest that the short-term expectations are not purely naïve type, but also contain adaptive as well as a static forms of expectations. This means that respondents consider their previous forecast errors about CPIIW inflation and draw recent price developments in the CPIIW while forming their overall short-term inflation expectations. This finding provides some formal evidence that the CPI based inflation measure is better suited, than WPI inflation, as a nominal anchor in the RBI's recent transition to inflation targeting regime.

JEL classification: D84; E31; E52; E37

Keywords: Inflation; Inflation expectations; Survey data; Price index; Monetary policy; Forecasting

1. Introduction

"Inflation expectations are one of the main drivers of current inflation, because expected inflation influences current wage negotiations, price setting, and financial contracting for investment. Because of this link, central banks can affect current and future inflation by better anchoring agents' expectations of long-term inflation" (Cunningham et al., 2010, p.17). However, the existing literature identifies two forms of expectation formation hypotheses namely, forward-looking rational expectations and backward-looking expectations. The rational expectation hypothesis implies that economic agents form their inflation expectations after processing all available information and also considering the

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Peer review under responsibility of National Association of Postgraduate Centers in Economics, ANPEC.

https://doi.org/10.1016/j.econ.2017.12.002

reaction function of the central bank. The backward-looking inflation expectations postulate that economic agents use only the information embodied in the history of the inflation.[1] Under forward looking monetary policy framework, a finding of rationality in inflation expectations implies that agents align their inflation expectations with central bank's inflation target, and hence its inflation objective. Rationality in expectations, thus, not only implies the agents' expectations are well-anchored and forward-looking but also suggests a high degree of central bank credibility among agents.[2] On the other hand, a finding of backward-looking inflation expectations indicates a low degree of central bank credibility. Fully backward-looking expectations imply that agents form their expectations looking only at past price development while ignoring the central bank's actions for achieving the inflation objective, on account of their disbelief in its efforts to achieve the inflation objective, which potentially impairs the efficacy of the central bank actions in anchoring agents' inflation expectation, and thus achieving its inflation objective.[3]

Despite the importance of finding about the process of expectation formation for the conduct of monetary policy, deriving true expectations is a difficult task as these are not directly observable. Two types of proxy measures of inflation expectations have been proposed in the literature namely, survey-based and market-based measure of inflation expectations. The market-based measures are derived indirectly through derivatives of some financial assets such as bond and swap. On the other hand, the survey based measures are, however, obtained directly from conducting the survey of economic agents, by adding questions about future inflation in the survey questionnaires. Since the survey measures of expectations directly provides agents' assessment with respect to the credibility of the central bank and its long-run inflation objective, many central banks have started conducting inflation expectations surveys regularly. Some important surveys on inflation expectations includes University of Michigan's consumer survey and Livingston surveys for the US, European Commission consumer survey for the Euro countries and Bank of England-GfK/NOP consumer survey, etc. A number of researchers have analyzed expectation properties from these survey data. Some prominent studies include Thomas (1999) and Mehra (2002) for US expectation survey data, Gerberding (2001), Forsells and Kenny (2002), Dias et al. (2010) and Łyziak (2012) for the European Union consumer survey data, Bakhshi and Yates (1998) for England's survey data; Razzak (1997) and Ranchhod (2003) for New Zealand survey data, and Bernanke (2007) for South Africa survey data. The empirical evidence of existing studies has been mixed about the extent to which expectations confirm to the forward looking-rational expectation hypothesis (REH). We therefore explore in this paper the question: to what extent inflation expectations are formed in forward-looking manner. Specifically, we evaluate the properties of forward-looking and backward-looking forms of expectations in the case of emerging market economy like India, which is the transition economy to inflation targeting regime. From this analysis, we draw inferences about likely expectation formation process in the case of India, which has remained neglected so far. It can provide some formal evidence about efficacy of the Reserve Bank of India's policy actions in anchoring public inflation expectations in the previous regime of multiple objective monetary policy framework.

The remainder of this paper is organized as follows: Section 2 deals with datasets and statistical descriptions of data. Section 3 presents the empirical analysis and the discussion of results. Section 4 presents the summary and conclusion.

2. Data

The Reserve Bank of India has started conducting inflation expectations survey of households since September 2005 on a quarterly basis. The survey seeks qualitative and quantitative responses of 5000 households using quota sampling on expectations of prices and inflation. Samples are collected from 16 cities across the four regions of the country. Quantitative responses of households are recorded on a quarterly basis in the month prior to the start of quarter to

[1] The difference between forward-looking and backward-looking forms of expectations is that the former implies agents do not make any systematic errors in forecasting while the latter concedes that possibility. The systematic errors in the expectations lead to a short-term trade-off between inflation and the real variable. However, most central banks assume in policy reaction function that expectations in long-run are rational that is the systematic error would disappear over the period of time. Are the expectations forward-looking over the period of time? The answer depends on the central bank's policy actions and its credibility in agents' perception in maintaining low and stable inflation. If the central bank exploits the short-term trade off, the credibility would be difficult to establish, the degree of credibility will continue to be paltry, and hence expectations would be consecutively formed in a backward-looking manner.

[2] Bernanke et al. (2001) argue that the survey data of agents' inflation expectations relative to the central bank's inflation target can provide information on credibility.

[3] Bernanke (2007) discusses that analytical framework of most central banks assumes economic agents are mainly forward-looking and rational.

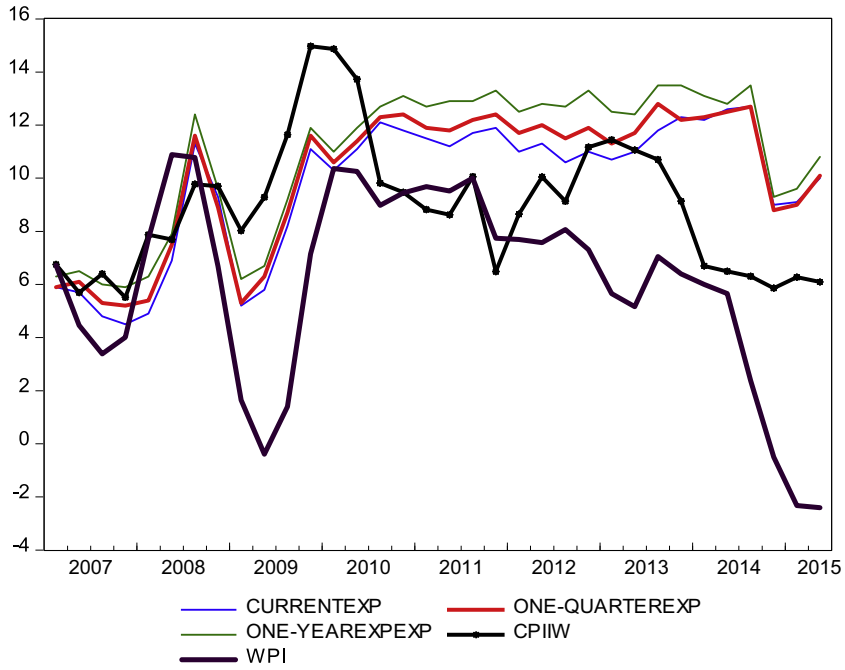

Fig. 1. Measures of inflation and inflation expectations.

deliver perception of current quarter inflation and three month (one-quarter ahead) and twelve month ahead (one-year ahead) expectations of the inflation rate.[4] The data on these survey results are available only since the last quarter of 2006. The study, therefore, uses data from March 2007 to June 2015, which were compiled from various rounds of quarterly survey results from the RBI website. Corresponding to a quarter's survey results, the quarter's end inflation numbers of WPI, CPIIW and CPI food, measured on year on year basis, are used as reference measures against which the results of survey data of inflation expectations are evaluated.

The data used in the study is plotted in Fig. 1 for visual inspection, to see how expectations vary compared to the official measures of inflation. It represents the average expected inflation rate of household respondents over the different forecasting horizon along with the official inflation measures based on Wholesale Price Index (WPI) and Consumer Price Index for Industrial Workers (CPIIW). It shows that for sample period starting from March 2007 to 2010, inflation expectations oscillate between WPI and CPIIW inflation; overestimating WPI and underestimating CPIIW inflation. However, after second quarter of 2010, the inflation expectations remain higher than the official inflation rates. This might imply that the RBI monetary policy has not been credible to anchor expectations even around its CPIIW inflation rate; the expectations are poorly anchored. Further, there is a significant diversion between expectations and CPIIW inflation between 2010 and 2014 periods. It is to be noted that whenever actual inflation is higher and more volatile, the accuracy of inflation expectations of the surveyed data is expected to be low. These observations are reflected further in the formal test of expectation formations in the next section.

Table 1 gives some descriptive statistics of expectation of inflation, in comparison with the actual inflation rate. It can be seen that the differences in mean value of expectations over different forecasting horizon and WPI inflation show considerable positive bias, giving an early indication of forecasting bias in the formation of expectations. This is also seen in terms of differences in standard deviation (SD). In case of CPIIW and CPI food, the bias is relatively low to that of WPI inflation. The standard deviation in the table indicates that the uncertainty of expectation increases with forecast horizon. The standard deviation is lower for the current inflation rate than for the one-quarter and one-year ahead. This is to be expected as it is more difficult to forecast future inflation and hence the accurate formation of expectations of inflation.

[4] Details of survey methodology are given in the "Report of the Technical Advisory Committee on Surveys", RBI, September 2009.

Table 1
Descriptive statistics of data.

	WPI	CPIIW	CPIFOOD	Currentexp	One-quarterexp	One-yearexpexp
Mean	6.00	8.95	10.22	9.72	10.10	10.81
Median	6.88	8.98	10.05	11.00	11.55	12.40
Maximum	10.89	14.97	21.29	12.70	12.80	13.50
Minimum	−2.40	5.51	1.97	4.50	5.20	5.90
Std. dev.	3.72	2.53	3.75	2.62	2.64	2.73

We next examine the empirical properties of inflation expectations to draw statistical inferences about the expectations formation of inflation in India.

3. Empirical analysis

The empirical analysis of assessing expectation formation of the survey data have been divided into two parts. First, the tests for the degree of forward-looking rational expectation are conducted and second, the alternative hypothesis of backward-looking expectation is examined. From these test results, it is possible to draw the inference about likely expectations formation process as seen from the household survey data of inflation expectations.

3.1. Rational expectation

The literature on expectations distinguishes between weakly rational, sufficiently rational and strictly rational.[5] The expectations are classified as weakly rational if expectations are unbiased and efficient forecast of inflation. The expectations are said to be sufficiently rational if forecasts obtained through surveys outperform forecasts by other models, such as naïve and ARMA models (see Pearce, 1987). These properties of rational expectation will be tested in subsequent sections to assess the degree of rationality of the survey data.

3.1.1. Tests of unbiasedness and efficiency

The existing literature focuses on two important properties of REH, namely, unbiasedness and efficiency. The unbiasedness property implies that the forecast error of rational expectations should have a zero mean value.[6] The commonly used test in the literature for the unbiasedness property involves estimating the following equation:

$$\pi_t = \alpha + \beta E_{t-k}\pi_t^e + \upsilon_t \tag{1}$$

where π_t is the inflation rate at date t and $E_{t-k}\pi_t^e$ stands for inflation expectation for date t formed at date $t-k$, k denotes the number of quarters ago when the expectations were formed, α is a constant, β is a coefficient and υ_t is stochastic error.

In the Eq. (1), Inflation expectations are said to unbiased predictors of inflation, if the null hypothesis of joint restriction $\alpha = 0$ and $\beta = 1$ is upheld. The Ordinary Least Squares (OLS) estimation of regression (1) exhibits autocorrelation, therefore the joint hypothesis is tested using Wald test with the corrected standard errors using the Newey and West (1987) procedures. The results of unbaisedness test in Table 2 suggest that the null hypothesis of joint restriction is decisively rejected for various forecasting horizons and inflation measures. The results indicate that inflation expectations are biased predictors of the inflation rate, regardless of the inflation measure used as reference inflation rate. However, we note that the estimated intercept term α shows a large amount of the bias for CPI inflation measures for all forecasting horizons, suggesting that the bias stems from the intercept term, which represents a systematic bias in the equation. The WPI inflation also shows significant bias over the one-year forecasting horizon.

[5] If the forecast of survey data outperforms a combination of various forecasts, then expectation is said to be strictly rational (Granger and Newbold, 1973)

[6] This means that Inflation expectations should be unbiased predictors of inflation.

Table 2
Unbiasedness test of inflation expectations — estimation results of Eq. (1).

	Constant (α)	Coefficient (β_1)	p-Values of Wald test	Unbiased
Currentexp				
CPIIW	5.76 (1.44)	0.32 (0.16)	0.00	No
CPIFOOD	10.04 (2.09)	0.01 (0.25)	0.00	No
WPI	0.98 (2.74)	0.51 (0.26)	0.00	No
One-quarterexp				
CPIIW	7.04 (1.93)	0.19 (0.18)	0.00	No
CPIFOOD	12.05 (2.62)	−0.18 (0.26)	0.00	No
WPI	2.68 (3.11)	0.33 (0.29)	0.00	No
One-yearexp				
CPIIW	10.29 (2.86)	−0.11 (0.24)	0.00	No
CPIFOOD	13.98 (3.06)	−0.35 (0.29)	0.00	No
WPI	8.72 (2.91)	−0.25 (0.29)	0.00	No

* Values in brackets are the standard errors which were calculated using Newey–West method to form the test statistic to account for autocorrelation of the regression residuals, which arise due to overlapping observations caused by the forecast horizons.

Table 3
Unbiasedness test of inflation expectations — estimation results of Eq. (2).

	p-Values of t-test	Unbiased
Currentexp		
CPIIW	0.38	Yes
CPIFOOD	0.71	Yes
WPI	0.00	No
One-quarterexp		
CPIIW	0.31	Yes
CPIFOOD	0.85	Yes
WPI	0.00	No
One-yearexp		
CPIIW	0.29	Yes
CPIFOOD	0.87	Yes
WPI	0.77	Yes

In order to crosscheck these results, we use alternative form of test for unbiasedness property as suggested by Holden and Peel, 1990. They propose a test for unbiasedness performed directly on forecast errors in the following equation.

$$\pi_t - E_{t-k}\pi_t^e = \alpha + \upsilon_t \tag{2}$$

The hypothesis that $\alpha = 0$ is tested by t-test statistics with the Newey and West (1987) corrected standard errors. The results of these tests are shown in Table 3. The table shows that the inflation expectations for all forecasting horizons appear to be unbiased predictors for CPI and CPI food inflation as the p-values of the t-test statistics are insignificant. The inflation expectation also appears to be an unbiased predictor for WPI over the one-year horizon.[7] To check the robustness of these results, we calculate the decomposition of the mean squared forecast error in its bias, variance and covariance proportions for inflation expectations at all forecasting horizons with all reference inflation measures.[8] The results of these statistics are given in Table 4. It shows that the bias and variance proportions of inflation expectations are very small for CPIIW and CPI food for all forecasting horizons, and so most of the forecast error is concentrated on

[7] In the interests of examining the robustness of our results, we conducted influence statistics to identify outliers in the sample data. We removed the identified outliers and re-estimated Eqs. (1) and (2) for unbiasedness tests. Statistically, findings from these unbiasedness tests resemble those of the original results. In order to crosscheck these results, we have also implemented the robust least squares method. The statistical inferences based on these results are same as those given by the OLS regression. Since the results are the same, we here only report the results obtained from the OLS. However, the results of influence statistics and robust least squares are available on request. We are grateful to an anonymous referee for suggesting these tests.

[8] See Appendix A for definitions and computation of these statistics.

Table 4
Decomposition of the mean squared forecast error.

	Bias proportion	Variance proportion	Covariance proportion
Currentexp			
CPIIW	0.07	0.00	0.93
CPIFOOD	0.01	0.06	0.93
WPI	0.51	0.04	0.45
One-quarterexp			
CPIIW	0.09	0.00	0.91
CPIFOOD	0.00	0.04	0.96
WPI	0.49	0.03	0.48
One-yearexp			
CPIIW	0.10	0.01	0.89
CPIFOOD	0.00	0.02	0.98
WPI	0.42	0.01	0.57

the covariance proportions, indicating forecast error stemming from the unsystematic error and not from the systemic error as suggested by estimated intercept term from Eq. (1). In other words, these results suggest that the forecast errors of inflation expectations in case of CPI inflation measures are random. It should be noted that the bias proportion for CPI food inflation is always zero, suggesting no systematic errors are made by survey respondents in forecasting the CPI food inflation. As per WPI inflation, the bias proportions are large and covariance proportions are small compared to those observed for the CPI inflation measures. This suggests that there are large systematic errors are made by survey respondents in forecasting the WPI inflation

Now we turn to the property of efficiency which implies an efficient use of all available information at the time the forecasts were made. The most readily available information is respondents' own past prediction error.[9] Ehlers and Steinbach (2007) point out that the existence of correlation between the forecast errors implies respondents did not utilize all the information contained in past forecast errors to improve their expectations formation process, and agents are therefore, not efficient in applying available information. We estimate the following regression for efficiency test.

$$\pi_t - E_{t-k}\pi_t^e = \alpha + \sum_{i=1}^{j}\beta_i \left(\pi_{t-i} - E_{t-k}\pi_{t-i}^e\right) + \upsilon_t \tag{3}$$

for each time horizon surveyed, where $(\pi_t - E_{t-k}\pi_t^e)$ represents the forecast error, t indicates time period t, α is a constant, β's are coefficients, υ_t is a stochastic error and j is the number of lags. The number of lags in the equation is selected using the Akaike information criterion (AIC). A Wald coefficient test is applied to test the hypothesis that all the coefficients and the constant are jointly equal to zero.

The results for the efficiency tests are reported in Table 5. It can be seen that the p-values of Chi-square test statistics suggest that the null hypothesis of informational efficiency is rejected for all forecasting horizons and for all reference measures of inflation. Further, the adjusted R-square values in the table indicate that the past forecast errors contain considerable information that was not utilized by the survey respondents and therefore they were inefficient in using the information at their disposal.

Overall, the results suggest that even if expectations appear to be an unbiased predictor of inflation, lack of efficiency in using readily available information leads to the conclusion that the RBI's survey data of inflation expectations cannot be considered as weakly rational.[10]

[9] Mehra (2002) pointed out that for rational agent; the question of what variables should be included in the information set depends on costs and benefits. Since past values of a variable being forecast (inflation) are readily available, that variable should be in the information set.

[10] By definition, rational expectations imply an efficient use of all available information at the time the expectations were made. If agents are inefficient in respect of use of freely available information while forming expectations, then the agent bound to make systematic error in their expectation formation. As our findings suggest that the property of efficiency is rejected, and hence test for unbaisedness may also be rejected.

Table 5
Tests for informational efficiency.

	Lag	p-Values of Wald test	Null hypothesis	R^2
Currentexp				
CPIIW	1	0.00	Reject	0.64
CPIFOOD	1	0.00	Reject	0.62
WPI	1	0.00	Reject	0.74
One-quarterexp				
CPIIW	1	0.00	Reject	0.61
CPIFOOD	1	0.00	Reject	0.57
WPI	3	0.00	Reject	0.72
One-yearexp				
CPIIW	1	0.00	Reject	0.71
CPIFOOD	1	0.00	Reject	0.64
WPI	3	0.00	Reject	0.79

3.1.2. Forecast accuracy

The sufficient rationality implies that the inflation expectations are said to be sufficiently rational if the expectations outperform forecasts of other models. To begin with, we estimate a naive model and an ARMA model for WPI and CPIIW inflation over the sample period.[11] The naive model estimates are derived assuming that the forecast for the current period is equal to a last period value. Various plausible alternative identification of ARMA (p, q)[12] models are estimated and the best model is selected based on minimization of AIC. Accordingly, the ARMA (4, 2) is selected for WPI inflation and the ARMA (3, 2) for CPIIW. The estimated model is given in the Appendix B. For evaluating forecasting performance, we have calculated a range of forecast error statistics. The definitions and computations of these forecast error statistics are given in the Appendix A.

Table 6 provides the forecast error statistics of the survey data of inflation expectations in explaining WPI inflation in penal A and in explaining CPIIW inflation in Panel B along with the forecast statistics of the naive and the ARMA model. We draw the following observations from the table.

First, the positive bias of expectations suggests that survey respondents on average overestimated inflation. Notable positive bias of expectations for WPI inflation indicates that respondents may not be forming expectation about WPI inflation. Second, all forecast error statistics of expectations increase with the forecast horizon which means that survey respondents' mistakes increase for forecasting inflation with distance in time. Lastly, it is noticeable in the table that survey respondents are worse forecasters than the ARMA and even the simple naive model in forecasting WPI and CPIIW inflation. As it can be seen in the table, for instance, the RMSE of expectations of survey data for WPI and CPIIW inflation over one-year horizons is 6.90 and 4.34 respectively, whereas the RMSE of the naive model for WPI and CPIIW is 2.21 and 1.75 respectively. The lower RMSE statistics indicate that the simple naive model forecast outperforms the forecasting capability of survey respondents. This result is supplemented by other forecasting error statistics and, as can be seen in the table. The ARMA model provides best estimates for both WPI and CPI inflation.[13] It delivers lowest forecast error statistics and is far better than expectations of survey data and the naive model as well. This finding is reinforced using the Theil inequality coefficient which is close to zero.

Overall, the results for tests of weak rationality and the sufficient rationality suggest that economic agents from the RBI's household survey do not form expectations rationally.

3.2. Forward-looking expectations vs. backward-looking expectations

The above findings indicate that the expectations errors are not systematically biased, but correlate with the past information, which may imply that the inflation expectations might be determined by past observations of the inflation.

[11] We exclude CPI food for further analysis, as it has shown same performance as CPIIW and also to simplify the analysis by focusing on WPI and CPIIW inflation measures.

[12] As usual, p and q refer to the order of lag for autoregressive (AR) and moving average (MA) process, respectively.

[13] Debabrata and Partha (2010) have suggested a measure of inflation expectations based on an ARMA model for India.

Table 6
Forecast error statistics.

	Currentexp	One-quarterexp	One-yearexp	NAÏVE	ARMA
Panel A: WPI					
Bias	3.72	3.95	4.47	0.28	0.00
Mean square error (MSE)	27.07	31.55	47.62	4.88	0.86
Root mean square error (RMSE)	5.20	5.62	6.90	2.20	0.92
Standard forecast error (SE)	3.64	3.99	5.26	2.19	0.93
Mean absolute error (MAE)	4.17	4.70	5.66	1.60	0.73
Mean percentage error	−0.68	−0.79	−1.12	−0.26	−0.08
Mean absolute percentage error (MAPE)	2.01	2.25	2.87	0.69	0.25
RMSE Ratio	2.36	2.55	3.14	1.00	0.42
Theil's U	0.30	0.32	0.38	0.16	0.07
Panel B: CPIIW					
Bias	0.77	1.00	1.38	0.13	0.00
Mean square error (MSE)	9.12	11.83	18.86	3.07	1.05
Root mean square error (RMSE)	3.02	3.44	4.34	1.75	1.02
Standard forecast error (SE)	2.92	3.29	4.12	1.75	1.02
Mean absolute error (MAE)	2.50	2.85	3.62	1.33	0.78
Mean percentage error	0.14	0.17	0.24	0.04	0.01
Mean absolute percentage error (MAPE)	0.31	0.35	0.44	0.16	0.10
RMSE Ratio	1.73	1.97	2.48	1.00	0.58
Theil's U	0.16	0.18	0.21	0.09	0.06

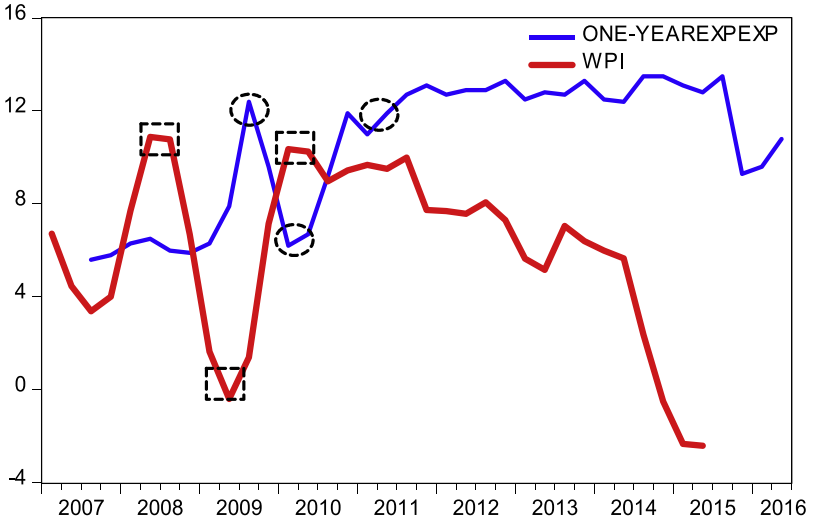

Fig. 2. WPI inflation and one-year ahead inflation expectations.

We thus proceed for testing backward-looking expectations. To begin with, we first plot the data of inflation expectations on the one-year forecast horizon to which they actually relate and inflation rate of WPI in Fig. 2.[14] There are indications in the beginning of sample periods that inflation expectations are influenced by the level of WPI inflation. It can be seen in the figure that the inflation expectations indicated by circles are influenced by the level of WPI inflation indicated by rectangular boxes, which prevailed at the time when the expectations were formed. However, these associations are observed until the second quarter of 2011, after that the associations seem to be breaking down. From then onwards the WPI inflation seems to be trending in downwards directions while the inflation expectations remain at an elevated

[14] The figure plots the WPI and CPIIW inflation rate data at date t while expectations data at four-quarter ahead i.e., at date $t + 4$ which were formed at date t.

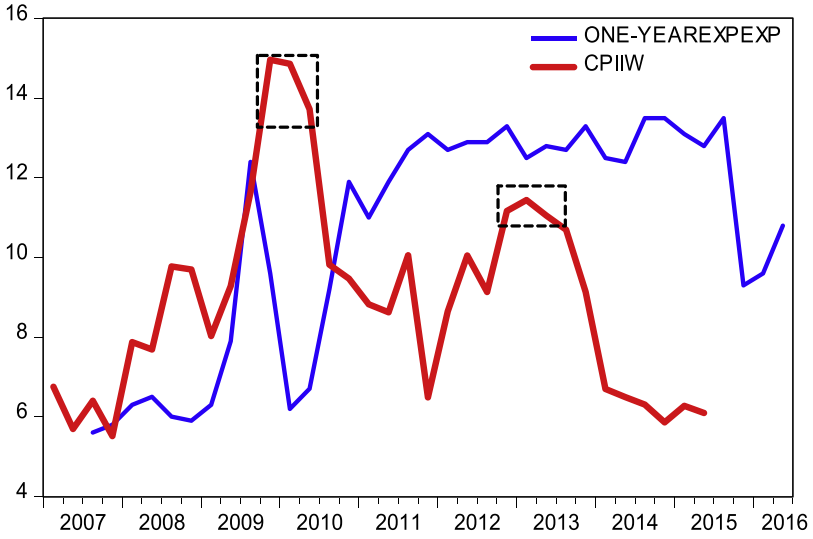

Fig. 3. CPI inflation and one-year ahead inflation expectations.

Table 7
Correlations between survey expectations and CPIIW inflation.

Horizon quarter (lag-lead)	Currentexp	One-quarterexp	One-yearexp
−6	0.32	0.32	0.33
−5	0.36	0.37	0.37
−4	0.40	0.41	0.40
−3	0.43	0.44	0.42
−2	0.42	0.43	0.41
−1	0.40	0.41	0.40
0	0.34	0.38	0.36
1	0.11	0.17	0.16
2	−0.15	−0.10	−0.10
3	−0.31	−0.28	−0.27
4	−0.28	−0.29	−0.28
5	−0.19	−0.22	−0.22

level. The elevated inflation expectations could be explained by the spikes in CPI inflation in 2010 and 2013, which are shown in the rectangular boxes in Fig. 3. The figure, however, does not provide statistical evidence about changes in actual inflation rate which precede changes in expectations in a very systematic manner. We, therefore, compute lag–lead correlation and an econometric approach to look at the relationship between survey data of expectations and inflation rate more closely. Tables 7 and 8 provide these correlations between expectations of survey data and, CPIIW and WPI inflation.

The shaded area in the table indicates a relatively stronger correlation. It can be seen that expectations data of all forecasting horizons tend to be correlated more strongly with past inflation than with future inflation. It further shows the negative correlation with actual inflation at the four-quarters ahead horizon on which it supposedly focuses and positive only at the current and at one-quarter ahead. The results of survey expectations also suggest that the strength of the past correlations with CPIIW inflation tends to be stronger than WPI inflation. Nevertheless, the findings are qualitatively robust to the measure of inflation used; suggesting that expectations of survey data are likely to be backward-looking nature.

Table 8
Correlations between survey expectations and WPI inflation.

Horizon quarter (lag-lead)	Currentexp	One-quarterexp	One-yearexp
−7	0.21	0.22	0.22
−6	0.17	0.20	0.21
−5	0.06	0.10	0.12
−4	0.00	0.03	0.06
−3	0.03	0.05	0.08
−2	0.18	0.18	0.21
−1	0.35	0.35	0.37
0	0.36	0.40	0.40
1	0.20	0.27	0.27
2	−0.10	−0.03	−0.03
3	−0.34	−0.28	−0.28
4	−0.30	−0.28	−0.29
5	−0.13	−0.15	−0.18

In order to draw statistical inference about backward-looking form of expectation, we estimate the following equation.[15]

$$E_{t-k}\pi_t^e = \alpha + \beta_1\pi_t + (1-\beta_1)\left[E_{t-k}\pi_{t-j}^e + \beta_2\left(\pi_{t-j} - E_{t-k}\pi_{t-j}^e\right)\right] + \upsilon_t \tag{4}$$

where π_t is the inflation rate at date t and π_t^e is expected inflation rate at date t, while j and k stand for the number of lags. π_{t-j}^e represents expected inflation rate at date $t-j$, but formed at date $t-k$, for one-quarter expected inflation $j=1$ and $k=2$, and for one-year ahead expected inflation $j=4$ and $k=8$.

The Eq. (4) is a hybrid model for testing expectation formation. It contains both rational expectation-forward-looking element (β_1) and a backward-looking element ($1-\beta_1$) which includes past realization of expectations and adaptive nature of expectations (β_2) which measure survey respondents' speed of adjustment to their past forecast errors. The above equation thus tests the relative importance of both notions of expectations in the formation of inflation expectations. The expectations are said to be forward-looking if the estimated coefficient (β_1) is significantly positive and can be considered fully forward looking if it shows statistically (significantly) equal to 1. The expectations are considered fully backward looking if the estimated coefficient (β_1) is insignificantly different from zero. The Eq. (4) are estimated for one-quarter and one-year ahead inflation expectations with WPI inflation and CPIIW inflation separately.[16]

Table 9 presents results of one-year ahead expectations for both inflation measures. Findings are indeed sharp in deciding expectation formation in India. As a glance at Table 9 shows, the estimated coefficient β_1 is negative in both cases of inflation measures, suggesting any contribution of forward looking expectation ($\beta_1 > 0$) is decisively rejected and therefore, null hypothesis of purely backward-looking expectations ($\beta_1 = 0,\ 1-\beta_1 = 1$) cannot be rejected.[17] Furthermore, the negative sign for coefficient β_1 suggests that expectations are not only purely backward-looking but also indicate that those backward looking formations of expectation do not predict directional change in inflation, raising questions as to their usefulness as proxies for true expectations. This finding should also be read with the following statement which appears in every RBI's survey round of inflation expectations report (for instant, Inflation Expectations Survey of Households: September 2010, 21 Round):

[15] Gerberding (2001) proposed similar type of model.

[16] The two-stage least squares method (2SLS) is used to obtain consistent estimation by using lagged values of explanatory variables as the instruments. The equation is also estimated with OLS with corrected standard error. The statistical inference of the obtained results resemble with 2SLS estimation.

[18] We also re-estimated Eq. (4) in unconstrained form by allowing the sum of the rational and adaptive terms to be different from one. Statistically findings are same as Eq. (4). Particularly, the negative sign for coefficients of forward-looking are observed in the expectation equation for one year ahead for both inflation measures.

[17] This result is not a complete surprise; Gerberding (2001) also found a purely backward-looking expectation for consumer expectations data for Italy.

Table 9
Estimation results of Eq. (4) based on one-year expectations.[18]

	WPI	CPIIW
The forward-looking element, β_1	−0.01 (0.04)	−0.07 (0.06)
The backward-looking element, 1-β_1	1.01*	1.07*
Adaptive element, β_2	0.41* (0.07)	0.37* (0.07)
Constant	2.32* (0.47)	1.19* (0.41)
R^2	0.81	0.64

Values in brackets are the standard errors which were calculated using Newey–West method to form the test statistic to account for autocorrelation of the regression residuals, which arise due to overlapping observations caused by the forecast horizons.
* Denotes significance at the 1% level.

Table 10
Estimation results of Eq. (4) based on one-quarter expectations.

	WPI	CPIIW
The forward-looking element, β_1	0.18 (0.25)	0.01 (0.04)
The backward-looking element, 1-β_1	0.82*	0.99*
Adaptive element, $\beta 2$	0.02 (0.32)	0.23* (0.04)
Constant	0.93* (0.16)	0.34* (0.04)
R^2	0.77	0.75

Values in brackets denote standard errors calculated using Newey–West method.
* Denotes significance at the 1% level.

> "The households' inflation expectations provide useful directional information on near term inflationary pressures and also supplement other economic indicators, to get a better indication of future inflation."

As regards the short term one-quarter expectations, Table 10 shows the estimated coefficient β_1 is positive but insignificant in both measures of inflation. The hypothesis of forward-looking expectations ($\beta_1 = 1$) can consequently be rejected, which leads to the conclusion that the short term expectation formation is also backward-looking.

3.2.1. Backward-looking expectations

Having identified that the expectations data are purely backward looking, it is interesting to explore further into the elements of backward-looking expectations formation. The fully backward-looking expectation may include either 'adaptive' or "static" or "naïve" or all of these backward looking forms of expectations. If the estimated coefficient β_2 in Eq. (4) is found to be significantly positive, backward-looking expectations are said to be adaptive form of expectations. The results of one-year ahead expectations for both inflation measures in Table 9 shows a significantly positive estimated value of coefficient β_2, indicating the existence of adaptive form of expectation in the backward-looking expectations.

However, results for one-quarter expectation in case of WPI inflation in Table 10 show that the estimated coefficient β_2 has a small and insignificant value which implies that the expectations could be either "static" or "naïve" or both forms of expectations. In order to explore further these two forms of expectations, namely "static" and "naïve", we modified the Eq. (4) and estimated in unconstrained form and by replacing adaptive part of equation with past realization of expectation and past inflation. This involves by estimating following equation.

$$E_{t-k}\pi_t^e = \alpha + \beta_1\pi_t + \beta_2\pi_{t-j} + \beta_3 E_{t-k}\pi_{t-j}^e + \upsilon_t \tag{5}$$

The degree of forward looking expectation is measured by β_1, where expectations are considered fully rational if $\beta_1 = 1$. The Eq. (5) is estimated to identify contribution of backward looking expectations, from the lagged inflation rate: β_2 (static expectations formation) and past realization of expectations: β_3 (naïve expectations formation). The results are summarized in Tables 11 and 12. It can be seen that the insignificant results of estimated coefficients β_1 for the one-quarter and one-year ahead expectation for both inflation measures confirm the findings of Eq. (4) that expectations are purely backward looking. The statistical inference and the explanatory content of the Eq. (5) resemble the results of the Eq. (4) thus pointing to the robustness of the results obtained from Eq. (4).

Table 11
Estimation results of Eq. (5) based on one-year expectations.

	WPI	CPI
The forward-looking element, β_1	−0.03 (0.06)	−0.07 (0.13)
The backward-looking element, β_2	0.40* (0.11)	0.31** (0.14)
The backward-looking element, β_3	0.56* (0.11)	0.58* (0.11)
Constant	2.82 (3.86)	3.16 (2.70)
R^2	78	64

Values in brackets denote standard errors calculated using Newey–West method.
* Denotes significance at the 1% level.
** Denotes significance at the 5% level.

Table 12
Estimation results of Eq. (5) based on one-quarter expectations.

	WPI	CPI
The forward-looking element,β_1	0.15 (0.10)	0.05 (0.16)
The backward-looking element, β_2	0.04 (0.10)	0.19* (.03)
The backward-looking element, β_3	0.78* (0.05)	0.76* (0.03)
Constant	1 (0.75)	0.21 (1.28)
R^2	0.75	0.73

Values in brackets denote standard errors calculated using Newey–West method.
* Denotes significance at the 1% level.

Taking together findings from Eqs. (4) and (5), we draw following interpretations for *the elements of backward-looking form of expectations.*

First, as noted above the results of Eq. (4) of one-quarter expectation for WPI inflation in Table 10 suggest an insignificant contribution of adaptive form of expectation with estimated value of $\beta_2 = 0.02$ (adaptive) and the result of Eq. (5) for WPI inflation in Table 12 shows an insignificant coefficient for lagged inflation with estimated value of $\beta_2 = 0.04$ (static expectations), but it shows a significant estimated value for the past expectations, $\beta_3 = 0.78$ (naïve expectations). The evidence presented here thus suggests that short term expectations in case of WPI inflation are purely naïve type of expectations which means survey respondents' expectations are naively influenced by their earlier expectations and they do not see any price development of WPI inflation while forming one-quarter inflation expectations. In case of CPIIW inflation, the results from Eq. (4) in Table 10 show a significant β_2 with estimated value 0.23. Further, the results of Eq. (5) in Table 12 show significant estimated values for both lagged inflation (β_2) and past expectation (β_3). The results thus indicate that the backward looking expectations in case of CPIIW inflation are not a purely naïve type, but these also contain adaptive as well as static form of expectations. The respondents consider their past forecast errors about CPIIW inflation and draw past price developments in CPIIW while forming their overall short term inflation expectations. The results for one-year expectations for both inflation measures (Tables 9 and 11) indicate that all forms of backward-looking expectations play a significant role in overall one-year ahead expectations.

4. Summary and conclusion

Two competing hypotheses of expectation formation, namely forward-looking rational expectations and backward-looking expectations are debated in the literature. An empirical inference about agents' expectations formation is crucial for the conduct of monetary policy since the finding of particular expectations formation has different practical implication for the central bank's past policy actions and for its use as useful information variable in the future course of action for achieving the inflation objective. The RBI has started conducting inflation expectations survey over 4000 urban households since September 2005. However, there is no study till date to explore expectations properties of the RBI's survey data. In this analysis, tests were performed to the properties of both forms of the expectations based on the RBI's inflation expectations survey data. The study used the WPI inflation and the CPIIW inflation against

which the expectations data of a different forecasting horizon were evaluated in order to draw inferences about likely expectations formation in India.

The analysis starts with visual inspection of the data, and then the formal tests were carried out to evaluate the weak and the sufficient forms of rationality. The weak form of rationality requires that expectations should be unbiased and efficient forecaster of inflation while sufficient rationality requires the expectations about inflation should be superior to other models, such as a Naïve and an ARMA model. Overall, the results for tests of weak rationality and the sufficient rationality suggested that agents included in the RBI's household surveys did not form expectations rationally. We thus proceed for testing the alternative: backward-looking form of expectations. The evidence from the lag–lead correlation suggests that expectations data of all forecasting horizons tended to be correlated more strongly with past inflation than with future inflation. In order to draw formal statistical inference about backward-looking form of expectations, the hybrid models were estimated which test both form of expectation elements in the survey data. The findings from these tests clearly indicate that there is no significant contribution of forward looking element in the expectations data for both inflation measures.

Having identified that the expectations data are purely backward looking, the study tried to identify the individual elements in the backward looking expectation, namely, "adaptive", "static" and "naïve" forms of expectations. We formulated a model to capture how much significant contribution of backward looking expectations are from the lagged inflation rate (static expectations formation) and past realization of expectations (naïve expectations formation). The estimation results suggest that the short term expectations in case of WPI inflation are purely naïve type of expectations which mean survey respondents' expectations are naively influenced by their earlier expectations and they do not see any price development of WPI inflation while forming one-quarter inflation expectation. In case of CPIIW inflation, the results however indicate that the short-term expectations are not purely naïve type, but these also contain adaptive as well as static forms of expectations. The respondents consider their past forecast error about CPIIW inflation and draw past price developments in CPIIW while forming their overall short-term inflation expectations. These findings suggest that the CPI inflation measure is better suited, than WPI inflation, as a nominal anchor in the RBI's new inflation targeting framework. Overall, results suggest that the RBI has a low degree of credibility within the survey respondents, as expectations have been found to be purely backward-looking with considerable bias.

Funding

The authors received no direct funding for this research.

Appendix A. Description of forecast error test statistics.

$$FE_t = F_t - A_t$$

$$\mathrm{BIAS} = \frac{1}{\mathrm{T}}\sum_{t=1}^{\mathrm{T}}\mathrm{FE}_t$$

$$\mathrm{SE} = \sqrt{\sum_{t=1}^{\mathrm{T}}\frac{1}{\mathrm{T}}(\mathrm{FE}_t - \mathrm{BIAS})^2}$$

$$\mathrm{MSE} = \frac{1}{\mathrm{T}}\sum_{\mathrm{t}=1}^{\mathrm{T}}\mathrm{FE}_{\mathrm{t}}^2$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{\mathrm{T}}\sum_{\mathrm{t}=1}^{\mathrm{T}}\mathrm{FE}_{\mathrm{t}}^2}$$

$$\text{MAE} = \frac{1}{\text{T}}\sum_{\text{t}=1}^{\text{T}}|\text{FE}_\text{t}|$$

$$\text{MAPE} = \frac{1}{\text{T}}\sum_{\text{t}=1}^{\text{T}}|\frac{\text{FE}_\text{t}}{\text{A}_\text{t}}|$$

$$\text{Theil} = \frac{\sqrt{\frac{1}{\text{T}}\sum_{\text{t}=1}^{\text{T}}(\text{F}_\text{t}-\text{A}_\text{t})^2}}{\sqrt{\frac{1}{\text{T}}\sum_{\text{t}=1}^{\text{T}}\text{F}_\text{t}^2}+\sqrt{\frac{1}{\text{T}}\sum_{\text{t}=1}^{\text{T}}\text{A}_\text{t}^2}}$$

Decomposition of MSE its bias, variance and covariance proportions.

The mean square error of prediction (MSE) can be decomposed into three sources:

i) The bias proportion (BP), which is an indication of systematic error, it tells us how far the mean of the forecast is from the mean of the actual series.
ii) The variance proportion (VP) measures the proportion of error arising from the mis-forecasting of the systematic component of the variance of outcomes; it tells us how far the variation of the forecast is from the variation of the actual series.
iii) The covariance proportion (CP), measuring the unsystematic error; the error remaining after taking into account deviations from average values and average variabilities. If the projection is accurate, the bias and variance proportions should be close to zero and the covariance proportion close to unity.

$$\text{Biasproportion} + \text{varianceproportion} + \text{covarianceproportion} = 1.$$

$$\text{MSE} = \text{BIAS}^2 + (\text{S}_\text{A} - \text{S}_\text{F})^2 + 2\,(1-\rho)\,\text{S}_\text{A}\text{S}_\text{F}$$

$$\text{BP} = \frac{\text{BIAS}^2}{\text{MSE}} = \frac{\left(\sum_{\text{t}=1}^{\text{T}}\text{F}_\text{t}/\text{T} - \sum_{\text{t}=1}^{\text{T}}\text{A}_\text{t}/\text{T}\right)^2}{\sum_{\text{t}=1}^{\text{T}}(\text{F}_\text{t}-\text{A}_\text{t})^2/\text{T}}$$

$$\text{VP} = \frac{(\text{S}_\text{A}-\text{S}_\text{F})^2}{\sum_{\text{t}=1}^{\text{T}}(\text{F}_\text{t}-\text{A}_\text{t})^2/\text{T}}$$

$$\text{CP} = \frac{2(1-\rho)\text{S}_\text{A}\text{S}_\text{F}}{\sum_{\text{t}=1}^{\text{T}}(\text{F}_\text{t}-\text{A}_\text{t})^2/\text{T}}$$

A_t: Actual series
F_t: Forecast series
FE_t: Forecast error
T: Number of observations
BIAS: Average bias
SE: Standard forecast error
MSE: Mean square forecast error
RMSE: Root mean squared error
MAE: Mean absolute error
MAPE: Mean absolute percentage error.
Theil: Theil's inequality coefficient
S_A: Standard deviation of actual series

S_F : Standard deviation of forecast series
BP: Bias proportion of MSE
VP: Variance proportion of MSE
CP: Covariance proportion of MSE
ρ: Correlation coefficient between actual and the forecast series.

Appendix B. Estimated ARMA models

Dependent variable: WPI

Method: ARMA maximum likelihood (OPG — BHHH)
Date: 11/29/15 Time: 19:08
Sample: 2007M01 2015M06
Included observations: 102
Convergence achieved after 55 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. error	t-statistic	Prob.
C	5.693976	1.350727	4.215489	0.0001
AR(1)	1.312931	0.107293	12.23692	0.0000
AR(2)	−1.044234	0.103160	−10.12246	0.0000
AR(3)	1.273638	0.091450	13.92710	0.0000
AR(4)	−0.654098	0.074441	−8.786754	0.0000
MA(1)	0.134400	0.080814	1.663074	0.0996
MA(2)	0.866971	0.080171	10.81403	0.0000
SIGMASQ	0.477955	0.062215	7.682326	0.0000
R-squared	0.961446	Mean dependent var		6.079142
Adjusted R-squared	0.958575	S.D. dependent var		3.538344
S.E. of regression	0.720161	Akaike info criterion		2.308258
Sum squared resid	48.75143	Schwarz criterion		2.514138
Log likelihood	−109.7211	Hannan-Quinn criter.		2.391626
F-statistic	334.8797	Durbin-Watson stat		2.114367
Prob (F-statistic)	0.000000			
Inverted AR roots	0.83 − 0.15i	0.83 + 0.15i	−0.18 − 0.94i	−0.18 + 0.94i
Inverted MA roots	−0.07 + 0.93i	−0.07 − 0.93i		

Dependent variable: CPIIW

Method: ARMA maximum likelihood (OPG — BHHH)
Date: 11/29/15 Time: 19:15
Sample: 2007M01 2015M06
Included observations: 102
Convergence not achieved after 500 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. error	t-statistic	Prob
C	8.449072	1.262018	6.694890	0.0000
AR(1)	1.376316	0.081327	16.92327	0.0000
AR(2)	−1.369505	0.104191	−13.14414	0.0000
AR(3)	0.876239	0.077364	11.32615	0.0000
MA(1)	−0.360365	0.208086	−1.731805	0.0866
MA(2)	0.997509	1.091312	0.914045	0.3630
SIGMASQ	0.791693	0.813650	0.973014	0.3330
R-squared	0.872359	Mean dependent var		8.967028
Adjusted R-squared	0.864297	S.D. dependent var		2.502777
S.E. of regression	0.921970	Akaike info criterion		2.800376
Sum squared resid	80.75267	Schwarz criterion		2.980521
Log likelihood	−135.8192	Hannan-Quinn criter.		2.873322
F-statistic	108.2122	Durbin-Watson stat		1.839684
Prob (F-statistic)	0.000000			
Inverted AR roots	0.92	0.23 + 0.95i	0.23 − 0.95i	
Inverted MA roots	0.18 − 0.98i	0.18 + 0.98i		

References

Bakhshi, H., Yates, A., 1998. Are U.K. Inflation Expectations Rational? Technical Report 81. Bank of England Working Paper.

Bernanke, B., 2007. Inflation expectations and inflation forecasting. Speech to the Monetary Economics Workshop of the NBER Summer Institute. Cambridge, Massachusetts, 10 July.

Bernanke, B., Laubach, T., Mishkin, F., Posen, A., 2001. Inflation Targeting: Lessons from the International Experience. Princeton University Press, Princeton.

Cunningham, R., Desroches, B., Santor, E., 2010. Inflation expectations and the conduct of monetary policy: a review of recent evidence and experience. Bank Can. Rev. (Spring).

Dias, F., Duarte, C., Rua, A., 2010. Inflation expectations in the euro area: are consumers rational? Rev. World Econ. 146, 591–607.

Debabrata, P.M., Partha, R., 2010. Inflation expectations and monetary policy in India: an empirical exploration. Working Paper No. WP/10/84, IMF.

Ehlers, N., Steinbach, M.R., 2007. The formation of inflation expectations in South Africa. Working Paper WP/07/06, South African Reserve Bank.

Forsells, M., Kenny, G., 2002. The rationality of consumer's inflation expectations: Survey-based evidence for the Euro area. Working Paper 163, European Central Bank.

Gerberding, C., 2001. The Information Content of Survey Data on Expected Price Developments for Monetary Policy. Economic Research Centre Discussion Paper 9/01. Deutsche Bundesbank, Frankfurt am Main.

Granger, C.W.J., Newbold, P., 1973. Some comments on the evaluation of economic forecasts. Appl. Econ. 5, 35–47.

Holden, K., Peel, D.A., 1990. On testing for unbiasedness and efficiency of forecasts. Manch. Sch. 48, 120–127.

Łyziak, T., 2012. Consumer inflation expectations in Poland. Working Paper 115, National Bank of Poland.

Mehra, Y.P., 2002. Survey measures of expected inflation: revisiting the issues of predictive content and rationality. Econ. Q. 88, 17–36.

Newey, W., West, K., 1987. A simple positive semi-definite, heterosckedasticity and autocorrelations consistent covariance matrix. Econometrica 55, 703–708.

Pearce, D., 1987. Short-term inflation expectations: evidence from a monthly survey. J. Money Credit Banking 19, 388–395.

Ranchhod, S., 2003. The relationship between Inflation expectation survey data and inflation. Reserve Bank N. Z. Bull. 66.

Razzak, W.A., 1997. Testing the rationality of the national bank of New Zealand's survey data. Discussion Paper 97/5, Reserve Bank of New Zealand.

Reserve Bank of India, 2010. RBI inflation expectations survey of households: September 2010, 21Round.

Reserve Bank of India, 2009. Report of the technical advisory committee on surveys.

Thomas Jr., L.B., 1999. Survey measures of expected U.S. inflation. J. Econ. Perspect. 13, 125–144.