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ABSTRACT
Inflation expectations data are commonly used to address a number of important questions primarily related to the inflation expectations formation. This work presents such an empirical analysis of Reserve Bank of India's (RBI) inflation expectations data for Indian urban population. First, we apply a battery of tests for verifying the assumptions of rationality of household expectations. The tests lead to the outright rejection of the assumptions. On the other hand, the inflation forecasts by professional forecasters seem to support the rational expectations assumptions. Second, considering a regression model we find that the inflation forecasts by the professionals forecast the actual inflation better than what could be predicted by the recently available actual inflation data. Finally, using a sticky information model (Mankiw and Reis (2001, 2002), Carroll (2003)) we also find the support for Carroll's contention that relevant macro economic information about future inflation flows from experts to the households not vice versa. Additionally, if the sticky inflation model describes the household inflation expectations formation, it is natural to expect that more news about inflation in the news channels would lead to the reduction of disagreement. Our empirical analysis using Google trend data supports this hypothesis.

KEYWORDS
expectation formation, sticky information, news data
JEL E31 and E50

1. Introduction

Expectations about macroeconomic variables gauge the forward-looking behavior of agents in the economy and play a very crucial role in economic theory and policy-making. Especially, Household inflation expectations are key to understanding household consumption, investment, and saving decisions, and hence ultimately impact the monetary policy. Yet how these expectations are formed, and how best to model this process, remains an open question (see Bernanke (2007), Bachmann, Berg, and Sims (2015), Coibion and Gorodnichenko (2015)). The basis for most of the macroeconomic models till early 2000s was laid in the rational expectations (RE) revolution of 1970s. A critical reception of rational expectations approach, reported in the words of Friedman (1979), such models lacked "a clear outline of the way in which economic agents derive the knowledge which they then use to formulate expectations." Recent criticisms of RE assumptions highlights the limitation of RE models in accurately capturing the behavior of macroeconomic data primarily: high persistence of inflation (Fuhrer and Moore (1995)), and the inevitable trade-off between inflation and unemployment (Ball (1994), Mankiw (2001)). Consequently, the empirical exploration in the literature emphasize the implications for macroeconomic

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dynamics of various alternative assumptions about expectations formation, most notably models of learning, see Sargent (1993) or Evans and Honkapohja (2001) for surveys. Surprisingly, however, use of actual empirical data on inflation expectations to test alternative models of expectations formation is a recent phenomenon (Carroll (2003), Sims (2003)). Manski (2017) summarized the historical development of the field very nicely: "However, collection of expectations data was long rare. Economists have tended to be skeptical of subjective statements. Students have been taught that a good economist believes what people do, not what they say. This perspective inhibited collection of data on expectations. Lacking data, economists have assumed that persons hold particular expectations or have sought to infer expectations from observed choice behavior."
This paper analyze the quarterly inflation expectations survey data of households (IESH) and the professional forecasters inflation forecasts collected by Reserve Bank of India (RBI) (see RBI (2010)) to address some important macroeconomic questions related to the formation of inflation expectations among urban Indians. To the best of our knowledge there is very little evidence of any empirical research being undertaken in understanding the inflation expectations formation process among urban Indians using IESH data.

In Section 2, we give a brief description of the IESH survey. For details, we refer to RBI (2010). We then discuss the general patterns observed in the expectations data of the households and professional forecasters' using graphs and charts. In Section 3, we report the results of a battery of statistical tests for testing rationality of expectations (RE) of households, and also of the professional forecasters'. The empirical results clearly suggest that the household expectations cannot be considered to be rational, while the professional forecasters' forecasts seem to be rational. In Section 4, after having observed a strong serial correlation in the actual inflation over time, we address the question whether the household expectations and/or the professional forecasters' forecasts have significant predictive power for predicting actual inflation given the recently available actual inflation data. The empirical analysis suggests that the household expectations do not have a significant predictive power, but the professional forecasters forecasts have. Since the household expectations are not found to be rational, we consider a general model for household inflation expectations formation in Section 5. The model includes several sub-models as special cases. Notable among them are the epidemiological model of Carroll (2003) and models for adaptive expectations which are suggested in the literature as alternatives to rational expectation model. Next in Section 6, we test for the direction of information flow and find that the professional forecasts Granger-cause the household expectations but not the other way around. In Section 7, we consider the effect of news, captured by Google trend data, on the disagreement between the household expectations and the professional forecasts. More news seems to lead to the convergence of the two. Finally, in Section 8, we give the concluding remarks.

2. Data & Data Patterns

2.1. *Brief Description of the Survey*

The Reserve Bank of India (RBI[2]), has been conducting quarterly Inflation Expectations Survey of Households (IESH) since September 2005 (RBI (2010)). The purpose of this survey is to measure the inflation expectations of urban households in India. In the first two rounds responses were obtained from 2000 households, 500 each from four metros viz. New Delhi, Chennai, Kolkata and Mumbai. These four major metros located in the northern, southern, eastern and western parts of India are assumed to be representative of the urban Indian population. The data on perceptions of the current inflation rate, and inflation expectations (both qualitative and quantitative) for the next quarter and for the next one year are collected from the selected households.[3]. From the third round (2006, March) onward, geographical coverage of IESH is expanded to three cities (one metro and two other major cities) in each zone viz., north, south, east and west. Each metro continues to be represented by a sample of 500 households, and from each of the other cities added later a sample of 250 households was selected giving an aggregate sample of 4000 households in each round. From the third quarter of 2008, IESH started capturing quantitative responses in more detail. Thus, in this paper we use the quarterly survey data collected between the third quarter, 2008 to the third quarter, 2018. Besides IESH data, we also use RBI's professional forecasters' forecasts of quarterly inflation for the same period. (RBI[4]).

We now introduce the following notations which will be used throughout the paper.
π_t: Inflation rate at quarter t as measured by the consumer price index number for industrial workers (CPI-IW) (Inflation rate is always with respect to price level at a four quarter lag).
M_t: Mean inflation expectations of the households for quarter t at quarter $t-1$
N_t: Mean inflation forecast of the professional forecasters for quarter t at quarter $t-1$

2.2. *Patterns in the data*

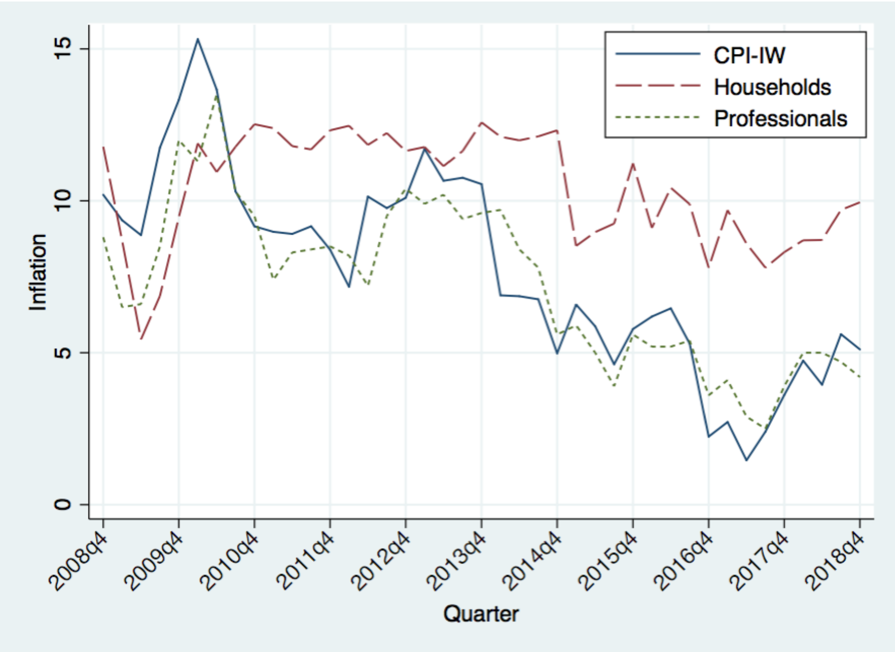
Figure 1 shows the plots of CPI-IW inflations (π_t), mean household expectations (M_t) and mean professional forecasts (N_t) for the quarters 2008$Q4$ ($t = 1$) to 2018$Q4$ ($t = 41$). It should be noted that in our data set, 2008$Q4$ is the first quarter for which households have made their forecast in 2008$Q3$. A double digit CPI-IW inflation is observed during most of 2009-2010 period primarily due to the global financial crisis. Clearly, the economic uncertainty during the period created the demand-supply disequilibrium, leading to the rise of price level worldwide and, of course, India is no exception. The period 2008$Q4$ to 2013$Q4$ may be considered a high inflation regime with two peaks at 2010$Q1$ (15.32%) and at 2013$Q1$ (11.71%) except the quarters between $2010, Q4$ and $2012, Q1$ with high single digit inflation. This high inflation regime is then followed by a low inflation regime with inflation hovering around 5%.

[2]the central bank of India

[3]Specifically, for qualitative responses, the respondents are asked whether they think price increases (i) more than, or (ii) similar to, or (iii) less than the current rate, or there is (iv) no change, or (v) decline in prices. For quantitative responses, the respondents are asked to tick one of the boxes giving inflation rates in intervals, less than 1%, 1-2%,..., 15-16%, more than 16%.

[4]RBI conducts a quarterly (now bi-monthly since 2014) survey of professional forecasters (SPF)

Figure 1. CPI-IW Inflation, SPF and IESH Time Series



The high inflation regime is commonly attributed to drought, the global rise in food prices and crude oil prices, among other factors.

Thus, the period of analysis considered in this paper comprises both high inflation and low inflation regimes.

Clearly, the inflation forecasts of the professional forecasters show a high degree of correlation (.91) with the actual inflation and the two series are moving almost in tandem with each other during this time period. Evidently, the professional forecasters being knowledgeable their forecasts seemed to be forward looking. It is also evident that throughout the period household expectations are substantially higher than the CPI-IW inflation except between 2009 and 2010. The reason for upward bias is discussed by Armantier, Nelson, Topa, van der Klaauw, and Zafar (2016), de Bruin, van der Klaauw, and Topa (2011), among others.

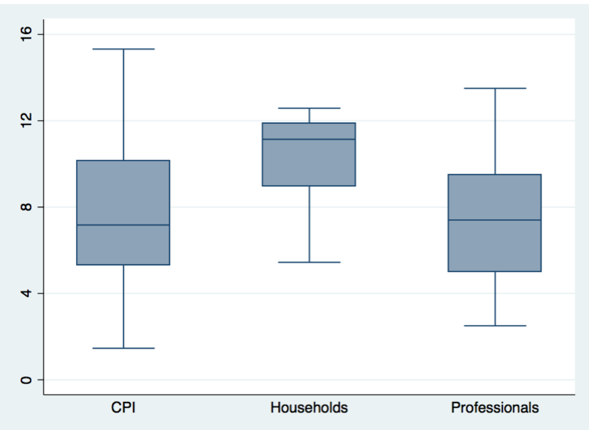


Figure 2. Box-plot: CPI-IW Inflation, Mean Inflation Expectation of IESHs (Households) and SPFs (Professionals)

It is to be noted that the double digit inflation expectations persist almost at a constant level between the first quarter of 2010 and the last quarter of 2014 though the CPI-IW inflation dropped significantly in between. As expected, it has a weak correlation (.40) with the CPI inflation, which is in clear contrast with the forecasts of the professional forecasters.

The box plots in figure 2 clearly vindicate the observations made above. The median inflation expectations is substantially higher than both the median CPI-IW inflation and the median inflation forecast by the professional forecasters, while the latter ones are close to each other. The variation of CPI-IW inflation over time is the highest followed by the variation of the inflation forecasts by the professional forecasters. On the other hand, the variation of inflation expectations is the least, and interestingly its values above the median show very little variation compared to the values below the median. This is a clear indication of the persistence of high household expectations.

Notably, RBI signed the Monetary Policy Framework Agreement (MPFA) with the Government of India (GoI) on February 20, 2015 on flexible-inflation targeting (FIT[5] framework in India). Under this agreement, GoI has set an initial target for RBI to contain the inflation[6] below 6 percent by January 2016. Also, inflation target is set to be 4 percent with a range of [2,6] for the financial year 2016-17 and all subsequent years. However, the inflation targeting does not seem to have an effect on the magnitude and movement of the household inflation expectations.

3. Survey Expectations and Rationality

It has been a standard practice for economists to assume that the expectations of economic agents are rational. It assumes that the agents share a common information set, and form expectations conditional on it. Unfortunately, the Rational Expectations (RE) assumptions made in economic research are found to have little credibility (Pesaran (1987), Manski (2004), Pesaran and Weale (2006), Coibion and Gorodnichenko (2015), Gennaioli, Ma, and Shleifer (2016), Manski (2017)). Under RE assumptions, the model itself dictates what expectations rational agents should hold to be consistent with the model Muth (1961), so the survey data are redundant. Following the RE Revolution in 70's the use of expectations data took a nosedive. "In our view, the marginalization of research on survey expectations deprives economists of extremely valuable information. ... The rational expectations assumption should not be taken for granted, but rather confronted with actual expectations data, imperfect as they are" (Gennaioli et al. (2016)). In the following we test the RE Assumptions using IESH data, and professional forecasters data collected by RBI.

Rationality of inflation expectations is judged by two of its fundamental characteristics. First, it should be unbiased, and second, it should be efficient (Thomas (1999), Nordhaus (1985)). If the agents forecast the inflation correctly on the average then it is unbiased. Efficiency, on the other hand, measures the degree to which information is incorporated into the forecasts. Efficient forecasts thus do not produce predictable forecast errors.

[5]On the basis of a previous recommendation of the Expert Committee for strengthening the Monetary Policy Framework (January, 2014)

[6]year-on-year change in the monthly CPI-C (consumer price index-combined) in percentage terms

Specifically, we apply a battery of tests for rationality by capturing its different dimensions as stated below (Mankiw, Reis, and Wolfers (2004)):

- Are the inflation expectations unbiased? To be specific, are the inflation expectations centred around the right value?
- Can the forecast errors be predicted by the forecasts themselves? In other words, whether inflation forecasts equipped themselves with any information that can be used to predict forecasting errors.
- Are the forecast errors persistent, i.e., are they serially correlated?
- Do the forecasts systematically underestimate the changes in the variable of interest? In other words, whether the changes in inflation are systematically under predicted.
- Are the inflation expectations forward looking (rational) or backward looking (adaptive) or a mix of both?
- Whether the publicly available macroeconomic information is useful for explaining the inflation forecast errors.

From Figures 1-2, it is evident that the household expectations are biased, persistent, predominantly backward looking, and underestimate changes. However, the professional forecasters forecasts may not be so. For the sake of completeness, in Table 1 we report the results of the statistical tests for testing the above hypotheses.

- Are the inflation expectations unbiased?
  Consider the following model and test for $\alpha = 0$,

$$\pi_t - M_t = \alpha + u_t, \tag{1}$$

$$\pi_t - N_t = \alpha + u_t. \tag{2}$$

  The results in Panel A of Table 1 suggest that the household expectations fail to pass the test of unbiasedness while the professional forecasters' forecasts pass the test.
- Can the forecast errors be predicted by the forecasts?
  Consider the following model and test for $\alpha = 0, \beta = 0$,

$$\pi_t - M_t = \alpha + \beta * M_t + u_t, \tag{3}$$

$$\pi_t - N_t = \alpha + \beta * N_t + u_t. \tag{4}$$

  Results in Panel B suggest that the household expectations fail to pass the test while the forecasts by the professional forecasters pass the test.

- Are forecast errors persistent (serially correlated)?
  Consider the following model and test for $\beta = 0$

$$\pi_t - M_t = \alpha + \beta * (\pi_{t-1} - M_{t-1}) + u_t, \tag{5}$$

$$\pi_t - N_t = \alpha + \beta * (\pi_{t-1} - N_{t-1}) + u_t. \tag{6}$$

	Households		Professionals	
Panel A: Unbiasedness?				
Model: π_t- $\pi_t^e = \alpha + u_t$				
α	-2.725**	(0.842)	0.458	(0.312)
H_0: $\alpha = 0$ (p-value)	0.0024		0.1498	
Panel B: Is Information Fully Exploited?				
Model: π_t- $\pi_t^e = \alpha + \beta\pi_t^e + u_t$				
β:	-0.273	(0.471)	0.116	(0.081)
α	0.122	(5.470)	-0.383	(0.606)
H_0: $\alpha = 0$, $\beta = 0$ (p-value)	0.0004		0.1521	
Panel C: Are forecast errors persistent (Serial correlated)?				
Model: π_t- $\pi_t^e = \alpha + \beta(\pi_{t-1}$ - $\pi_{t-1}^e) + u_t$				
β:	0.823***	(0.113)	0.395*	(0.157)
α	-0.556	(0.527)	0.258	(0.220)
H_0: $\beta = 0$ (p-value)	0.0000		0.0114	
Panel D: Are changes in inflation systematically underestimated?				
Model: π_t^e - $\pi_{t-2} = \alpha + \beta(\pi_t$ - π_{t-2} $) + u_t$				
β:	0.333	(0.267)	0.619***	(0.096)
α	2.611**	(0.793)	-0.516*	(0.253)
H_0: $\alpha = 0$, $\beta = 1$ (p-value)	0.0171		0.0003	
Panel E: Are expectations forward looking or backward looking (adaptive) or both?				
Model: $\pi_t^e = \alpha_0 + \alpha_1\ \pi_t + (1$ - $\alpha_1)\ \pi_{t-2} + u_t$				
α_1: π_t (forward looking)	0.333	(0.232)	0.619***	(0.100
1 - α_1: π_{t-2} (backward looking)	0.667**	(0.232)	0.381***	(0.100)
α_0	2.611***	(0.449)	-0.516*	(0.190)
Panel F: Usage of macroeconomic information?				
Model: π_t - $\pi_t^e = \alpha + \beta_1\ \pi_t^e + \beta_2\ \pi_{t-2} + \beta_3\ P_{t-2} + \beta_4\ G_{t-2} + \beta_5\ I_{t-2} + u_t$				
β_1: Survey Expectation π_t^e	-1.149***	(0.201)	-0.055	(0.193)
β_2: Inflation π_{t-2}	0.527**	(0.146)	0.090	(0.143)
β_3: Crude Oil price P_{t-2}	0.066*	(0.026)	0.008	(0.015)
β_4: Output gap G_{t-2}	-2.784	(10.296)	-1.604	(7.587)
β_5: Interest rate (T-364) I_{t-2}	-1.127*	(0.438)	-0.334	(0.359)
α: Intercept	8.028*	(3.731)	1.896	(2.512)
H_0: $\beta_3 = 0$, $\beta_4 = 0$, $\beta_5 = 0$	0.0710		0.7577	
π_t^e: M_t, N_t				

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: M_t is the IESH survey measure of mean inflation expectation for quarter t at quarter $t-1$, N_t is the Survey of Professional Forecasters mean inflation forecast for quarter t at quarter $t-1$ and π_{t-2} is the published inflation for the most recent quarter. All equations are estimated over the period 2008Q3 to 2018Q3. Estimates are through Newey-West regression with lag 3 Newey and West (1987). Lag is chosen as per $.75T^{\frac{1}{3}}$ criteria. In Panel F, Crude Oil price is USD/gallon and interest rate is T-364 yield, both averaged over the quarter. Output gap is calculated using Hodrick-Prescott (HP) filter as the deviation of log values of actual (quarterly) output from the trend line. Inflation π_{t-2} is the latest published CPI inflation, computed as the quarterly average of monthly index on y-o-y basis.

Table 1. Battery of Test for Forecast Rationality

Results in Panel C suggest that, for the household expectations, the forecast errors seem to be persistent. On the other hand, for professional forecasters, the forecast errors do not seem to be persistent at 1% level of significance, but at higher level of significance.

- Are changes in the inflation systematically underestimated?
  Consider the following model and test for $\alpha = 0, \beta = 1$,

$$M_t - \pi_{t-2} = \alpha + \beta(\pi_t - \pi_{t-2}) + u_t, \tag{7}$$

$$N_t - \pi_{t-2} = \alpha + \beta(\pi_t - \pi_{t-2}) + u_t. \tag{8}$$

Testing this hypothesis is considered by Lovell (1986). Results in Panel D suggest that both the households and the professional forecasters systematically underestimate the changes in inflation. Additionally, households show a significant upward bias of around 3%.

- Are the expectations forward looking or adaptive or a mix of both? (Lyziak (2009))
  Consider the following model and test for $\alpha_1 = 1$ (forward looking), $\alpha_1 = 0$ (adaptive), $0 < \alpha_1 < 1$ (mixed),

$$M_t = \alpha_0 + \alpha_1 \pi_t + (1 - \alpha_1)\pi_{t-2} + u_t, \tag{9}$$

$$N_t = \alpha_0 + \alpha_1 \pi_t + (1 - \alpha_1)\pi_{t-2} + u_t. \tag{10}$$

From Panel E it is evident that the household expectations and the professional forecasts both seem to be showing a mixed behaviour, albeit professional forecasts seem to be more forward looking where as households seem to be more backward looking. It is also interesting to note that the intercept term in the household regression is significant almost at any practically meaningful level. A possible explanation could be Carroll (2003), the formation of inflation expectations of the households may happen through other channels, like conversations with neighbours.

- Whether the publicly available macroeconomic information is useful for explaining the inflation forecast errors. If they are then the forecasts are not efficient. This amounts to testing $\beta_3 = \beta_4 = \beta_5 = 0$ for the following model.

$$\pi_t - M_t = \alpha + +\beta_1 M_t + \beta_2 \pi_{t-2} + \beta_3 P_{t-2} + \beta_4 G_{t-2} + \beta_5 I_{t-2} + u_t \tag{11}$$

$$\pi_t - N_t = \alpha + +\beta_1 N_t + \beta_2 \pi_{t-2} + \beta_3 P_{t-2} + \beta_4 G_{t-2} + \beta_5 I_{t-2} + u_t \tag{12}$$

where, P_{t-2} is the crude oil price, G_{t-2} is the output gap, and I_{t-2} is the short-term interest rate at time $t - 2$.

Results in Panel F suggest that the household forecasts are not efficient (at 8% level) while professional forecasts seem to be so.

To summarize the results, the household inflation expectations seem to be biased upward and inefficient while the professional forecasters' forecasts seem to be unbiased, and reasonably efficient. However, both underestimate the change in actual inflation which was also evident from the box plots furnished in Section 2. Also, both the expectations show a mix of forward looking and adaptive behaviour, though the professional forecasters seem to be more forward looking and households seem to be more (only) backward looking.

4. Forecasting Inflation by Forecasts

In this section we address an important question: Do the survey forecasts have predictive power for the future inflation beyond what could be predicted by the past inflation? This question is meaningful in the following context.

Notice that the CPI-IW inflation data fail to reject the unit root hypothesis. Both the tests, augmented Dickey-Fuller (ADF) (Dickey and Fuller (1979)) (p-value .57) and Phillips–Perron (PP) (Phillips and Perron (1988)) (p-value .52) support the unit root hypothesis. Incidentally inflation data in other countries also exhibit similar pattern (Culver and Papell (1997)). The inflation over time thus have a strong serial correlation, and hence the inflation in the quarter t (π_t) could be predicted well in the quarter $t-1$ from the the most recent available inflation (π_{t-2}). Thus, the finding that the survey forecasts have significant predictive power for inflation is simply not useful unless the predictive power of the survey forecasts is significantly more than what could be predicted by the past inflation. Table 2 presents the results of the regression analysis of inflation π_t at time t on the mean household expectations M_t for time t, the professional forecasters' forecast N_t for time t and the most recent annual inflation rate (π_{t-2}) available at time $t-1$.

The full regression model is given by equation (13). Table 2 shows the results of regression for the three variants of equation (13).

$$\pi_t = \alpha + \beta_1 \pi_{t-2} + \beta_2 M_t + \beta_3 N_t + u_t \tag{13}$$

The first column of Table 2 shows the results of regression of π_t on π_{t-2} and M_t. Only π_{t-2} is found to be significant. Thus, given the past inflation, household expectations do not contain any additional information for predicting future inflation. The model has adj-R^2 value .66. The second and the third columns show the results of regression of π_t on π_{t-2} and N_t, and on π_{t-2}, M_t and N_t, respectively. Clearly, professional forecasts have highly significant predictive power. Also, it is interesting to note that given the professional forecasts, neither past inflation nor household forecast is significant. The models have adj-R^2 value .84. It seems, the information set that the professional forecasters use to make superior forecasts is not available to the households. Also, it is interesting to note that the coefficient of professional forecast is close to unity while the other coefficients are nearly zero. The past inflation is significant only when the professional forecasts are not included in the regression model. These results indirectly vindicate the results obtained in Section 3, that the professional forecasts are rational.

Model: $\pi_t = \alpha + \beta_1\ \pi_{t-2} + \beta_2\ M_t + \beta_3\ N_t + u_t$			
	(1)	(2)	(3)
	π_t	π_t	π_t
β_1: π_{t-2}	0.620***	0.001	0.004
	(0.140)	(0.077)	(0.085)
β_2: M_t	0.434		-0.013
	(0.331)		(0.203)
β_3: N_t		1.098***	1.102***
		(0.143)	(0.145)
α: Constant	-2.125	-0.493	-0.391
	(2.918)	(0.608)	(1.788)
DA	0.007	0.439	0.444
Q	0.011	0.429	0.429
StdErr	1.896	1.308	1.328
AdjR2	0.660	0.838	0.833

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: M_t is the IESH survey measure of mean inflation expectation for quarter t at quarter $t-1$, N_t is the Survey of Professional Forecasters mean inflation forecast for quarter t at quarter $t-1$ and π_{t-2} is the published inflation for the most recent quarter. All equations are estimated over the period 2009Q4 to 2018Q3.Estimates are through Newey-west regression with lag 3 Newey and West (1987). Lag is chosen as per $.75T^{\frac{1}{3}}$ criteria. Autocorrelation for all the different model is checked with Durbin's alternative (DA) and not Durbin–Watson (DW) statistic as lagged dependent variables are included among the regressors. Null hypothesis of DA test is that there is no autocorrelation. For all the models the presence of autocorrelation is rejected except model (1). For all estimates, Portmanteau (Q) test for regression residuals being white-noise are checked and null hypothesis of errors being white-noise couldn't be rejected except model (1).

Table 2. Forecast Ability of Survey Forecasts

Thus, it makes a substantial difference from household expectations both in statistical and economic terms. Finally, we conclude that the professional forecasts incorporate all the information in the past inflation besides some additional information relevant for forecasting future inflation not contained in the past inflation.

5. Models for Expectation Formation of Households

5.1. Some Alternative Models

Clearly, a model for expectation formation that presupposes common people behave rationally is to be discounted. Consequently, the researchers felt the need for developing alternative models of expectations formation.

One strand of models assumes that the common people have limited knowledge of the economy, but adjust their forecast rule as new data become available over time. This viewpoint introduces an adaptive learning approach to expectations formation, and can be considered as a specific form of "bounded rationality" to macroeconomics

(Evans and Honkapohja (2001), Malmendier and Nagel (2016))

Mankiw and Reis (2001, 2002) on the other hand, simply assume that the agents update their expectations only periodically because of costs of collecting and processing relevant information. Such models are termed as 'sticky' information model. However, they do not provide an explicit model of information processing costs that leads to their specification. Carroll (2003) on the other hand provides a micro foundation of Mankiw-Reis model using a simple idea of disease propagation in a population. The idea is, of course, borrowed from the epidemiology literature.

Carroll contends that the common people do not have either the knowledge or the ability to understand the true macroeconomic model, and thus to produce their own macroeconomic forecasts by processing the latest statistics. Typically, they form their views from the news media. Households update their expectations-from news, but only a fraction (λ) of people are able to do so at a given period of time because of information asymmetry, idiosyncrasies, etc. This is similar to Calvo (1983) model of sticky prices where only a fraction of firms (agents) update their prices.

In other words, every individual does not pay close attention to all the macroeconomic news all the time, instead, individuals absorb the economic content of the news periodically with certain probability. News media, in turn, are supposed to report the views of the experts. The model then assumes that "expert opinion" slowly spreads through the common people similar to a disease spreading through a population. Assuming "professional forecasts" as the proxies of "expert opinion", Carroll (2003) proposes the following model for mean household expectations:

$$M_t = \lambda N_{t-1,t} + (1-\lambda)\{\lambda N_{t-2,t} + (1-\lambda)(\lambda N_{t-3,t} + ...)\}, \tag{14}$$

where $N_{t-k,t}$ represents the professional forecast of inflation for time t at time $t-k$, and λ represents the fraction of the population which absorb the current period experts' forecast for time t. Notice that $\lambda N_{t-2,t} + (1-\lambda)(\lambda N_{t-3,t} + ...)$ represents the mean expected inflation for time t of the individuals in the population who are yet to update their forecasts at time $t-1$, which reduces to M_{t-1} under certain conditions (for details cf. Carroll (2003)). The above equation thus reduces to

$$M_t = \lambda N_t + (1-\lambda)M_{t-1}. \tag{15}$$

Notice that, the model model (15) assumes that the mean expectation of the population for time t is a weighted average of the professional forecast for time t, and the mean expectation at time $t-1$. Notice that, the model's explicit assumption that people derive their expectations from the news reports (or equivalently professional forecasts) responds to Friedman (1979) criticism on the failure of the rational expectations model by providing a mechanism that explains expectation formation. Also, by relaxing the assumption of rationality, it is observed that this model is able to explain many macroeconomic phenomena unexplained by rational expectation models (Mankiw and Reis (2001, 2002)). In the next section we consider estimation of a general model for information expectations formation which includes model (15) as well as a few other related models as particular cases.

5.2. Estimating a General Model for Inflation Expectations

We consider a general regression model of M_t on the predictors N_t, M_{t-1} and π_{t-2}:

$$M_t = \alpha_0 + \alpha_1 N_t + \alpha_2 M_{t-1} + \alpha_3 \pi_{t-2} + \epsilon_t. \tag{16}$$

The regression model considers three important causal variables as the predictors, viz., the information flow from the news channels captured through professional forcasters' forecasts, mean inflation expectations of the households in the previous quarter, and the most recent available information on actual inflation. Notice that, as particular cases of the model (16) different models arise exhibiting the joint impact of these predictors. Table 3 shows the estimates of these models. In the following, we interpret the results reported in Table 3 and then discuss the suitability of different models in explaining the formation of the household inflation expectations of urban Indians. Among the models considered, model (15) is of particular interest to us. The columns of Table 3 show the estimates of different sub-models.

Notice that for the model $M_t = \alpha_1 N_t + \alpha_2 M_{t-1} + u_t$, estimate of which is reported in the first column of Table 3, the hypothesis $\alpha_1 + \alpha_2 = 1$ is rejected both at 5% and 1% level of significance. Thus, the model (15) does not seem to fit the expectations data well. In the second column, the estimates for the same model are obtained by constraining α_1 and α_2 to $\alpha_1 + \alpha_2 = 1$ which provides the first unambiguous estimate of the crucial coefficient λ of model (15) which is 0.105. It suggests that in each quarter only about 10.5% of the households update their inflation forecasts for the next quarter from the news channels. For Michigan Survey data Carroll estimated it to be 27%. Also, notice that the increase in the standard deviation for the model (15) from the unrestricted model does not seem to have a significant difference considering that the raw standard deviation of the dependent variable is 1.82. It is interesting to note in this context that both Durbin's alternative (DA) and the Portmanteau (Q) test indicate that there is no serial correlation in the residuals though the individual series exhibits high serial correlation. Thus we find that the model (15) is able to represent the household expectations data reasonably well.

The next question that naturally arises, whether there could be other models that arise as particular cases of (16) which explain the formation of the household expectations better. The next four columns of the table consider four such models. The third column reports estimates of the model $M_t = \alpha_0 + \alpha_1 N_t + \alpha_2 M_{t-1} + u_t$, which is the model in the first column with an intercept term added. The intercept is strongly significant. However, the improvement in fit compared to the models considered above is modest. The decline in standard error from 1.25 to 1.14 does not seem to be very impressive considering the fact that the model has an extra parameter. Further, it seems that the model as a description of the true process of expectation formation does not make much of a sense because it implies that if both actual inflation and professional forecasts were to go to zero, still the mean household expectations would be around 2.5%. In such circumstances, on the other hand, it is expected that the mean household expectations will also converge to zero. More generally, it implies that if the actual inflation rate and the professional forecasts are kept at a constant value, the mean household expectations will never converge to the true value, and will perpetually be biased. An alternative explanation could be, the model (15) is not an accurate description of the process by which information gets transmitted in the economy. Estimation of a misspecified model may result in spurious significant coefficients.

Model: $M_t = \alpha_0 + \alpha_1 N_t + \alpha_2 M_{t-1} + \alpha_3 \pi_{t-2} + u_t$						
	(1)	(2)	(3)	(4)	(5)	(6)
α_1: N_t	0.226***	0.105+	0.213***	0.397*	0.336+	
	(0.062)	(0.055)	(0.037)	(0.163)	(0.175)	
α_2: M_{t-1}	0.832***	0.895***	0.609***	0.855***	0.654***	0.920***
	(0.053)	(0.055)	(0.084)	(0.039)	(0.118)	(0.053)
α_3: π_{t-2}				-0.185	-0.131	0.090
				(0.147)	(0.177)	(0.067)
α_0: intercept			2.501*		2.179+	
			(0.936)		(1.184)	
DA	0.772	0.546	0.302	0.856	0.550	0.639
Q	0.851	0.717	0.914	0.633	0.785	0.773
RMSE	1.210	1.252	1.143	1.182	1.136	1.182
$\bar{R}^2$	0.987		0.610	0.987	0.615	0.987
$1^*\Sigma\alpha_i = 1$						
p-value	0.002		0.039	0.001	0.216	0.680

Standard errors in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: M_t is the IESH survey measure of mean inflation expectation for quarter t at quarter $t-1$, N_t is the Survey of Professional Forecasters mean inflation forecast for quarter t at quarter $t-1$ and π_{t-2} is the published inflation for the most recent quarter. All equations are estimated over the full sample period i.e. 2008Q3 to 2018Q3. Estimates are through Newey-west regression with lag 3 Newey and West (1987). Lag is chosen as per $.75T^{\frac{1}{3}}$ criteria. Autocorrelation for all the different model is checked with Durbin's alternative (DA) and not Durbin–Watson (DW) statistic as lagged dependent variable is included among the regressors. Null hypothesis of DA test is that there is no (any k_{th} order) autocorrelation. For all the model's the presence of autocorrelation is rejected. For all estimates, Portmanteau (Q) test for regression residuals being white-noise are checked and null hypothesis of errors being white-noise couldn't be rejected.

Table 3. Stickiness of Inflation Expectation and Different Models of Expectation Formation

Carroll (2001) suggests an alternative explanation that a significant intercept could be due to the transmission of inflation expectations through conversation with neighbours in addition to the transmission through news channels. However, another highly plausible statistical explanation of a strongly significant positive intercept could be the inadequate coverage of the inflation range in the expectations data used for estimating the models. Since a substantial part of the data are from high inflation regime, and during which the economic agents' expectations have an upward bias (see Figure 1), a positive intercept is expected. The model in column (4) (see Table 3) allows for the possibility that some people may update their expectations using the most recently published actual inflation rate in addition to the inflation forecasts provided by news channels. For this model, interestingly the coefficient of the professional forecasts is still strongly significant while the coefficient of past inflation rate has come out as non-significant which plausibly suggests that given the professional forecasts and the last quarter household inflation expectations, the most recently available inflation does not have a significant predictive power for predicting M_t. The next column shows the results when an intercept term is added to the model in column (4) (see Table 3). The past inflation rate is still not statistically significant. The professional forecasts is still significant at a level of significance 6% or more but with a coefficient smaller compared to that of model in column (4) (see Table 3). Regarding the intercept similar comments like model in column (3) are applicable. The last column shows the estimates of the model with the inflation expectations in the last quarter and the most recently available actual inflation rate as predictors. Clearly M_{t-1} is strongly significant, and π_{t-2} is significant at a level 18% or more. It shows that around 92% of the economic agents update their inflation expectations from their last quarter expectation and around approximately 8% from the last available actual inflation rate.

6. Information Flow Across Surveys

Here we test the assumption made by Carroll (2003) while proposing model (15) as a description of the process of household inflation expectations formation, that the professional forecasts shape the household expectations, but not the other way around. In other words, it assumes that the relevant macroeconomic information flows from experts to the households but not vice versa. We test it by using Granger causality frame work. This amounts to considering the following var models, and testing the null hypotheses H_{01}: $b_1 = ... = b_k = 0$ and H_{02}: $d_1 = ... = d_k = 0$. Number of lags i.e. k, is called 'causality lag' (Granger (1969)), beyond which no significance of coefficient is assumed.

$$N_t = a + \Sigma_{i=1}^{k} a_i N_{t-i} + \Sigma_{i=1}^{k} b_i M_{t-i} + u_t \tag{17}$$

$$M_t = c + \Sigma_{j=1}^{k} c_j M_{t-j} + \Sigma_{j=1}^{k} d_j N_{t-j} + v_t. \tag{18}$$

Notice that H_{01} (H_{02}) represents the hypothesis that household (professional) forecasts do not Granger-cause the professional (household) forecasts. The results in Table 4 clearly support H_{01} but H_{02}, thus confirming the assumption of Carroll's model.

It should be noted in this context that Granger causality is not a causality in the strict sense, but rather in the temporal sense. In the strict notion of causality if X causes Y then Y cannot cause X, but in Granger causality, both X and Y can be the cause and the effect, as well. The statistical interpretation of this is as follows: X and Y both can Granger-cause each other as in the case when both variables can be better forecasted with the presence of lagged value of another variable (along with its own lag). So Granger causality exists as a form of lagged dependence of variables.

7. News Search and Inflation Expectations

The empirical results in Section 6 suggest that the household inflation expectations are caused by the professional forecasts other than their own lagged expectations. Stretching this argument a little further one may expect, higher the volume of the inflation related news better the households are informed. By "better informed" we mean the lesser is the disagreement between the professional forecasts and the households expectations. To test this hypothesis we regress squared difference between the mean household expectations and professional forecast on the quarterly volume of

Granger Causality:				
VAR Model: $Y_t = \alpha + \Sigma_{i=1}^{k} a_i \, Y_{t-i} + \Sigma_{i=1}^{k} b_i \, X_{t-i} + u_t$				
H_0: X do not Granger-cause Y				
H_a: X Granger-cause Y (X→Y)				
H_0	Y	X	Hypothesis	Result (p-value)
H_{01}	N_t	M_t	M_t do not Granger-cause N_t	Not rejected (0.257)
H_{02}	M_t	N_t	N_t do not Granger-cause M_t	Rejected (0.00)

Note: M_t is the IESH survey measure of mean inflation expectation for quarter t at quarter $t-1$, N_t is the Survey of Professional Forecasters mean inflation forecast for quarter t at quarter $t-1$. The above granger causality between IESH and SPF is established with respect to var model in equation 17 and 18. The Johansen (1991) cointegration test rejects the null hypothesis of no cointegrating equations for both time series i.e. IESH and SPF. But this could not reject the null for one or fewer cointegrating equation. Thus we accept 1 as our estimate of the number of cointegrating equations between the two variables. Optimal lag for the var model of SPF and IESH is found to be 1 based on the information-criteria. Information criteria: final prediction error (FPE), Akaikes information criterion (AIC), Schwarzs Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC), all reports to the same lag number. This var model (equation 17- 18) is checked for serial correlation and only at lag 7 and higher, that the model exhibits no serial correlation. Toda and Yamamoto (1995) also suggest adding the max of the order of integration of variables to the lag order of var model. The lag used in establishing grange-causality for the model is 8 (7 lags for no serial correlation and an additional lag of 1 as an integration order).

Table 4. Granger Causality Between Households and Professionals

news search on "inflation" obtained from google trend data. "GTREND" measures quarter-wise google trend data on 'inflation'. The regression model is shown below.

$$(N_t - M_t)^2 = \alpha_0 + \alpha_1 GTREND_t + \epsilon_t \tag{19}$$

Table 5 presents the OLS estimates of the equation (19). The estimate of the regression coefficient is negative and significant. This suggests that the disagreement as measured by the squared difference between the households inflation expectations and professional forecasts reduces with the increase in the quarterly volume of news search on "inflation".

Table 5. Regression Estimates of Square of Difference of Survey Forecasts on Media Volume (Google Trend) on Inflation

	$(N_t - M_t)^2$
$\alpha_1 : GTREND_t$	-0.307***
	(0.0796)
α_0 : Constant	27.56***
	(3.712)
Observations	37

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

8. Concluding Remarks

This paper presents an empirical analysis of RBI inflation expectations data to address a number of important questions primarily related to the inflation expectations formation among the Indian urban population. First, we apply a battery of tests for verifying the assumptions of rationality of household expectations. The tests lead to the outright rejection of the assumptions. On the other hand, the inflation forecasts by professional forecasters seem to support the rational expectations assumptions. Considering a regression model we find that the inflation forecasts by the professionals forecast the actual inflation better than what could be predicted by the recently available actual inflation data. In order to seek alternative models for household inflation expectations formation we consider a regression model for mean household inflation expectations (M_t) with lagged mean household expectations (M_{t-1}), the inflation forecasts by the professional (N_t), and the most recently available actual inflation (π_{t-2}) as predictors presuming that the common people update their inflation expectations using one or more of these predictors. There are some interesting models which can be obtained as special cases of this regression model which we estimate and discuss its appropriateness as models of household inflation expectations. Notable, among these is the sticky information model (Mankiw and Reis (2001, 2002), Carroll (2003)). Carroll's model assumes that relevant macro economic information about future inflation flows from experts to the households not vice versa. We carry out tests using Granger causality framework which support Carroll's contention.

We observe that there is a significant disagreement between mean household expectations (M_t) and inflation forecasts by the professionals N_t. If the sticky inflation model describes the household inflation expectations formation, it is natural to expect that more news about inflation in the news channels would lead to the reduction of disagreement. Our empirical analysis using Google trend data supports this hypothesis.

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