Inflation Attention Cycles: A Costly Information Model of Inflation Expectations

(Job Market Paper Draft)*

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Abstract

This paper contributes to the discussion and understanding of how households update their inflation expectations. I develop a model where it is costly for individuals to gather information about the state of the economy, but beneficial for them to do so. Using a new dataset of U.S. news articles related to inflation, I estimate the effect of information availability on household inflation forecast error. I find little evidence that forecast error decreases after inflation data is released.

*For most recent draft see: https://jtregde.github.io/WPs.html

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1 Introduction

To quote Federal Reserve Board Chairman Jerome Powell, "... Inflation has just about everyone's attention right now..." (Powell, 2022) Inflation expectations have long been discussed as an important determinant of economic outcomes. Their importance can be traced all the way back to Irving Fisher who claimed that nominal interest rates are determined by real interest rates and expected inflation. However, they remain relevant in the recent literature since the New Keynesian Phillips Curve uses inflation expectations as a determinant of inflation. Even more recently, in his speech at the annual Kansas City Fed's annual Jackson Hole Economic Symposium, Chair Powell noted that "the public's expectations about future inflation can play an important role in setting the path of inflation over time." Powell (2022) went on to explain how during periods of high inflation, "the anticipation of high inflation became entrenched in the economic decisionmaking of households and businesses." But how do agents form their expectations? Answers to this question originally hinged on backward-looking agents adapting to recent developments in inflation (adaptive expectations: expand). More recent developments assume a rational, forward-looking agent who utilizes all the information available to them in order to form accurate predictions about future inflation.

But are consumers fully rational when it comes to forming their inflation expectations? Much recent literature has focused on relaxing the strict assumption of full information in the full information rational expectations (FIRE) models. This paper contributes to this literature by developing a costly information model of consumer inflation expectations. The consumers face a time cost of observing a signal which provides information aboout the state of the economy. Observing the signal reduces their forecast error, but at the cost of signal acquisition. This cost of signal acquisition is state-dependent, therefore I predict that it is only optimal to observe the signal in some states and not in others. That is, agents will rationally choose to not gain information before forming their expectations in some states of the economy, but will choose to bear the cost in other states.

I use a new data set of newspaper articles as a measure of the relative cost of information gathering. As the relative number of articles about inflation/prices increases, the time cost of gathering information should decrease. I use this to estimate an equation of inflation expectations for consumer forecasts from the New York Fed's Survey of Consumer Expectations (SCE). I look for evidence that consumers are rationally inattentive/ choose to be uninformed when the cost of information is high/benefit is low, but begin gathering information when the cost of information is low/the benefit is high. That is, I predict that agents' expectations about inflation will be more informed when inflation is higher (more salient) and less informed when inflation is lower (less salient).

Irving Fisher introduced the idea of adaptive expectations and noted how realized inflation could affect expectations about future inflation. Work by Phelps (1967) and Friedman (1968) found that in fact, expected inflation could also affect realized inflation. A main point under this framework was that *unanticipated* inflation caused the trade-off between unemployment and inflation. This implied that expectations were made in a backward-looking manner. However, as Binder and Kamdar (2022) note, "if inflation expectations are formed in a backward-looking manner, then expected inflation for the next period will rise. In order to maintain the low unemployment rate, inflation must once again surpass the newly-revised expectations, and so on."

After Muth (1961) introduced the idea of rational expectations, Lucas (1972) developed a model of inflation expectations in which agents use all the information that is useful in predicting future inflation, not just lagged inflation data. The rational expectations approach is used in the New Keynesian framework which is a popular approach currently. This approach utilizes profit maximizing firms that face pricing frictions. But could economic agents perhaps face some information frictions when forming their beliefs about the future?

Some questions still remain about what affects the way agents form their expectations. Fisher (1911) recognized that agents may be inattentive to information or unable to process information accurately in a manner that would allow them to form good expectations. For instance, it is well-documented that changes in gas prices have a strong impact on consumer inflation expectations (Binder, 2018). Similarly, D'Acunto et al. (2019) find evidnce that households' inflation expectations are shaped by the prices they see when shopping for non-durable goods. They use the Nielsen Homescan Panel to create household-level inflation perceptions which they use to analyze the relationship between perceived inflation and expectations. Gas and grocery prices can be thought of as being quite salient, and thus are perhaps a low-cost indicator for agents to use in forming their expectations. If agents make their information acquisition decisions in this manner, that is, only choosing to acquire information from relatively low-cost indicators, or only choosing to view the indicators when the cost is low, then it would follow that agents would acquire more information about the economy when the cost to viewing this information is quite low. The cost to acquiring this information should be directly related to the amount of information that is available, and one should expect information to be more plentiful in times of higher uncertainty or when inflation is reaching unexpected levels.

Others have examined how consumer expectations are impacted by central bank announcements and other news. Lamla and Vinogradov (2019) find that there is little to no effect of Fed announcements on expectations. However, numerate individuals' inflation expectations were affected by the June 2021 CPI release (Binder, 2021). In that work, Binder also found a fairly large increase in the number of respondents who had heard news about inflation. While the survey used only focused on a single month's announcement, it does seem likely that announcements where the statistic being released is quite shocking would tend to increase awareness of that statistic. Carroll (2003) finds evidence that households only occasionally update their expectations which leads to "'stickyness' in aggregate expectations." Carroll's work also uses news reports, but focuses on how households update their expectations to the reported expectations of professionals as found in the news. I instead use numbers of news articles in given time periods to proxy for the time cost of gathering information about inflation as well as the published year-over-year inflation rate.

The remainder of the paper is organized as follows. Section 2 develops a costly information model of inflation expectations. Section 3 describes the data used and the surveys from which the data was gathered. Section 4 explains the empirical methodology used. Section 5 explains the empirical results and checks for robustness of the results. Section 6 concludes.

2 Model

I consider a model of inflation expectations similar to that of Frankel and Kamenica (2019) where it is costly for agents to observe a signal which provides information about the true state of the economy. Observing the signal reduces their forecast error, but at the cost of signal acquisition. The cost of the signal is state-dependent, so choices regarding signal observation may vary by state. Each period, agents must decide whether to observe the signal or not, then they make their forecast. Agents know the cost of observation, and can only know the true state of the economy by observing the signal. I first illustrate a simple version of this model.

There is an objective state space, $\Omega = \{\omega_H, \omega_L\}$, with ω_H and ω_L denoting a state of high inflation and low inflation, respectively. The economy in this model follows a Markov process. Agents have a prior belief, μ, which is a distribution on Ω that puts weight μ^ω on state ω. Information is generated by signals $\gamma \subset S$, and an element $s \in S$ is a signal realization. Let α denote the S-valued random variable induced by signal γ_α. Given a prior μ, we denote posterior induced by signal realization s by $\mu(s)$.

For every signal γ_α, we have $E[\mu(\alpha)] = \mu$.

A decision problem $D = (A, B, u)$ specifies an action set A, an information choice B, and a quadratic utility function $u : A \times \Omega \to \mathbb{R}$. Assume that there exists some action a such that $u(a, \omega)$ is finite for every ω. The information choice, B, is the agent's decision regarding whether or not to incur the cost, C, of observing the signal, γ.

The value of information for D, denoted v_D, is given by

$$v_D(p, q) = E_q[u(a^*(q), \omega)] - E_q[u(a^*(p), \omega)] \tag{1}$$

where, for belief q, $a^*(q) \in \arg\max_{a \in A} E_q[u(a, \omega)]$. I denote the prior belief as p and the posterior as q where these are the believed probability that $\omega = 1$. An agent with posterior q views the pay off to $a^*(p)$ as $E_q[u(a^*(p), \omega)]$, while the payoff of taking the "correct" action under this belief is $E_q[u(a^*(q), \omega)]$. So $v_D(p, q)$ denotes the ex post value of information that updates beliefs from p to q.

I assume a quadratic utility function as this yields the benefit of allowing the use of mean-variance analysis. Agent's are risk averse, and thus their expected utility increases in the expected value of their action's expected outcome but decreases in the variance of the their action's expected outcome. That is, agents prefer to be more precise in their forecast as well as have a higher mean expected payoff. The utility function is

$$E[u(a,\omega)] = E(a,\omega) - \{Var(a,\omega) + [E(a,\omega)]^2\} \tag{2}$$

Agents can choose one of two forecast actions $a \in \{0,1\}$, which correspond to expecting either low or high inflation, respectively. I now denote the states of the world as $\omega \in \{0,1\}$ so the actions match their appropriate states. I normalize the payoff of $a = 0$ to zero in both states. The action $a = 1$ is optimal if $\mu u(1,1) + (1-\mu)u(1,0) \geq 0$, where μ is the probability of $\omega = 1$. The resulting payoff matrix is shown in 1.

TABLE 1: Agent's Payoff Matrix

		a	
		0	1
ω	0	0	-1
	1	0	1

The cost of information, $C(\omega)$, is only dependent on the state ω since it is independent of the amount of information acquired and only determined by a "time cost" spent observing the signal. The time cost is lower in the high inflation state since information is assumed to be more easily accessible, thus $C(\omega)$ is decreasing in ω.

2.1 Agent's Optimization Problem

The decision-maker's optimization problem is

$$\begin{aligned} &\max_{a,b}\, (1-b)\Big(E_p[u(a,\omega)]\Big) + b\Big(E_q[u(a,\omega)] - C(\omega)\Big) \\ &\text{s.t. } v_D(p,q) \geq C(\omega) \\ &\quad E[u(a,\omega)] = E(a,\omega) - \{Var(a,\omega) + [E(a,\omega)]^2\} \end{aligned} \tag{3}$$

where $b \in [0,1]$ and $b = 1$ when the agent chooses to observe the signal, thus incurring the cost of signal acquisition. Thus, since the agent knows the cost, they will choose to observe the signal when the net expected utility of updating their belief is greater than the expected utility of their prior.

This problem yields the result that the value of information $v_D(p,q)$ must be greater than or equal to the difference in expected utilities between the posterior q and the prior p. That is, the individual rationality constraint is binding and agents will only choose to observe the signal if the cost of signal acquisition is less than or equal to the value of the information. Since the value of information increases in ω and the cost decreases in ω,

$$b^* = \begin{cases} 1 & if\ \omega = 1 \\ 0 & if\ \omega = 0 \end{cases}$$

Agents observe the cost, and are thus able to make their information decision based on

3 Data

I use Inflation expectations data from the New York Federal Reserve's Survey of Consumer Expectations (SCE) * which gives 127,905 observations over the sample period June 2013- July 2021. This is a monthly survey of a rotating panel of around 1,300 consumers. Respondents participate for up to 12 months before being cycled out of the panel, with individuals being cycled out in equal numbers each month. The responses to the survey occur throughout the month, with the date of the response being recorded. This allows me to identify individuals who respond to the survey before the most recent inflation statistics are released and those who respond after the release.

I also gather data on news articles about inflation from major US newspapers using the Newspaper Source Plus database. This database contains full text for close to 500 U.S. newspapers. I retrieve 24,075 articles from a search of this database for articles containing certain key phrases related to inflation over the sample period, then calculate the number of news articles related to inflation on different days as a proxy for the salience of inflation information. Periods where there are more articles about inflation are periods where it is easier to access information on inflation since the news media are discussing it more.

Table 2: Summary Statistics

	Pre	Post
Female	0.228	0.254
Full time	0.258	0.291
Part time	0.062	0.070
Student	0.014	0.015
Retired	0.114	0.121
Hispanic	0.037	0.044
Black	0.043	0.047
Asian	0.019	0.020
Other race	0.002	0.002
Inc under 50k	0.171	0.183
Inc between 50k and 100k	0.167	0.188
Inc over 100K	0.131	0.150
High School	0.054	0.060
Some College	0.156	0.174
College	0.262	0.292

I match the SCE and newspaper data to the Bureau of Labor Statistics' (BLS) closest CPI release date and calculate how many days before or after the announcement the survey response was recorded or the article was printed. Figure 1 shows the average number of news articles by days since the last inflation announcement. There appears to be a cyclical nature to these articles in that there are spikes roughly every seven days. By far the largest spike occurs right after an

* "Source: Survey of Consumer Expectations, © 2013- 2020 Federal Reserve Bank of New York (FRBNY). The SCE data are available without charge at http://www.newyorkfed.org/microeconomics/sce and may be used subject to license terms posted there. FRBNY disclaims any responsibility for this analysis and interpretation of Survey of Consumer Expectations data."

announcement, suggesting that news outlets do tend to produce more articles about inflation right after the monthly announcement.

Figure 1: Average Number of News Articles

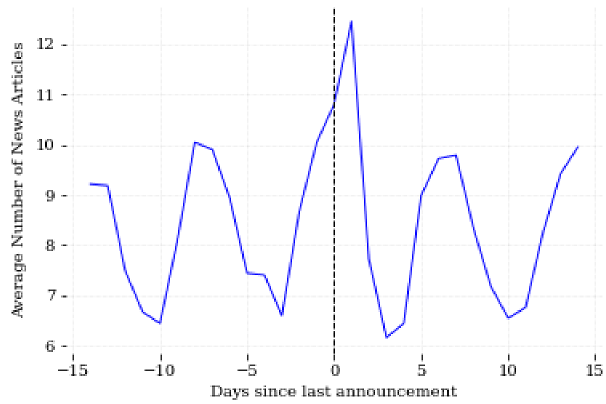
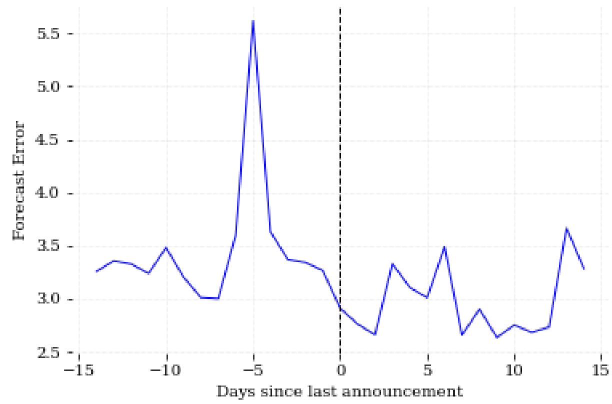


Figure 2 appears to show a local decrease in the forecast error at the announcement date, but the error decreases significantly right before the announcement as well. Forecast error after the announcement does seem to be generally lower than before, which provides some suggestive evidence of more informed forecasts after an announcement.

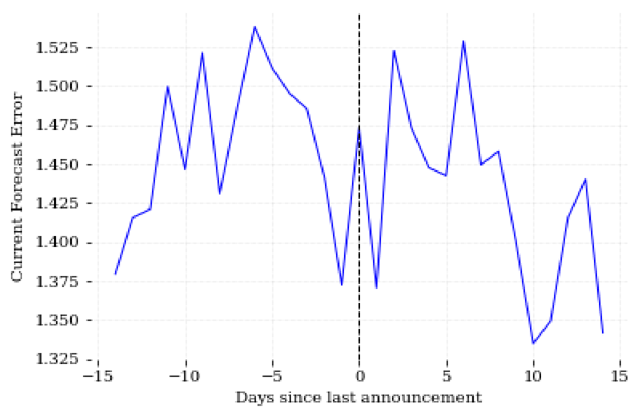
Figure 3 shows the difference in consumer forecasts from the inflation level at the time they took the survey. Interestingly, it does not appear that consumer forecasts get closer to the current reported level of inflation after a BLS announcement. The figure displays a drop the difference between forecasts and current inflation about ten days after an announcemnt which could suggest that consumers are taking note of reporting on inflation several days after the announcement is released, but generally forecasts do not seem much closer to current reported inflation after an announcement.

FIGURE 2: FORECAST ERROR AVERAGES



Note: Forecast error is calculated as the difference between consumers' forecast of inflation in 12 months and what realized inflation was at that time.

FIGURE 3: CURRENT ERROR AVERAGES



Note: Current error is calculated as the difference between consumers' forecast of inflation in 12 months and what inflation was in the period in which the survey was taken.

4 Empirical Methodology

I will use the SCE data to estimate response functions to information shocks. I use the monthly CPI announcement dates from the Bureau of Labor Statistics (BLS) as an exogenous information shock since these are predetermined dates that are not affected by the level of the CPI. The SCE data gives the exact date that the respondent completed the survey, so I can use variations in forecast errors around announcement dates to determine if agent forecast error is lower after an announcement. I exploit these facts to use a difference-in-differences design to estimate information release effects on forecast error. Since response dates are random, survey participants who respond to the survey prior to the CPI announcement within the month should not be systemically different from those who respond after the announcement. Therefore, respondents who respond after the announcement date in a month are the treatment group, and those who respond before the announcement are the control group.

I first estimate the following

$$FE_{t+1|t,i} = \alpha + \gamma_1 Post_{i,t} + \gamma_2 Infl_t + \gamma_3 Post_{i,t} \times Infl_t + \beta_1 X_i + \varepsilon_t \tag{4}$$

Where $Post$ indicates if the observation was from after the most recent CPI announcement and gives the difference in the mean forecast error between forecasts made before and after a CPI announcement.. $Infl_t$ is the current period inflation level that would have been reported in the recent announcement. The coefficient (γ_3) in $Post \times Infl$ shows the relationship between inflation and forecast error for forecasts made after an announcement. The model would sugest that γ_3 should be negative since individuals should be choosing to acquire information about inflation when inflation is higher, thus reducing their forecast error. X_i are a set of individual-specific demographic controls.

Next, I use the news data as proxy for the availibility of information about inflation on the day the individual completed the survey. Recall, that the higher the number of articles, the lower the cost of acquiring information should be, so the lower the forecast error should be.

$$FE_{t+1|t,i} = \alpha + \gamma_1 Post_{i,t} + \gamma_2 News\_count_t + \gamma_3 Post_{i,t} \times News\_count_t + \beta_1 X_i + \varepsilon_t \tag{5}$$

5 Results

I report the results from estimating Equations 4 and 5 in Table 3. Focusing first on Column (1), Inflation has a small negative association with forecast error in the base specification of Equation 4 when no demographic controls are included. However, when looking at Column (3), the news count measure has a small positive effect on forecast error. The interaction term in neither of the base specifications has the expected sign and it is not significant. When the demographic controls are included (Columns (2) and (4)), the interaction terms do have the expectred sign, but remain insignificant.

As has been well-documented, gender is an important factor in determining forecast error. Females have a forecast error that is on average 3 percentage points higher than that of males. Income is also signficant, with people who earn more than \$100,000 per year have a forecast error that is about 1.7 percentage points lower than that of middle-income earners.

The last column of Table 3 shows results from a full specification of the model. Again, only the demographic variables discussed above are of any significance and they maintain similar.

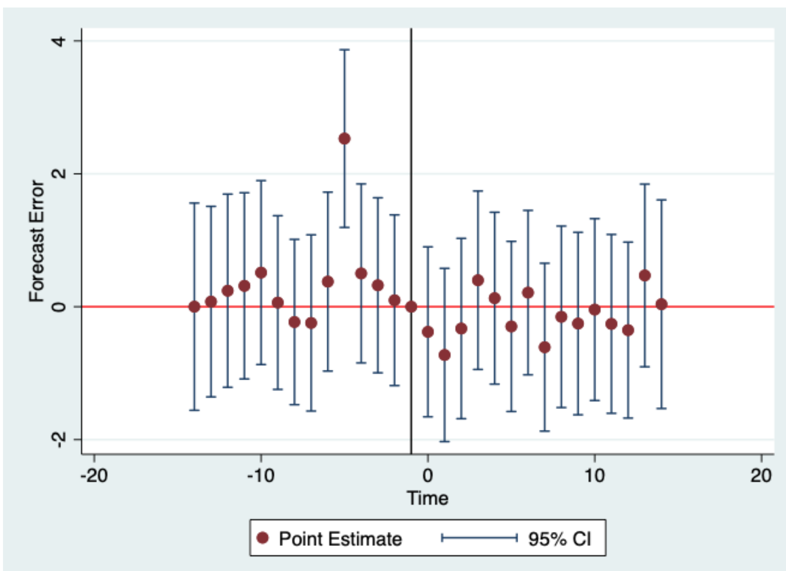
5.1 Robustness

I continue my analysis by searching for any lagged effects to announcements. I perform several event studies following similar structure to the main difference-difference-models

$$FE_{i,t+1|i,t} = \alpha + \sum_{k=T_0}^{-1} \beta_k \times News\_count_k + \sum_{k=0}^{T_1} \beta_k \times News\_count_k + \Gamma X_{i,t} + \gamma_t + \varepsilon_{i,t} \quad (6)$$

$$FE_{i,t+1|i,t} = \alpha + \sum_{k=T_0}^{-1} \beta_k \times Infl_k + \sum_{k=0}^{T_1} \beta_k \times Infl_k + X_{i,t}\Gamma + \gamma_t + \varepsilon_{i,t} \quad (7)$$

Figure 4: News Article effects on Forecast Error (no controls)



Note: Forecast error is calculated as the difference between consumers' forecast of inflation in 12 months and what realized inflation was at that time.

I look for heterogeneity in the results by splitting the sample on several different demographic variables including income, education, profession, gender, and numeracy. I also split the sample by Fed chair (Bernenke (-2014), Yellen (2014-2018), and Powell (2018-))

Table 3: Main Results

	Dependent variable: Forecast Error				
	(1)	(2)	(3)	(4)	(5)
Post	-0.717	2.193	-0.751	1.523	3.142
	(0.669)	(1.808)	(0.616)	(2.737)	(3.882)
Inflation	-0.641**	0.119			0.177
	(0.270)	(0.253)			(0.260)
Post x Inflation	0.263	-0.665			-0.778
	(0.277)	(0.419)			(0.622)
News count			0.058*	0.037	0.044
			(0.034)	(0.043)	(0.044)
Post x count			0.053	-0.050	-0.085
			(0.042)	(0.173)	(0.196)
Female		3.161***		3.145***	3.159***
		(0.877)		(0.850)	(0.860)
Age		-0.006		-0.007	-0.007
		(0.029)		(0.030)	(0.030)
Full time		-4.692		-4.705	-4.694
		(3.847)		(3.871)	(3.863)
Part time		-4.695		-4.691	-4.688
		(3.219)		(3.184)	(3.183)
Student		-3.607		-3.611	-3.607
		(2.505)		(2.516)	(2.516)
Retired		-4.511		-4.518	-4.504
		(2.902)		(2.930)	(2.921)
Hispanic		9.876		9.871	9.871
		(8.339)		(8.307)	(8.304)
Black		3.459***		3.453***	3.457***
		(1.097)		(1.102)	(1.099)
Asian		-0.309		-0.308	-0.308
		(0.788)		(0.790)	(0.790)
Inc over 100K		-1.710***		-1.712***	-1.698***
		(0.414)		(0.410)	(0.417)
Inc under 50k		3.475**		3.470**	3.476**
		(1.488)		(1.489)	(1.492)
Demographic Controls	No	Yes	No	Yes	Yes
Observations	116,918	16,262	116,918	16,262	16,262
Adjusted R^2	0.000	0.002	0.000	0.002	0.002
Residual Std. Error	46.220	89.858	46.220	89.859	89.863
F Statistic	15.371***	17.987***	8.254***	19.898***	17.715***

Note: *p<0.1; **p<0.05; ***p<0.01

I first show the two-day average forecast errors for males and females. Figures 5 and 6 show these. The average female forecast error is always higher than that of males, and it actually seems to increase after an announcement. Males have a generally lower forecast error, and they see a dip in their forecast error about a week after an announcement.

FIGURE 5: AVERAGE MALE FORECAST ERROR (2-DAY AVERAGES)

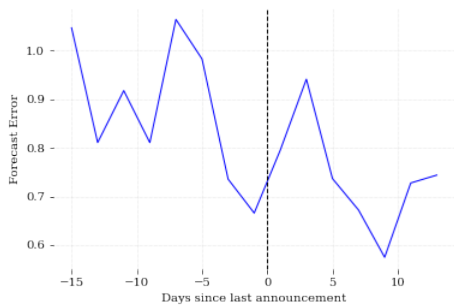
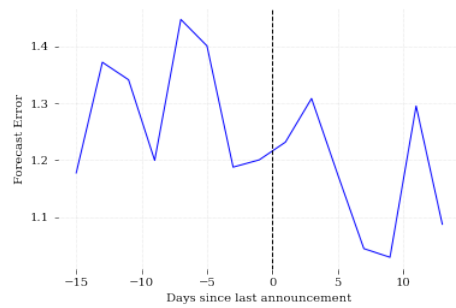


FIGURE 6: AVERAGE FEMALE FORECAST ERROR (2-DAY AVERAGES)



Next I turned focus to the forecast errors of highly numerate individuals compared to forecast errors of less numerate individuals. Survey participants were asked several mathematical questions and classified as either "high" or "low" numeracy based on the accuracy of their answers. As shown in Figures 7 and 8, the average forecast errors for more numerate individuals was much lower than that of less numerate individuals, but both seemed to experience a similar delayed reduction in their forecast error after an announcement.

FIGURE 7: AVERAGE FORECAST ERROR FOR HIGH NUMERACY INDIVIDUALS (2-DAY AVERAGES)

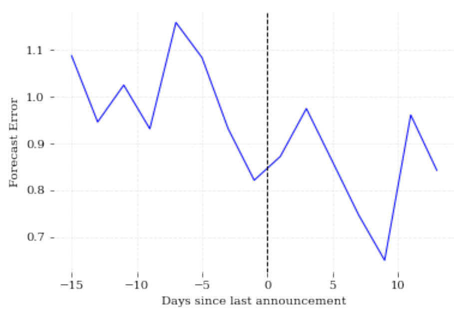


FIGURE 8: AVERAGE FORECAST ERROR FOR LOW NUMERACY INDIVIDUALS(2-DAY AVERAGES)

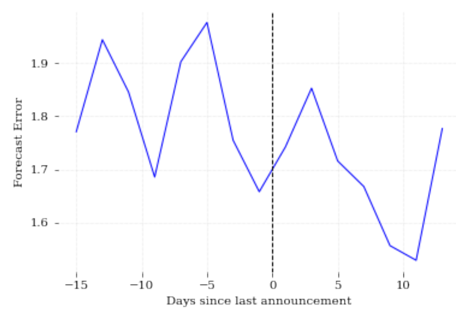
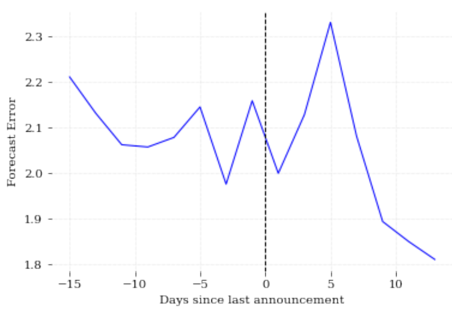


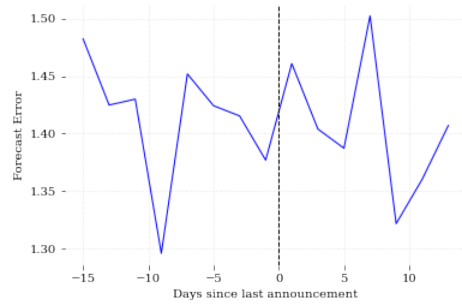
Figure 9 shows average forecast error relative to announcement dates split by Fed Chair. Inflation was relatively stable during the period of chair Bernanke's tenure that I have have data for as well as the entirety of chair Yellen's tenure, so it is not too surprising that we see little evidence that consumers are paying attention to announcements of inflation during these periods. Chair Powell has had the unfortunate task of being at the helm during the pandemic and the aftermath. It does appear that consumers do pay at least some attention to inflation news during chair Powell's tenure as there is a distinct drop in forecast error after announcement dates. Also note that average forecast error is much lower during this period than under the other two chairs.

Figure 9: Average Forecast Error During Recent Fed Chairs

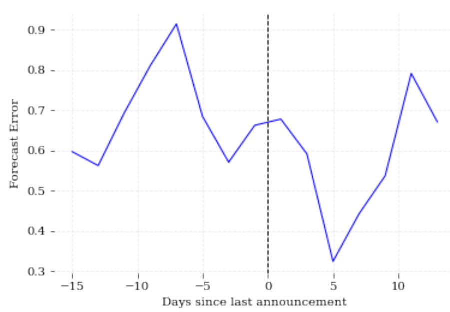
(a) Chair Bernanke (2-day averages)



(b) Chair Yellen (2-day averages)



(c) Chair Powell (2-day averages)



I use FOMC announcement dates rather than BLS announcements to check if agents pay more attention to Fed announcements rather than CPI releases.

6 Conclusion

Inflation expectations remain an important factor for central banks to consider when making policy. Chairman Powell has noted recently the importance of the public's inflation expectations in affecting the future path of inflation, as well as how important it is to manage expectations of high inflation. I develop a model of costly information where agents must decide whether or not to acquire information about current inflation. The model provides insight into how rational consumers might engage in information acquisation when it comes to forming their inflation expectations. The model implies that agents should acquire more information when the economy is in a state of higher inflation, and thus have a more accurate inflation forecast. I then investigate if the release of inflation data induces consumers to pay attention and have more accurate forecasts of future inflation. I find suggestive evidence that forecast error decreases after an announcement about current inflation is made. There are heterogeneous effects since male forecast error averages decrease more than those of females.

One limitation of my analysis is that the sample period I consider does not contain many incidences of elevated inflation, so it may be difficult to extrapolate from these results whether historically high CPI or inflation shocks would show a larger effect or not. As SCE data from more recent surveys is released, it would be easy to extend this work to include the current period where inflation has been very high.

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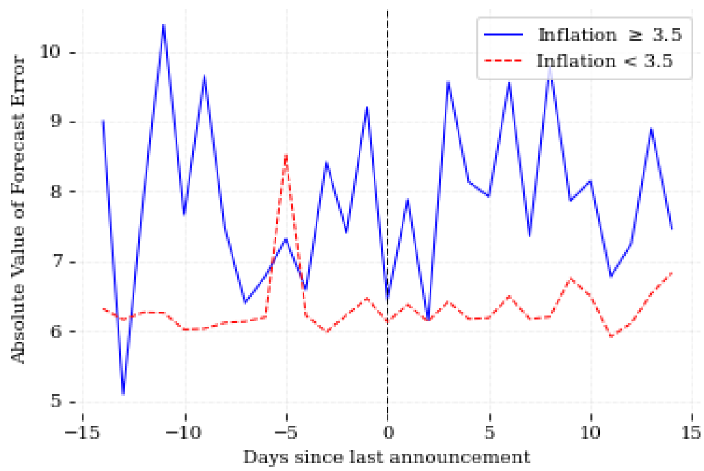
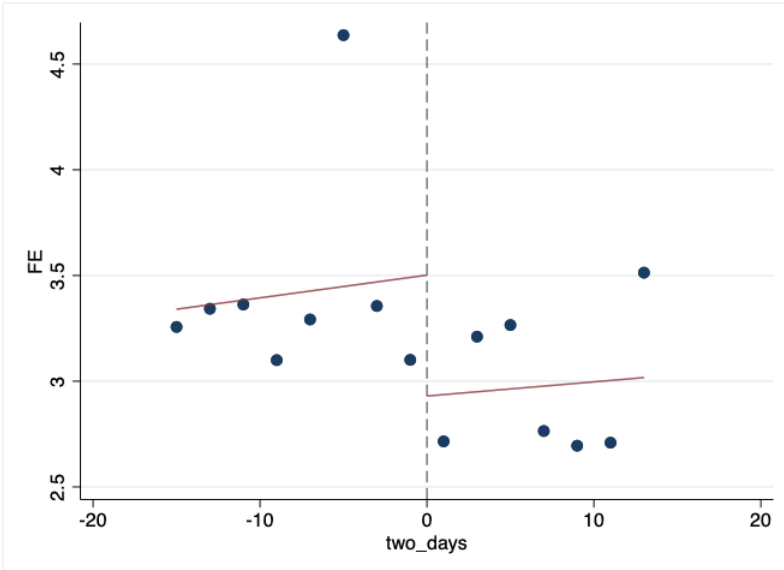
7 Appendix

Figure 10: FE by Inflation Levels



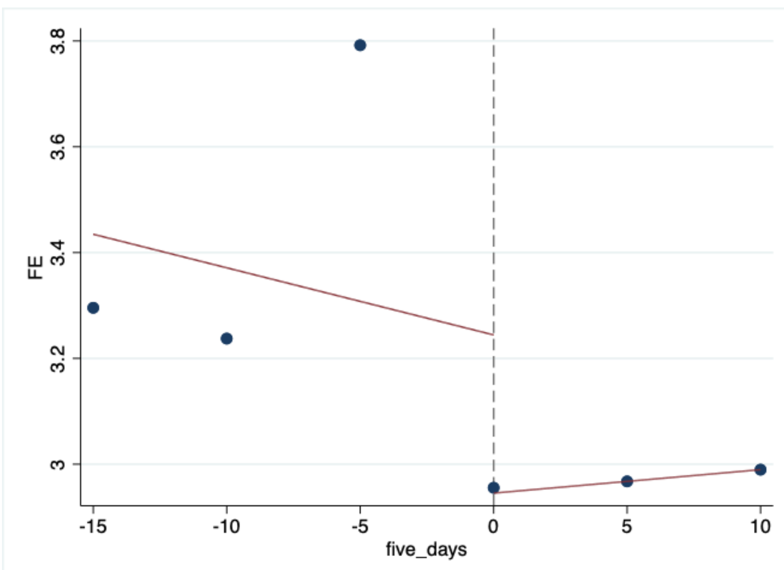
Note: Forecast error is calculated as the difference between consumers' forecast of inflation in 12 months and what realized inflation was at that time.

Figure 11: Two-day Binned Average Forecast Error



Note: Forecast error is calculated as the difference between consumers' forecast of inflation in 12 months and what realized inflation was at that time.

Figure 12: Five-day Binned Average Forecast Error



Note: Forecast error is calculated as the difference between consumers' forecast of inflation in 12 months and what realized inflation was at that time.