Expectations with Endogenous Information Acquisition: An Experimental Investigation

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Introduction

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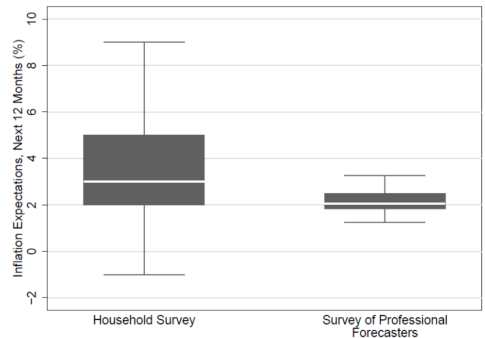
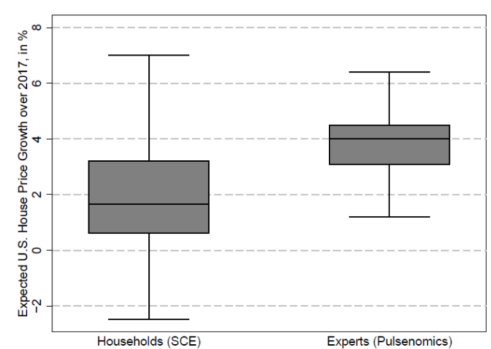
- Mounting empirical evidence of departures from RE
  - Systematic biases in measured expectations of households, managers, investors, professional forecasters (e.g. Gennaioli and Shleifer 2018)
- Important for policy makers
  - Inflation expectations: anchoring; forward guidance
  - Financial stability: “Survey evidence that ferrets out expectational errors can provide early warning signals of impending market corrections and a powerful new tool to prevent future financial crises” (Janet Yellen)

Motivation

Stylized fact: wide dispersion in expectations, especially among consumers (Mankiw, Reis, and Wolfers, 2003)





Source: Cavallo, Cruces and Perez-Truglia (2017)

Modeling expectation formation and dispersion

Various approaches in the literature to model expectation formation and generate such dispersion (non-exhaustive list!):

1. Sticky information models (Mankiw and Reis, 2002; Carroll, 2003; Reis, 2006)
2. Noisy information models (Sims, 2003; Woodford, 2003; Mackowiak and Wiederholt, 2009)
3. "Behavioral" – e.g. experience-based learning (Malmendier and Nagel); diagnostic expectations (Bordalo, Gennaioli, Shleifer); natural expectations (Fuster, Laibson, Mendel); sparsity (Gabaix)
4. Heterogeneous learning models (Hommes et al.)

Empirical approaches to understanding expectation formation

- Lab experiments (e.g. Beshears et al. 2013; Landier, Ma, Thesmar 2019)
  - Provide historical series; elicit (incentivized) forecasts
- "Regular" surveys
  - Consumers (e.g. Michigan survey; BoE Inflation Attitudes Survey)
  - Investors (Vissing-Jorgensen 2004, Greenwood and Shleifer 2014)
  - CFOs (Duke survey – e.g. Gennaioli, Ma, Shleifer 2015)
  - Professional forecasters (Coibion and Gorodnichenko 2012, 2015)
- To cleanly study belief updating and causal effects of information: randomized information experiments ("RCT approach") in custom-designed surveys

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Setting: online survey of households from across US

- Measure respondents' 1-year and 5-year expectations of local house price growth
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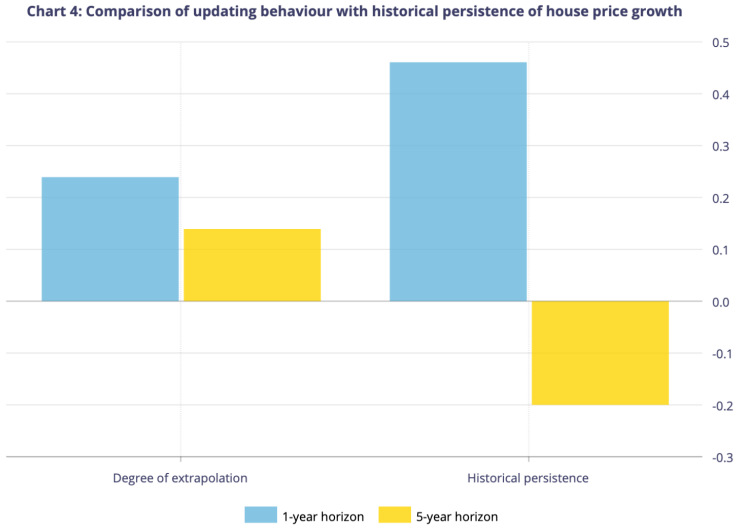
$\Rightarrow$ Do respondents update based on the information, and if yes, in what direction?

Extrapolation: E(ΔHP) moves in direction of "surprise"

Mean reversion: E(ΔHP) moves in opposite direction

- Dependence on forecast horizon (1 yr vs. 5 yrs)?
- Dependence on type of information (past 1 yr vs. past 5 yrs)?
- Are effects persistent?

AFZ – Summary of results



(from replication by Gosselin, Khan and Verstraete, Bank of Canada 2019)

Other information provision experiments

- Inflation expectations of households (Armantier et al. 2016, Cavallo et al. 2017)
- Inflation expectations of firms (Coibion et al. 2018, 2019)
- GDP/unemployment expectations of households (Roth and Wohlfart 2018)

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Robust findings:

- Information affects expectations (and effects partly persist over weeks/months)
- Expectations of respondents who see same information converge
- Expectations matter for behavior

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Limits/caveats:

- These studies cannot shed light on why consumers/firms were ex-ante misinformed
- or the type of information they would have paid attention to if they had a choice
- May give too much credence to sticky information approach

Our contribution in this paper

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  - But: substantial disagreement about which information source to look at

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- Show that many results consistent with model featuring heterogeneous priors about accuracy of different information sources, and info-processing frictions

Overview of experimental design

- Setting: online household survey (NY Fed Survey of Consumer Expectations)
- Respondents are asked to forecast one-year national home price growth
  - Research design applicable to all sorts of expectations (inflation, GDP growth, etc).
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- Later asked to forecast again, now with “high” or “low” incentives for accuracy
- Before providing their final forecast, they can buy one of three pieces of information
  - 1-year past HPA, 10-year past HPA, or expert forecast
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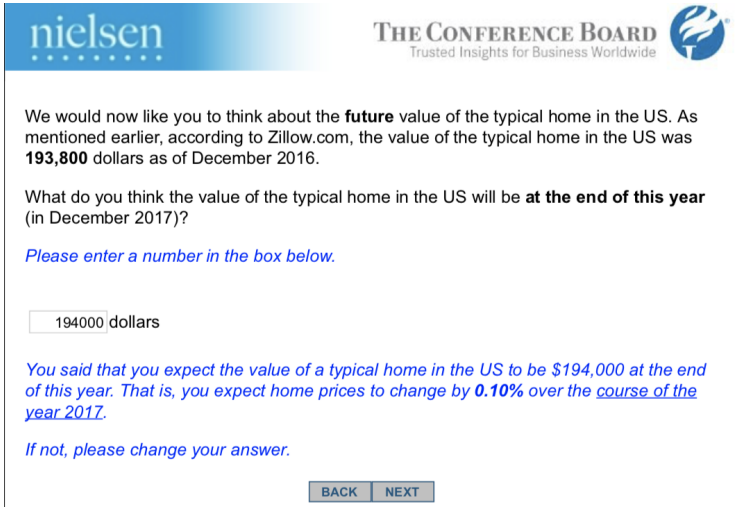
  - 1-year past HPA, 10-year past HPA, or expert forecast
  - Elicit WTP using multiple-price list method
- Depending on WTP and randomness, some are shown their preferred piece of information; then all provide final forecast
- Follow-up survey 4 months later: provide forecast again

Stage 1: Prior belief about year-ahead national home prices

- Elicit both point estimate and density (uncertainty)



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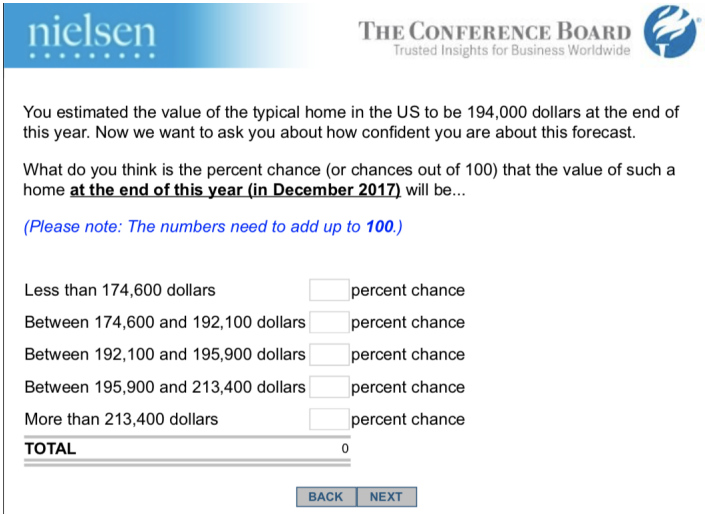
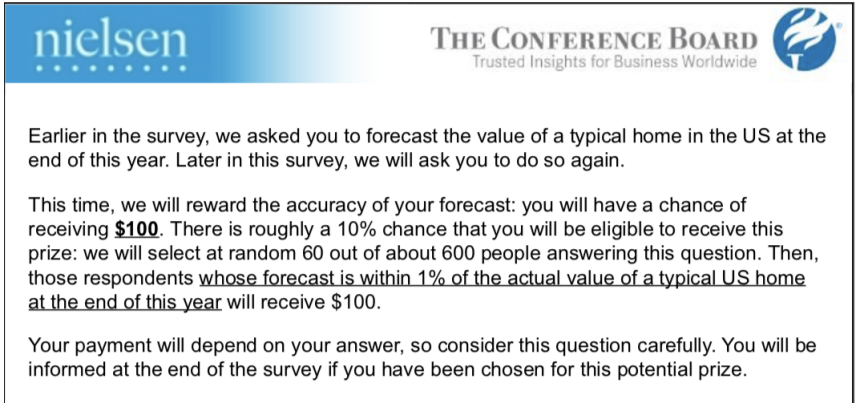


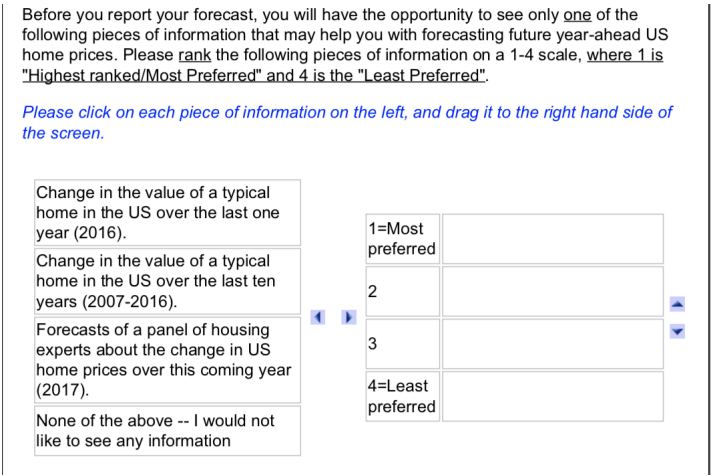
Stage 2: Information preferences

- About 15 min after Stage 1
- First informed about potential prize in case of accurate forecast ($10 or $100, randomized)



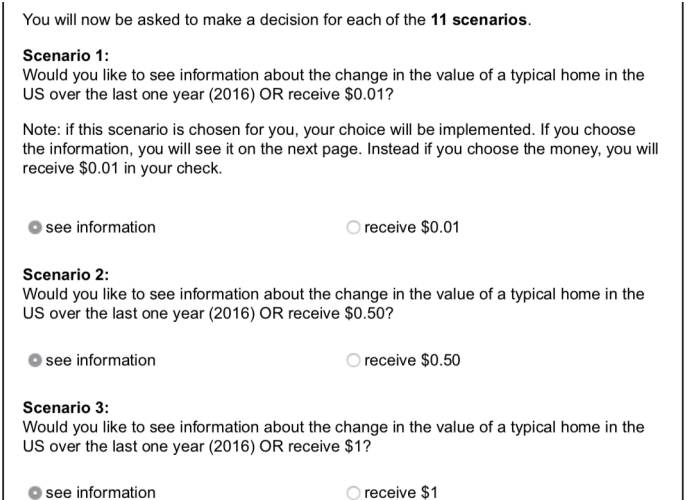
Stage 2: Information preferences

- Then asked to rank three possible information sources



Stage 3: Willingness-to-pay for preferred information

- Elicit the WTP for the most preferred information source using the multiple list price method. Choose between the info or a monetary payoff [$0.01, $5] in $0.50 increments (11 scenarios).



You will now be asked to make a decision for each of the **11 scenarios**.

Scenario 1:
Would you like to see information about the change in the value of a typical home in the US over the last one year (2016) OR receive $0.01?

Note: if this scenario is chosen for you, your choice will be implemented. If you choose the information, you will see it on the next page. Instead if you choose the money, you will receive $0.01 in your check.

◉ see information ○ receive $0.01

Scenario 2:
Would you like to see information about the change in the value of a typical home in the US over the last one year (2016) OR receive $0.50?

◉ see information ○ receive $0.50

Scenario 3:
Would you like to see information about the change in the value of a typical home in the US over the last one year (2016) OR receive $1?

◉ see information ○ receive $1

Stage 4: Posterior belief

- Depending on the scenario picked at random in Stage 3 and the respondent's choice, she might see one of the information sources.
- HP expectations are re-elicited from all respondents

Scenario 1 was picked at random for you.

You had chosen to receive information about the change in the value of a typical home in the US over the last one year (2016).

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Scenario 1 was picked at random for you.

You had chosen to receive information about the change in the value of a typical home in the US over the last one year (2016).

According to the Zillow Home Value Index, the value of a typical home in the US increased by 6.8% over the last one year (December 2015 - December 2016). That means a typical home in the US that currently has a value of **193,800** dollars would have had a value of **181,500** dollars in December 2015. If home values were to increase at a pace of 6.8% next year, that would mean that the value of a typical home would be **206,978** dollars in December 2017.

Earlier in the survey, you reported that you thought the value of the typical home in the US at the end of this year (in December 2017) would be 194,000 dollars.

We would now like to ask you again about the future value of a typical home in the US **at the end of this year**.

What do you think the value of the typical home in the US will be at the end of this year (in December 2017)?

Please enter a number in the box below.

dollars

Outline of analysis / design considerations

0. Sample description / characteristics; prior beliefs (stage 1)

1. **Choice over signals:** preference for informative signals? Systematic heterogeneity?

2. **Valuation and use of information:** what determines WTP for information?
   If information is obtained, do people incorporate it in their beliefs?
   Heterogeneity by stakes / prior uncertainty / personal characteristics?
   - Use randomization of reward amount ($10 vs. $100)

3. **Information and belief dispersion:** does lowering the cost of information reduce cross-sectional dispersion in expectations?
   - Use random effective price of information (from $0.01 to $5)

Sample characteristics and randomization check

- NY Fed SCE: monthly online survey of rotating panel of $\sim$1,400 hh heads from across US
- Annual module on housing issues (every Feb.; here: 2017)
- Participation rate: 78% ($N = 1{,}161$)
- Trim top/bottom 2.5% based on prior point forecast ($< -7.1\%, > 16.1\%$)
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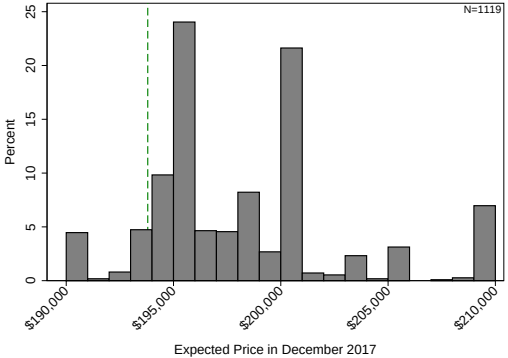
- Characteristics broadly representative of US population, but higher education, income, home ownership
  - Common with online surveys

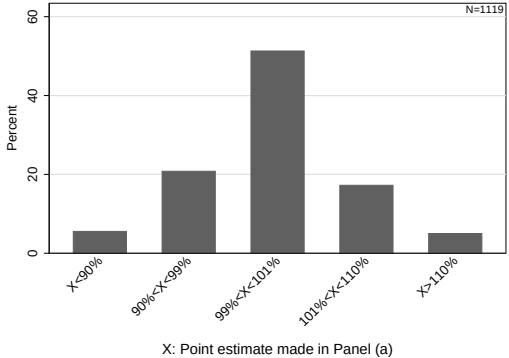
	All	Low Reward	High Reward	P-value
Prior Belief ($1,000s)	198.1	198.2	197.9	0.374
	(5.97)	(6.10)	(5.84)	
Prior Belief (% change)	0.0220	0.0230	0.0210	0.374
	(0.031)	(0.031)	(0.030)	
Income > $60,000 (0/1)	0.553	0.574	0.532	0.164
	(0.497)	(0.495)	(0.499)	
College Graduate (0/1)	0.552	0.550	0.554	0.877
	(0.498)	(0.498)	(0.497)	
Age	50.83	51.18	50.48	0.450
	(15.45)	(15.64)	(15.29)	
Female (0/1)	0.474	0.467	0.481	0.641
	(0.500)	(0.499)	(0.500)	
Married (0/1)	0.634	0.656	0.611	0.115
	(0.482)	(0.475)	(0.488)	
White (0/1)	0.813	0.788	0.837	0.039
	(0.390)	(0.409)	(0.370)	
Homeowner (0/1)	0.748	0.752	0.744	0.771
	(0.434)	(0.432)	(0.437)	
Observations	1,119	556	563	

Prior beliefs about end-2017 home price (end-2016: $193,800)

a. Point Estimate



b. Uncertainty



- Mean expected HP growth: 2.2%
- p5: −0.9%; p50: 1.7%; p95: 8.4%

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Naively using the information source historically would have yielded the following RMSE (in %):

- Experts’ forecast: 2.8
- Last year: 3.2
- Last ten years: 7.9

Ranking is consistent with basic insights from real estate literature (e.g. strong short-term momentum in home prices). Experts’ forecast should incorporate all of this.

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Signals very different across the three sources:

- Last year home price change: 6.8% (Zillow Home Value Index)
- Annualized HP change in last ten years: -0.1% (ZHVI)
- Average forecast of experts: 3.6% (Zillow Home Price Expectations Survey)

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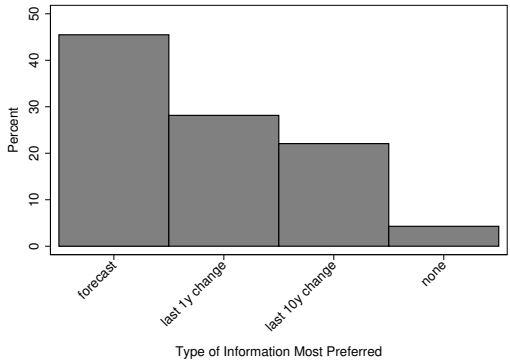
Note: realized HP growth over 2017: 6.5% – so in this case 1-year info “won”

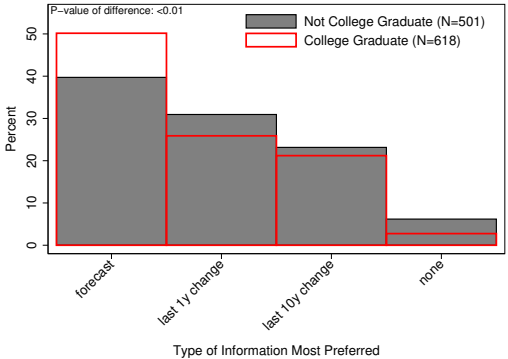
1) Demand for “informative” sources?

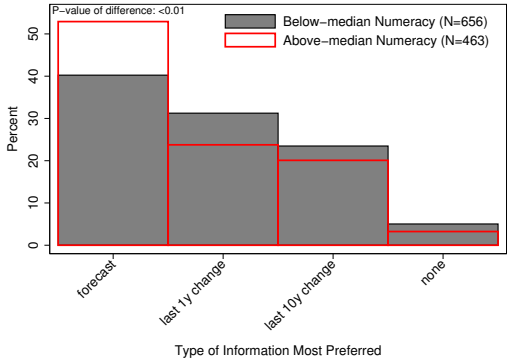
- “Only” 45.5% choose expert forecast (28% past 1 yr, 22% past 10 yrs)



1) Demand for “informative” sources?

- “Only” 45.5% choose expert forecast (28% past 1 yr, 22% past 10 yrs)
- More educated/numerate respondents more likely to choose expert forecast
  - Numeracy: 5-item test from Lipkus et al. (2001) and Lusardi (2009)





- Median respondent spent 2.2 min on ranking (p10 = 1.2 min; p90 = 4.9 min)

Determinants of information choice

	Indicator: chose...			
	Forecast	1yr	10yrs	None
Income > 60,000 (0/1)	0.034	0.002	-0.009	-0.027**
College Graduate (0/1)	0.066**	-0.023	-0.027	-0.016
Age	0.000	0.002**	-0.002***	0.000
Female (0/1)	0.037	-0.014	-0.017	-0.006
Married (0/1)	-0.035	0.001	0.039	-0.005
White (0/1)	0.060	-0.031	-0.019	-0.009
Numeracy (0-5)	0.058***	-0.042***	0.000	-0.015*
Uncertainty in Prior Belief (Std)	0.014	0.002	-0.001	-0.015*
Median House Value in State (Std)	0.027*	-0.009	-0.010	-0.008
House Value Volatility in State (Std)	-0.007	-0.007	0.010	0.003
Looked for Info in Past (0/1)	-0.014	0.035	-0.010	-0.010
Homeowner (0/1)	-0.049	0.070**	0.004	-0.025
Conf. in Past Recall (1-5)	-0.019	0.011	0.006	0.001
Prob Move and Buy in 3 Years	0.129**	-0.038	-0.051	-0.040**
High Reward (0/1)	0.011	0.008	-0.015	-0.005
Mean	0.45	0.28	0.22	0.04
Observations	1119	1119	1119	1119
R2	0.05	0.03	0.01	0.05

- Multivariate regression, separate for three info-source dummies
  - Similar with multinomial logit
  - Similar with bivariate correlations

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- Significant effects: education & numeracy; homeowner; Pr(move&buy). No effect of randomized reward. $R^2 \leq 0.05$.

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Prob Move and Buy in 3 Years	0.129**	-0.038	-0.051	-0.040**
High Reward (0/1)	0.011	0.008	-0.015	-0.005
Mean	0.45	0.28	0.22	0.04
Observations	1119	1119	1119	1119
R2	0.05	0.03	0.01	0.05

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Determinants of information choice

	Indicator: chose...			
	Forecast	1yr	10yrs	None
Income $>$ 60,000 (0/1)	0.034	0.002	-0.009	-0.027**
College Graduate (0/1)	0.066**	-0.023	-0.027	-0.016
Age	0.000	0.002**	-0.002***	0.000
Female (0/1)	0.037	-0.014	-0.017	-0.006
Married (0/1)	-0.035	0.001	0.039	-0.005
White (0/1)	0.060	-0.031	-0.019	-0.009
Numeracy (0-5)	0.058***	-0.042***	0.000	-0.015*
Uncertainty in Prior Belief (Std)	0.014	0.002	-0.001	-0.015*
Median House Value in State (Std)	0.027*	-0.009	-0.010	-0.008
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- **Result 1:** Considerable disagreement across households on ranking of sources. Relationship with ability measures suggests cognitive limitations play some role.

2a) Valuation of information

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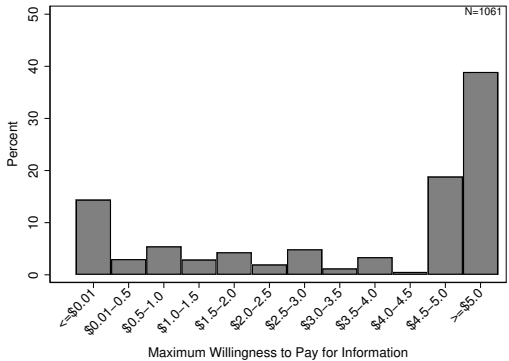

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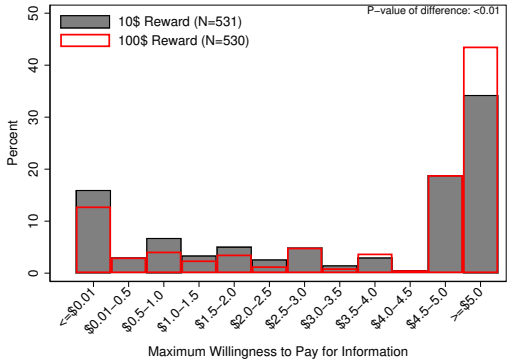

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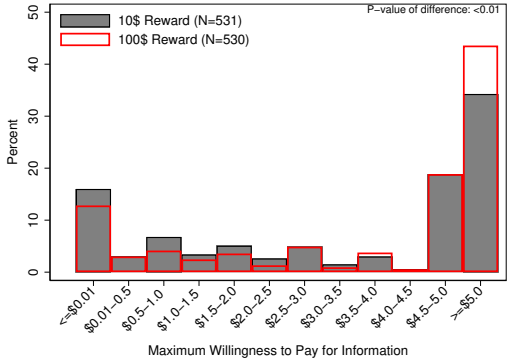

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$$WTP_i = U_{Info} + 0.1 \cdot Reward_i[P_i(Acc|Info) - P_i(Acc|NoInfo)] + \varepsilon_i$$

Avg. individual expects that, by acquiring info, her probability of being accurate will increase by 9.2pp (18% increase vs. baseline)

Cross-sectional correlates of WTP

	Bivariate		Multivariate	
High Reward (0/1)	0.828***	[0.107]	0.843***	[0.246]
Income $>$ \$60,000 (0/1)	0.862***	[0.259]	0.719**	[0.298]
College Graduate (0/1)	0.398	[0.257]	0.184	[0.273]
Age	0.031***	[0.008]	0.037***	[0.009]
Female (0/1)	-0.289	[0.254]	0.135	[0.269]
Married (0/1)	0.445*	[0.268]	-0.012	[0.298]
White (0/1)	0.300	[0.350]	-0.103	[0.361]
Numeracy (0-5)	0.244*	[0.126]	0.066	[0.137]
Uncertainty in Prior Belief (Std)	-0.276**	[0.136]	-0.128	[0.136]
Median House Value in State (Std)	0.254**	[0.126]	0.166	[0.134]
House Value Volatility in State (Std)	0.249**	[0.125]	0.203	[0.127]
Looked for Info in Past (0/1)	0.773***	[0.256]	0.481*	[0.267]
Homeowner (0/1)	0.906***	[0.293]	0.284	[0.331]
Conf. in Past Recall (1-5)	0.288*	[0.154]	0.087	[0.160]
Prob Move and Buy in 3 Years	0.172	[0.437]	0.402	[0.606]

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- Higher WTP in high stakes treatment

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- Income and age strongly positively correlated with WTP; relation with numeracy and education also positive (but statistically weak)

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- Higher WTP by those who already know more — suggests “selection” / heterogeneous “taste” for information

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Two measures: **Updating of forecast** and time spent on reporting posterior forecast.

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We estimate (following e.g. Cavallo et al., 2017)

$$posterior_i - prior_i = \alpha\ (signal_i - prior_i) \times S_i + \beta\ (signal_i - prior_i) + WTP_i\delta + \varepsilon_i.$$

α measures the learning rate; β is the spurious mean-reversion

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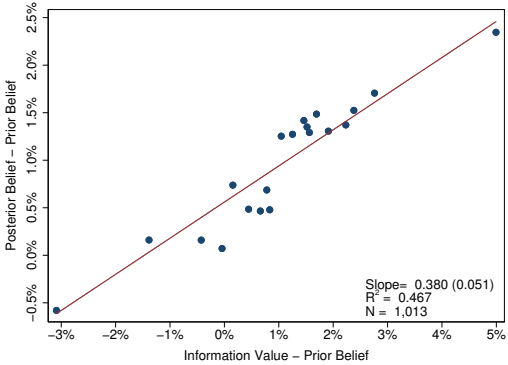
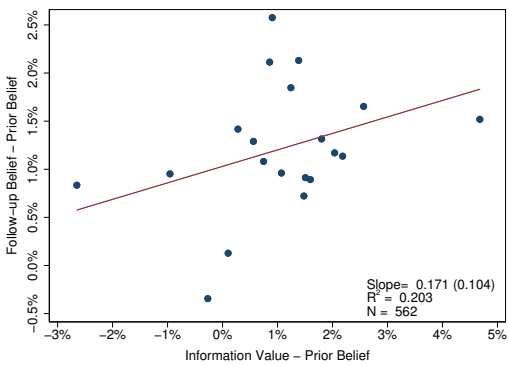
Standard Bayesian updating also implies that α should increase in prior uncertainty (for fixed noise in signal).

Learning rates

a. Main survey



b. Follow up



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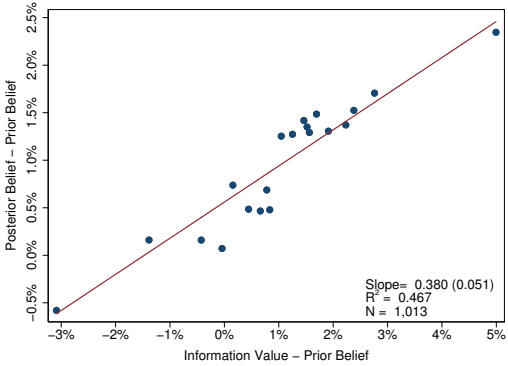

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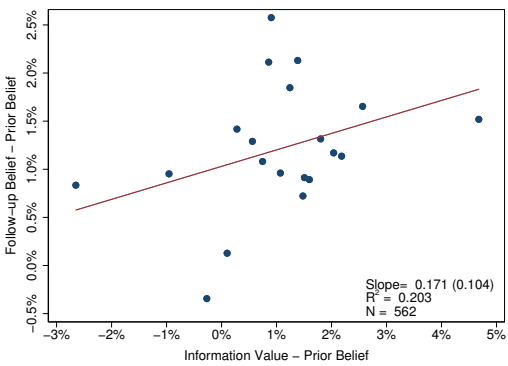
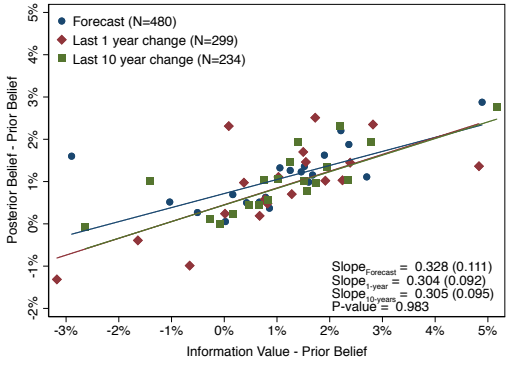


- $\hat{\alpha} = 0.38$ – meaning respondents put substantial weight on signal
- Persistence of effect 4 months later ($\hat{\alpha} = 0.17$, $p < 0.1$) suggests genuine learning (not just anchoring)

Heterogeneity in use of information

- No differences across information sources



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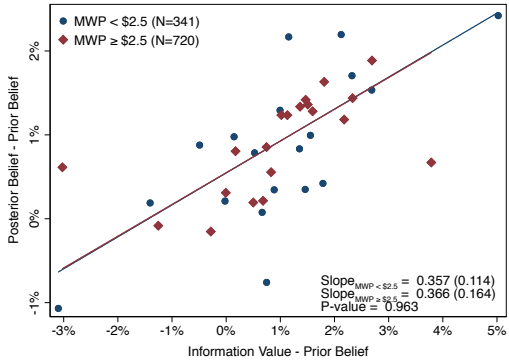

Heterogeneity in use of information

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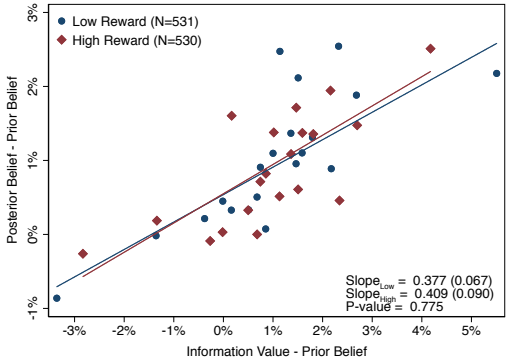

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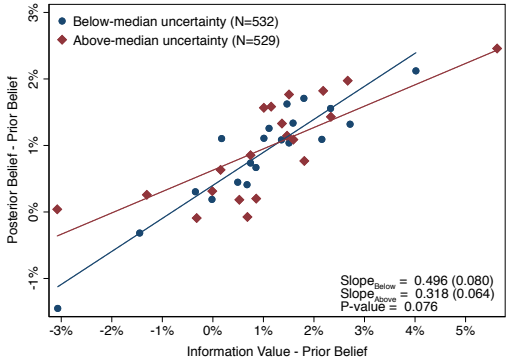

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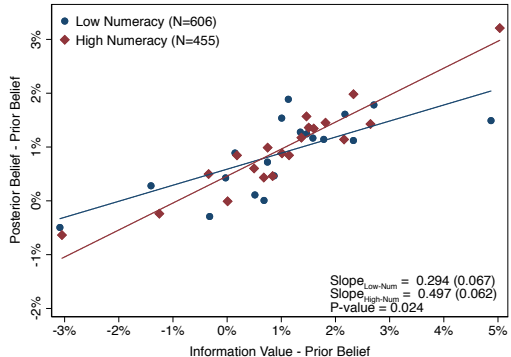

Heterogeneity in Time Spent on Posterior

	Log Min	Log Min | See Info
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Income $> 60,000 (0/1)$	-0.086**	-0.176***
College Graduate (0/1)	-0.002	-0.040
Age	0.007***	0.007***
Female (0/1)	0.022	0.067
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Uncertainty in Prior Belief (Std)	-0.078***	-0.069***
Median House Value in State (Std)	-0.018	-0.032
House Value Volatility in State (Std)	0.009	-0.012
Looked for Info in Past (0/1)	0.040	-0.025
Homeowner (0/1)	0.110**	0.055
Conf. in Past Recall (1-5)	-0.016	-0.047
Prob Move and Buy Home in 3 Years	-0.003	-0.050
Look at Info During Survey (0/1)	0.320***	0.263***
WTP	0.104***	0.056***
Mean	0.65	0.77
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Result 2: Respondents put value on information, and incorporate the signal. Contrary to standard models of rational updating, we do not find the weight (or time spent) to be higher for individuals with higher prior uncertainty.

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Prior	2.06 (0.098)	2.04 (0.100)	0.88
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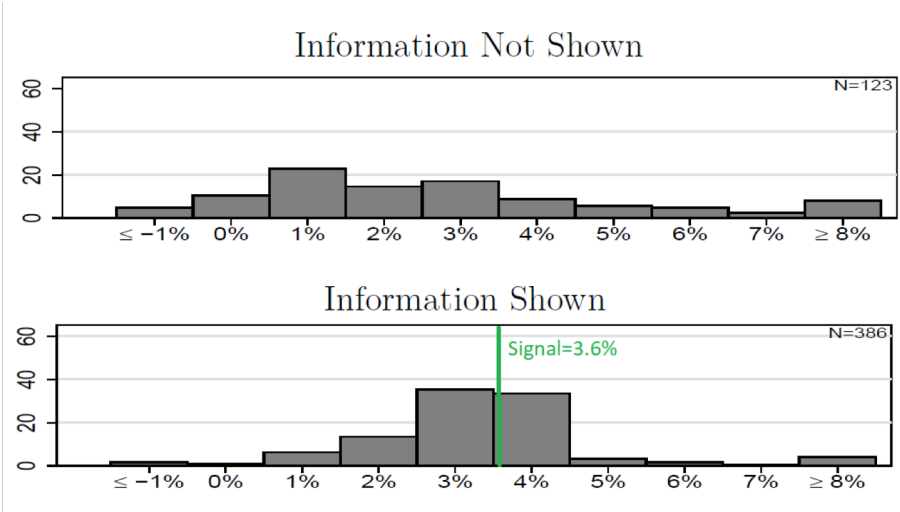
$\Rightarrow$ Lower cost of information does not lead to a decline in dispersion/disagreement. Why?

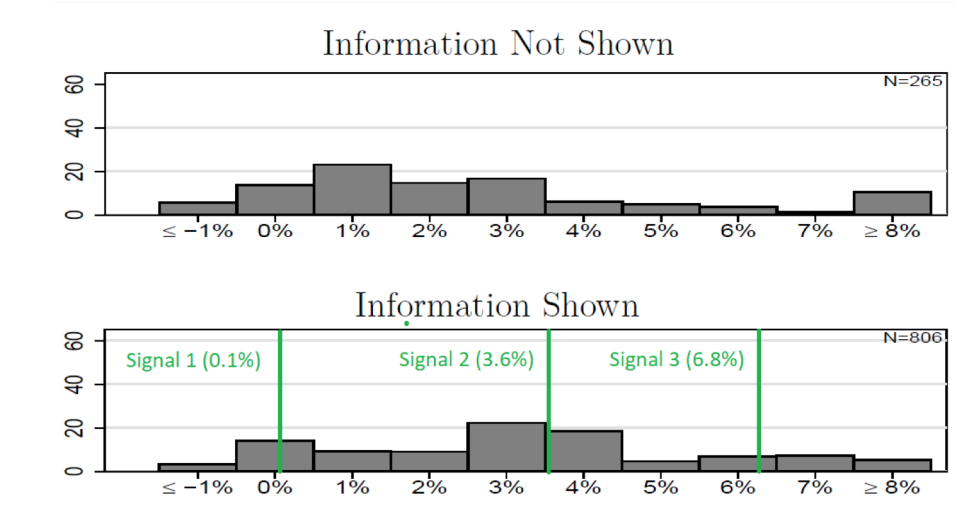
Information and dispersion

- **Conditional on information source** (in this case, expert forecast), posterior beliefs converge for the group that sees information



Information and dispersion

- **Across all individuals:** within information types, dispersion goes down. But overall, it does not.



Dispersion and disagreement within and across groups

		Baseline Sample		Follow-Up
		Prior	Posterior	(4 mths later)
Information Shown				
All	Mean	2.27	3.28	3.36
N=806 (450)	MAD	2.04	2.05	2.73
	Uncertainty	3.86	2.76	3.13
	Disagreem. (%)	10.68	19.74	20.34
Forecast (+3.6%)	Mean	2.41	3.38	3.72
N=386 (205)	MAD	2.19	1.14	2.80
	Uncertainty	3.82	2.78	3.33
	Disagreem. (%)	10.36	7.75	17.58
1 Year Change (+6.8%)	Mean	2.42	5.17	3.77
N=223 (131)	MAD	2.01	2.25	3.14
	Uncertainty	3.61	3.09	3.51
	Disagreem. (%)	14.97	17.80	21.89
10 Year Change (-0.1%)	Mean	1.82	0.92	2.23
N=197 (114)	MAD	1.79	1.35	2.15
	Uncertainty	4.22	2.34	2.32
	Disagreem. (%)	6.66	10.30	22.03
Information Not Shown				
All	Mean	2.15	2.77	3.16
N=265 (146)	MAD	2.27	2.61	2.83
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Result 3: Lower cost of information does not lead to a decrease in the dispersion in beliefs, due to endogenous info selection

Allowing for multiple signals

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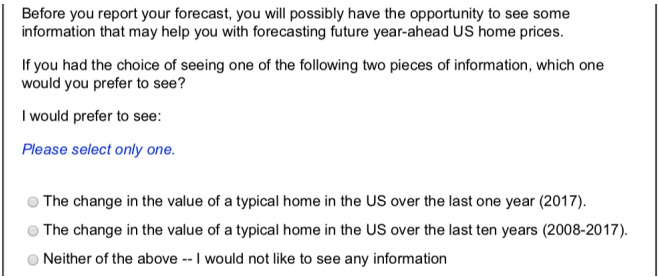
- One concern with last result: “unrealistic” restriction to only see 1 signal
- Supplementary experiment embedded in 2018 SCE Housing survey (new panelists)
- Same basic setup (priors in Stage 1; randomly assigned to high/low incentive)
- Information choice:



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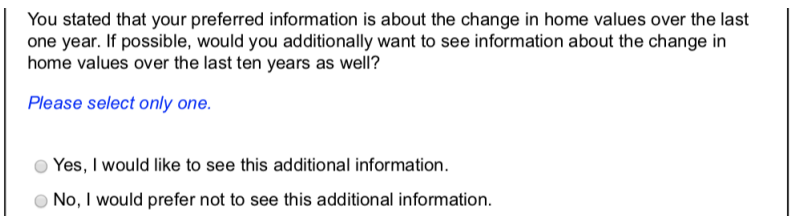

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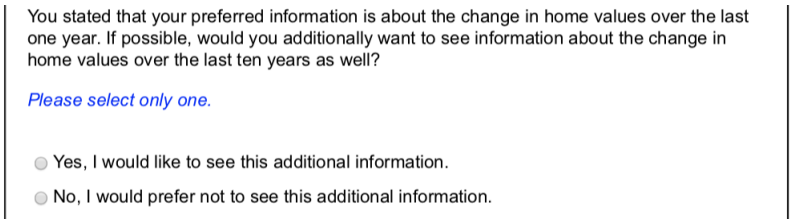

- With $p = 1/3$ each, get assigned (i) no info, (ii) preferred info, or (iii) both pieces of info (unless said that don’t want to see any info)
  - Signals: +6.5% (past one year); +0.7% (average over past 10 years)

Allowing for multiple signals – effects on dispersion

	Prior	Posterior
Both Pieces of Info (N=338)		
Mean	2.42 (0.176)	3.86 (0.200)
MAD	2.17 (0.130)	2.54 (0.145)
Uncertainty	3.68 (0.155)	2.67 (0.134)
Disagreement (%)	13.48 (1.42)	22.89 (1.67)
One Piece of Info (N=327)		
Mean	2.35 (0.190)	3.28 (0.194)
MAD	2.11 (0.150)	2.55 (0.133)
Uncertainty	3.90 (0.156)	2.83 (0.146)
Disagreement (%)	11.56 (1.31)	22.67 (1.61)
Control – No Info (N=338)		
Mean	2.58 (0.210)	3.00 (0.216)
MAD	2.39 (0.165)	2.54 (0.166)
Uncertainty	3.63 (0.154)	3.29 (0.149)
Disagreement (%)	13.11 (1.39)	16.06 (1.54)

- Similar increase in MAD and disagreement with 1 or 2 signals (and more than w/o info) $\Rightarrow$ Supports role of information processing constraints

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Other findings from supplementary experiment

Replicate/extend findings from main study:

- Higher education/numeracy respondents more likely to say they would like to see info, and (if possible) both pieces of info (e.g. college grads: 89%; non-grads: 81%)

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- These groups also agree less strongly with two further follow-up questions:
  - "Housing market experts can forecast future house price growth with high accuracy."
  - "In general, I trust the credibility of people referred to as experts."

$\Rightarrow$ Distrust of experts likely explains some of the disagreement (but can explain only a quarter of the gap by numeracy)

Summary of empirical results

1. Disagreement about what information to see. Less numerate/educated respondents less likely to pick expert forecast.
2. WTP for information increases in stakes. Not increasing in prior uncertainty.
3. Received signal incorporated in expectations. Less so for ex-ante more uncertain individuals.
4. Cheaper access to information does not reduce dispersion/disagreement, because of heterogeneous information sources chosen.

Sketch of model

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Furthermore, assume that numeracy is a good proxy for having low cost of attention

- Would imply a negative correlation of prior uncertainty with numeracy. Indeed, the correlation in the data is -0.13

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- (Possibly) higher WTP and stronger updating among those with more precise priors (because higher $\phi \rightarrow$ pay more attention) (✓)

Model implications

Under these assumptions:

- Individuals select different information sources, but will not have differential learning rates across sources (data: ✓)
- Some individuals select no information because not worth paying attention (✓)
- When incentives for accuracy are higher, WTP is higher (✓); expend more effort on processing information (data: mixed - spend more time on posterior but weight on signal is not higher)
- Individuals with lower cost of attention (i.e., more numerate individuals) update more in response to info (✓)
- (Possibly) higher WTP and stronger updating among those with more precise priors (because higher $\phi \rightarrow$ pay more attention) (✓)
- Lowering cost of information does not necessarily reduce dispersion in beliefs (✓)
  - heterogeneous choice of signals
  - individual-specific noise $\Rightarrow$ dispersion even within group

Summarizing model under different assumptions

	All individuals choose the same information source?	Relationship between prior precision and learning rate?	Is numeracy and reward relevant? (conditionally on info displayed)
Data	**No**	**Positive**	**Yes**
Model			
Common prior about information sources	Yes	Negative	No
Heterogeneous priors about information sources	No	Negative	No
Heterogeneous priors about information sources & attention costs	No	Non-Negative	Yes

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Only a model with heterogeneous beliefs about precision of information sources and costs of attention can reconcile (most) experimental results

Conclusion

- New micro-level evidence on information acquisition and processing by consumers
- Our findings provide an explanation for why:
  - Consumers tend to have so much disagreement in their expectations
  - Expectations may differ systematically by measures of ability (D'Acunto et al. 2019).
    - We show that numeracy matters for *all* stages of belief formation.

$\Rightarrow$ Where you look for information is as important as how frequently you look. Due to the first channel, dispersion persists even when the acquisition costs are lowered.

Implications

- Implications for modeling – highlight importance of:
  - Disagreement about precision of different information sources
  - (Heterogeneous) information processing frictions (not just information costs)
- Implications for trade and activity in housing markets: disagreement is an important driver for trade (Harrison and Kreps, 1978; Hong and Stein, 2007; Bailey et al., 2017)
- Implications for information disclosure — more info w/o guidance could be harmful