Expectations with Endogenous Information Acquisition: An Experimental Investigation

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November 2019

The views expressed do not necessarily reflect the position of the Federal Reserve Bank of New York, the Federal Reserve System, or the Swiss National Bank.

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- 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)

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"Recent" theory approaches that depart from full-information rational expectations (non-exhaustive list!):

- Information frictions / rational inattention
  - "Sticky" information models (Mankiw and Reis 2002; Reis 2006)
  - "Noisy" information models (Sims 2003; Woodford 2003)
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- Learning
  - Evans and Honkapohja (2001); Pastor and Veronesi (2009); Eusepi and Preston (2011)
- "Behavioral" / bounded rationality
  - Experience-based learning (Malmendier and Nagel 2011, 2016)
  - Natural expectations (Fuster, Laibson, Mendel 2010: Fuster, Laibson, Hebert 2012)
  - Diagnostic expectations (Bordalo, Gennaioli, Shleifer 2017, 2018)
  - Sparsity (Gabaix 2014, 2019)
- Agent-based / heterogeneous learning models
  - Tesfatsion and Judd (2006); Hommes (2013)

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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Extrapolation: $E(\Delta HP)$ moves in direction of "surprise"

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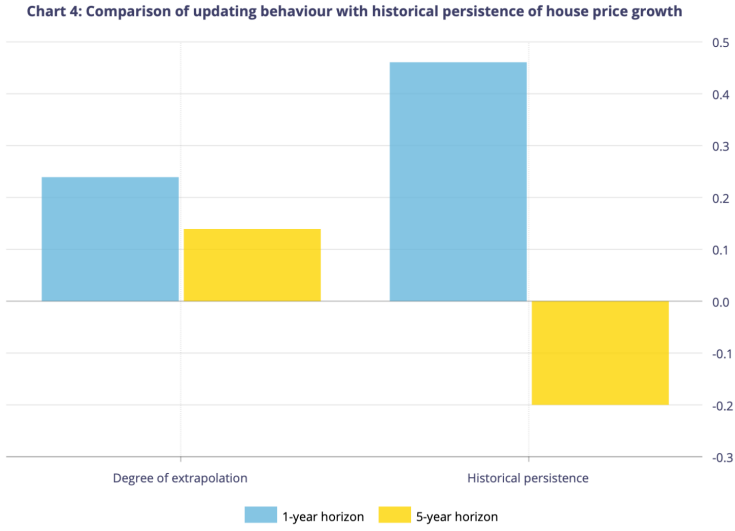
- Dependence on forecast horizon (1 yr vs. 5 yrs)?
- Dependence on type of information (past 1 yr vs. past 5 yrs)?
- Are effects persistent?

AFZ – Summary of results



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

AFZ – Summary of results

- Response to information:
  - Significant extrapolation from 1-yr info to 1-yr expectations
  - Relative to actual HP patterns (strong momentum), *underreact* to past 1-yr growth
  - Also extrapolation (though quantitatively smaller) in 2-5 yr expectations
  - Relative to actual HP patterns, fail to anticipate mean reversion

$\Rightarrow$ findings consistent with "behavioral" models of housing market dynamics (e.g. Glaeser and Nathanson 2017)

- Effects of information remain significant in follow-up 2 months later
- Significant link from measured expectations to behavior:
  - Within stylized investment experiment
  - Also with stated intentions for real-world behaviors

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)
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Robust findings:

- Information affects expectations (and effects partly persist over weeks/months)
- Expectations of respondents who see same information converge
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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)
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- 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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Before providing their final forecast, they can buy one of three pieces of information
  - 1-year past home price growth, 10-year past home price growth, or expert forecast; can also say "none"

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(3) Elicit valuation (WTP) using multiple-price list method with 11 scenarios ($0.01 - $5, in $0.50 increments)

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

(4) Depending on WTP and randomness, some are shown their preferred piece of information; then all provide final forecast

Outline of analysis / design considerations

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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$1,300 hh heads from across US
- Annual module on housing issues (every Feb.; here: 2017)
- Participation rate: 78% ($N = 1{,}161$)
- Trim top/bottom 2.5% based on prior point forecast ($< -7.1\%, > 16.1\%$)
  - Posterior: winsorize at those values

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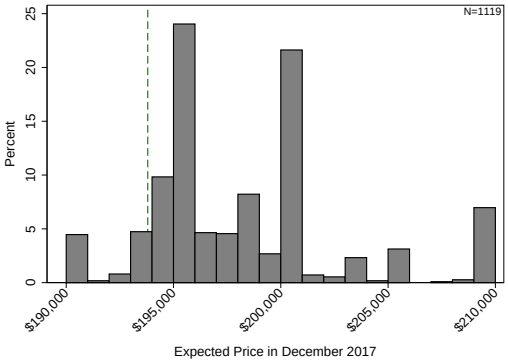
- Characteristics broadly representative of US population, but higher education, income, home ownership
  - Common with online surveys

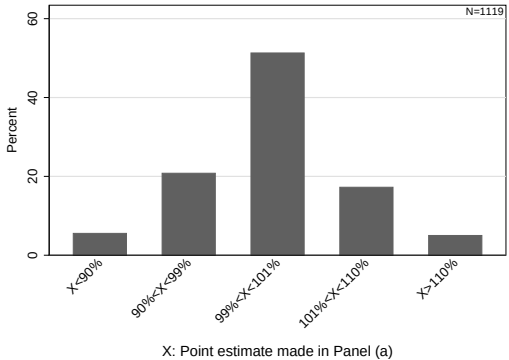
	All	Low Reward	High Reward	P-value
Prior Belief ($1,000s)	198.1	198.2	197.9	0.374
	(0.178)	(0.258)	(0.246)	
Prior Belief (% change)	0.0220	0.0230	0.0210	0.374
	(0.001)	(0.001)	(0.001)	
Income > $60,000 (0/1)	0.555	0.577	0.533	0.135
	(0.015)	(0.021)	(0.021)	
College Graduate (0/1)	0.552	0.550	0.554	0.898
	(0.015)	(0.021)	(0.021)	
Age	50.83	51.18	50.48	0.450
	(0.462)	(0.663)	(0.644)	
Female (0/1)	0.476	0.471	0.481	0.735
	(0.015)	(0.021)	(0.021)	
Married (0/1)	0.634	0.656	0.611	0.115
	(0.014)	(0.020)	(0.021)	
White (0/1)	0.811	0.784	0.837	0.025
	(0.012)	(0.017)	(0.016)	
Homeowner (0/1)	0.748	0.752	0.744	0.771
	(0.013)	(0.018)	(0.018)	
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%

“Quality” of the information sources

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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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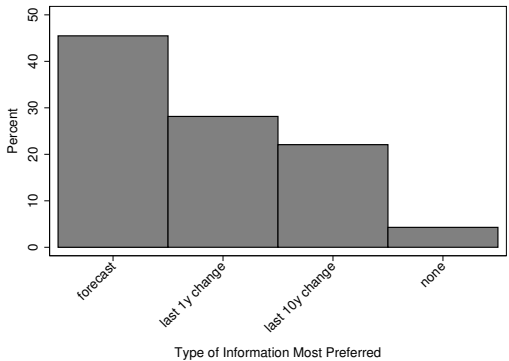
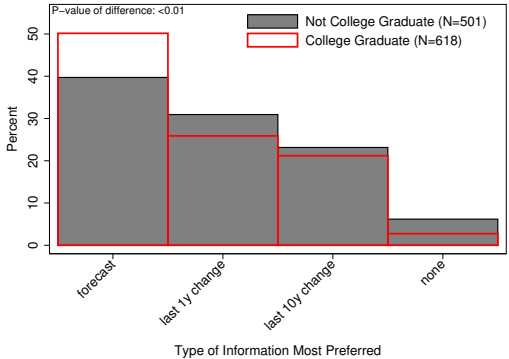
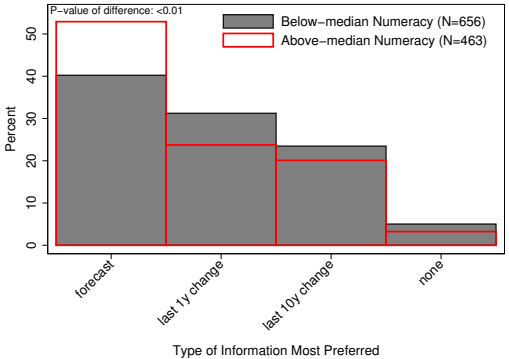


1) Demand for "informative" sources?

- "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)





- Robust to adding other controls in regression framework (few other sig. coeff.)

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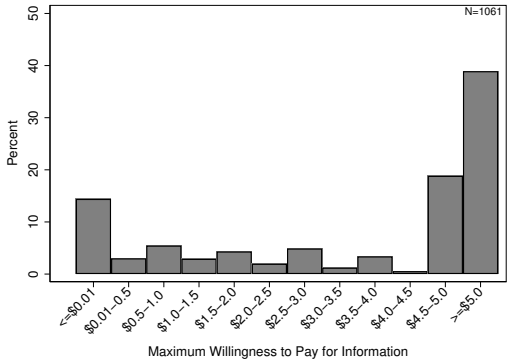

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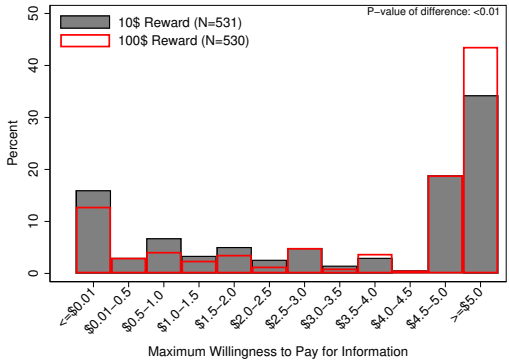

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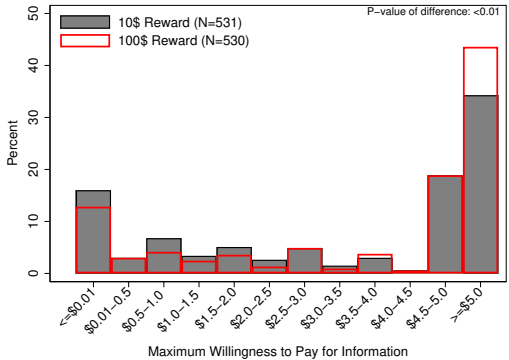

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$$WTP_i = U_{Info} + 0.1 \cdot Reward_i[P_i(Acc|Info) - P_i(Acc|NoInfo)] + \varepsilon_i$$

Average 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***	[0.250]	0.843***	[0.246]
Income $>$ \$60,000 (0/1)	0.862***	[0.259]	0.719**	[0.298]
Age	0.031***	[0.008]	0.037***	[0.009]
College Graduate (0/1)	0.398	[0.257]	0.184	[0.273]
Numeracy (0-5)	0.244*	[0.126]	0.060	[0.137]
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]
Uncertainty in Prior Belief (Std)	-0.276**	[0.136]	-0.128	[0.136]
Looked for Info in Past (0/1)	0.773***	[0.256]	0.481*	[0.267]
Conf. in Past Recall (1-5)	0.288*	[0.154]	0.087	[0.160]
Homeowner (0/1)	0.906***	[0.293]	0.284	[0.331]
Prob Move and Buy in 3 Years	0.172	[0.437]	0.606	[0.435]
Median House Value in State (Std)	0.254**	[0.126]	0.166	[0.134]
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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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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]
Uncertainty in Prior Belief (Std)	-0.276**	[0.136]	-0.128	[0.136]
Looked for Info in Past (0/1)	0.773***	[0.256]	0.481*	[0.267]
Conf. in Past Recall (1-5)	0.288*	[0.154]	0.087	[0.160]
Homeowner (0/1)	0.906***	[0.293]	0.284	[0.331]
Prob Move and Buy in 3 Years	0.172	[0.437]	0.606	[0.435]
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]

Robust standard errors in square brackets.

- 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 forming posterior forecast.

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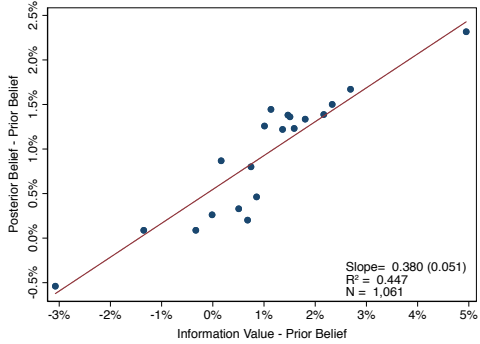

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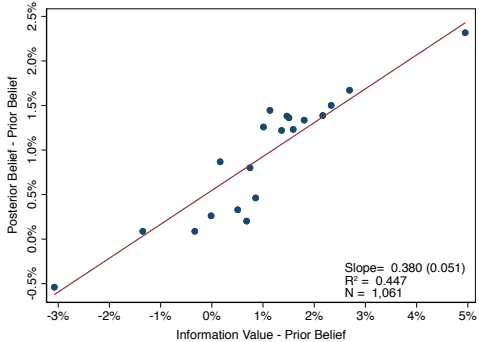
- Effect persists in follow-up 4 months later ($\hat{\alpha} = 0.17, p < 0.1$)



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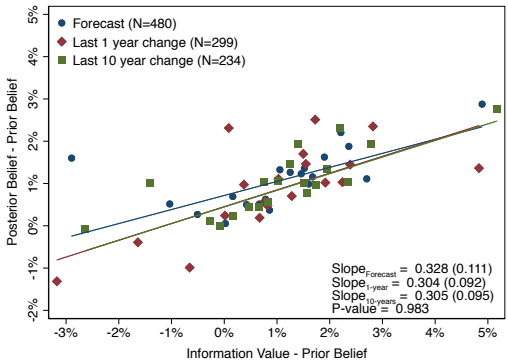

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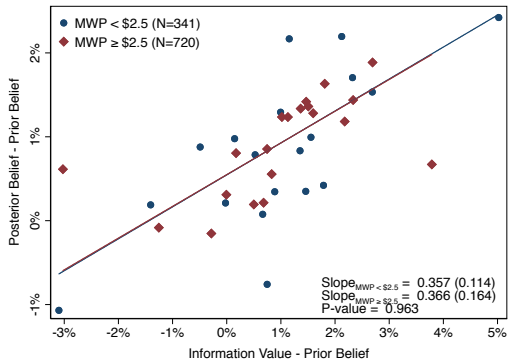
  (but: higher WTP $\rightarrow$ spend more time)



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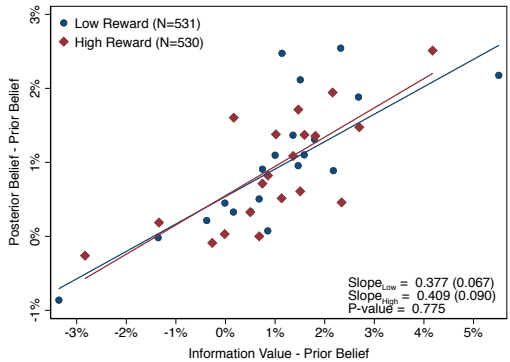

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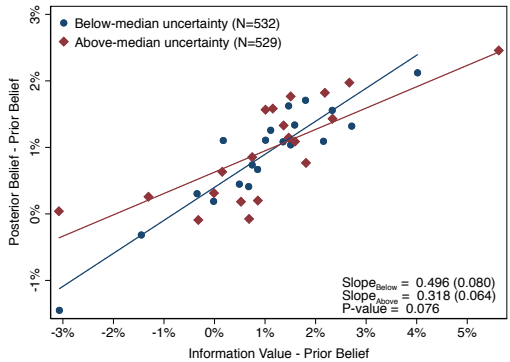

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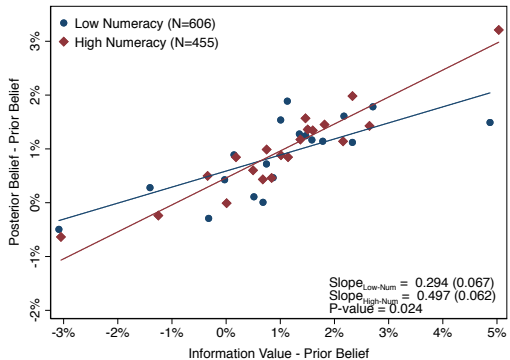

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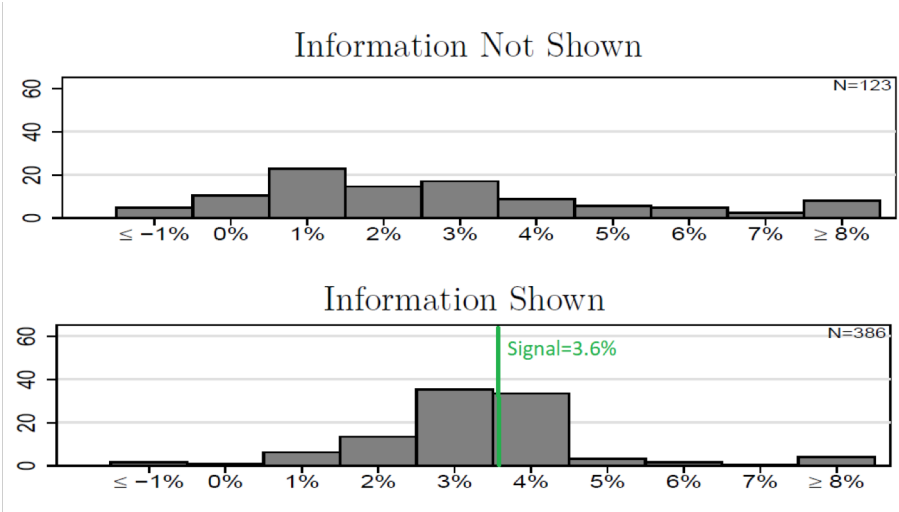
$\Rightarrow$ Lower cost of information does not lead to a decline in dispersion/disagreement. Why?

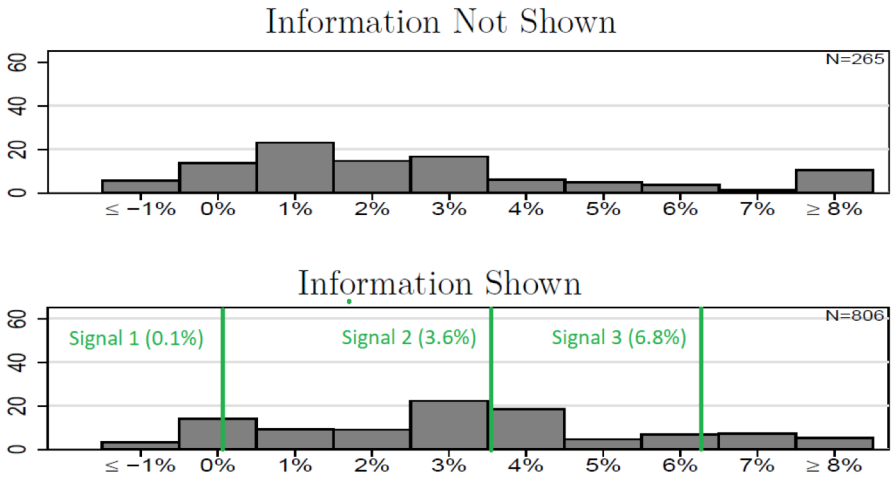
Information and dispersion

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



Information and dispersion

- **Across all individuals:** within information types, dispersion goes down. But overall, it does not, due to endogenous info selection.



Dispersion and disagreement within and across groups

		Prior	Posterior
Information Shown			
All (N=806)	Mean	2.27 (0.106)	3.28 (0.107)
	MAD	2.04 (0.077)	2.05 (0.078)
	Uncertainty	4.02 (0.117)	2.95 (0.104)
	Disagreem. (%)	11.59 (0.83)	20.77 (1.10)
Forecast (N=386)	Mean	2.41 (0.164)	3.38 (0.124)
	MAD	2.19 (0.121)	1.14 (0.109)
	Uncertainty	3.99 (0.167)	2.97 (0.149)
	Disagreem. (%)	11.46 (1.17)	7.84 (1.05)
1 Year Ch. (N=223)	Mean	2.42 (0.198)	5.17 (0.209)
	MAD	2.01 (0.145)	2.25 (0.145)
	Uncertainty	3.85 (0.239)	3.48 (0.234)
	Disagreem. (%)	15.25 (1.89)	18.33 (2.09)
10 Year Ch. (N=197)	Mean	1.82 (0.179)	0.92 (0.164)
	MAD	1.79 (0.125)	1.35 (0.132)
	Uncertainty	4.27 (0.226)	2.28 (0.162)
	Disagreem. (%)	7.98 (1.29)	12.01 (1.73)
Information Not Shown			
All (N=313)	Mean	2.07 (0.185)	2.66 (0.225)
	MAD	2.17 (0.139)	2.64 (0.168)
	Uncertainty	4.32 (0.211)	3.78 (0.205)
	Disagreem. (%)	9.61 (1.15)	18.64 (1.75)

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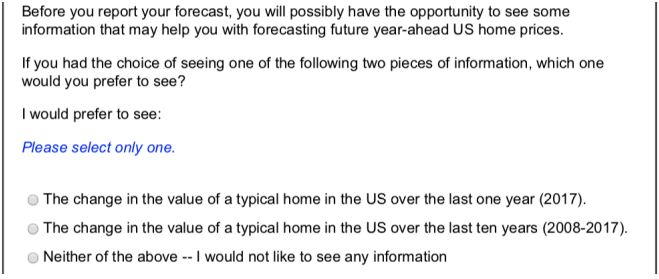
- Mean absolute deviation decreases within 2 of 3 info groups, but remains unchanged overall
- Uncertainty reduced by signal
- Potential disagreements mixed within group (due to uncert. ↓); almost doubles overall
  - Share of non-overlapping 95% confidence intervals in all pairs of respondents within a group

Summary of empirical results

1. Disagreement about what information to see. Less numerate/educated respondents less likely to pick expert forecast.
2. Valuation 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.

Allowing for multiple signals

- 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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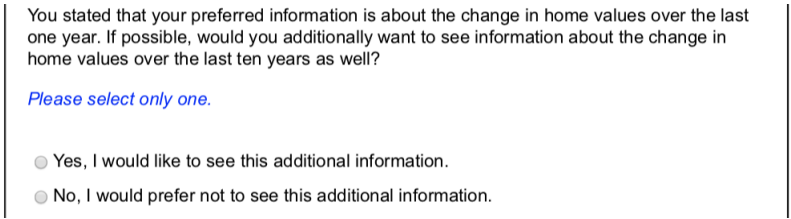

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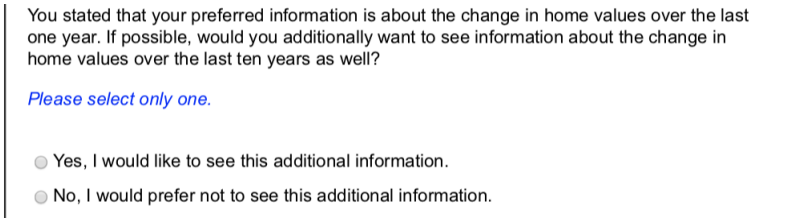

- With $p = 1/3$ each, get assigned (i) no info, (ii) preferred info, or (iii) both pieces of info (unless said that don’t want to see any info)
  - Signals: +6.5% (past one year); +0.7% (average over past 10 years)

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%)
  - High-numeracy respondents more likely to prefer 1yr info (better signal)

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- After final stage, ask "*If you had been offered the opportunity to see the forecast of a panel of housing experts about year-end home prices before you reported your expectation, would you have chosen to do so (instead of seeing information about past home price changes)?*"
- Fewer "yes" among less educated/numerate

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%)
  - High-numeracy respondents more likely to prefer 1yr info (better signal)
- After final stage, ask "*If you had been offered the opportunity to see the forecast of a panel of housing experts about year-end home prices before you reported your expectation, would you have chosen to do so (instead of seeing information about past home price changes)?*"
- Fewer "yes" among less educated/numerate
- Less educated 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."

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  $\Rightarrow$ Distrust of experts likely explains some of the disagreement
- Respondents with more precise priors update more

Brief summary of the model

▸ More

Combination of sticky info (as in Reis, 2006) and noisy info (as in Sims, 2003), with various potential heterogeneities:

- Heterogeneous priors about fundamental of interest (here: HP growth)
- Can acquire one signal (out of several) at a fixed cost; heterogeneous beliefs about precision of different signals
- Paying attention to the signal (in order to make it more precise) is costly; this cost may be heterogeneous
- Incentive/taste for accuracy of belief, ϕ, potentially heterogeneous as well

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Assume that ϕ is positively correlated with precision of prior

- Natural in dynamic setting: “more interested” likely have acquired more info before

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Then, model can generate (among other things):

- Disagreement about chosen signals; some choose no info
- Lowering cost of information does not necessarily reduce dispersion in beliefs
- Higher WTP and stronger updating among those with more precise priors (because higher $\phi \rightarrow$ pay more attention)
- Individuals with lower cost of attention (high numeracy) update more from info

$\Rightarrow$ Info processing frictions (cost of attention) crucial for last two implications

Conclusion

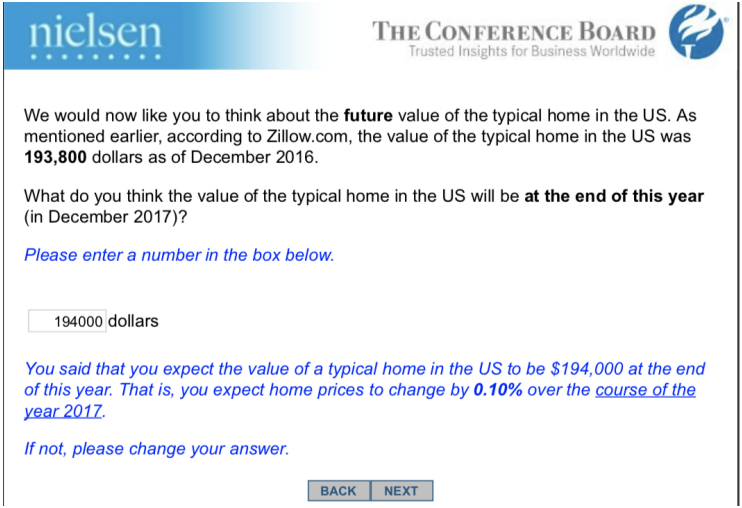
- New micro-level evidence on information acquisition and processing by consumers
- Findings may help us understand why:
  - Consumers tend to have so much disagreement in their expectations
  - Expectations may differ systematically by measures of ability (D'Acunto et al. 2019)
- Implications for policymakers – how to disclose info to have desired impact?
  - If aim is to reduce dispersion: provide targeted info, or offer guidance
- Implications for modeling – highlight importance of:
  - Disagreement about precision of different information sources
  - (Heterogeneous) information processing frictions (not just information costs)

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

Additional slides

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

- Elicit both point estimate and density (uncertainty)



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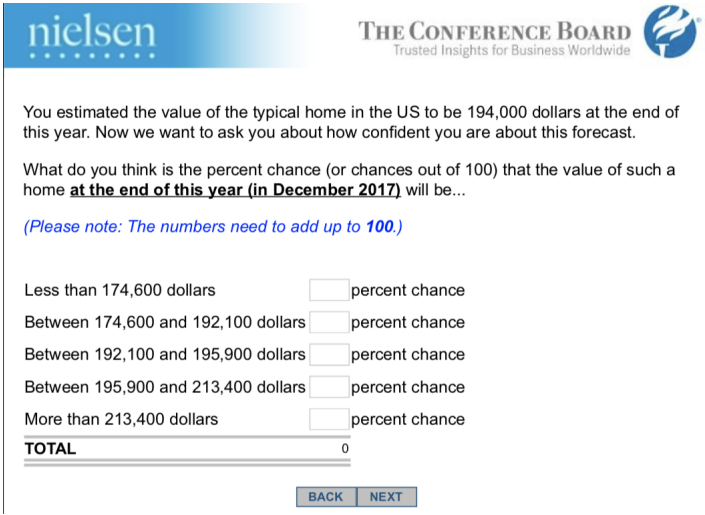
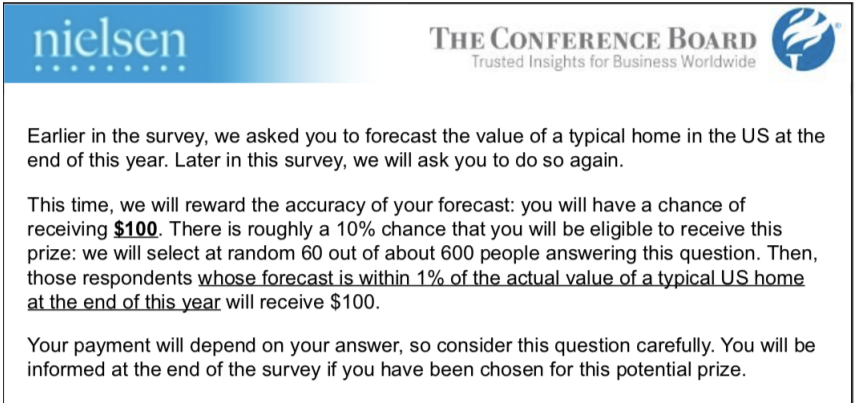


Stage 2: Information preferences

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


nielsen

THE CONFERENCE BOARD
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Earlier in the survey, we asked you to forecast the value of a typical home in the US at the end of this year. Later in this survey, we will ask you to do so again.

This time, we will reward the accuracy of your forecast: you will have a chance of receiving **$100**. There is roughly a 10% chance that you will be eligible to receive this prize: we will select at random 60 out of about 600 people answering this question. Then, those respondents whose forecast is within 1% of the actual value of a typical US home at the end of this year will receive $100.

Your payment will depend on your answer, so consider this question carefully. You will be informed at the end of the survey if you have been chosen for this potential prize.

Stage 2: Information preferences

- Then asked to rank three possible information sources

Back

Before you report your forecast, you will have the opportunity to see only one of the following pieces of information that may help you with forecasting future year-ahead US home prices. Please rank the following pieces of information on a 1-4 scale, where 1 is "Highest ranked/Most Preferred" and 4 is the "Least Preferred".

Please click on each piece of information on the left, and drag it to the right hand side of the screen.

Change in the value of a typical home in the US over the last one year (2016).	1=Most preferred	
Change in the value of a typical home in the US over the last ten years (2007-2016).	2	
Forecasts of a panel of housing experts about the change in US home prices over this coming year (2017).	3	
None of the above -- I would not like to see any information	4=Least preferred	

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 said that you would most prefer seeing information on the change in the value of a typical home in the US over the last one year (2016). Now we want to assess how much you would value this information.
>
> You will next be presented with 11 scenarios. In each scenario, you will be given the choice of either seeing information about the change in the value of a typical home in the US over the last one year (2016) OR receiving extra money with the check that you will be getting for completing this survey. The amount of money that you will be offered in these scenarios is pre-determined, and goes from $0.01 to $5. For instance, in *Scenario 1*, you will need to choose between seeing information or receiving $0.01; and in *Scenario 11*, you will need to choose between seeing information or receiving $5.
>
> We will draw one of these 11 scenarios at random for you. Your choice in the randomly chosen scenario will then be implemented. That is, you will have to make 11 choices, but only one of those choices will be implemented.
>
> Since one scenario will be picked at random, your choices will not affect which scenario will be chosen.

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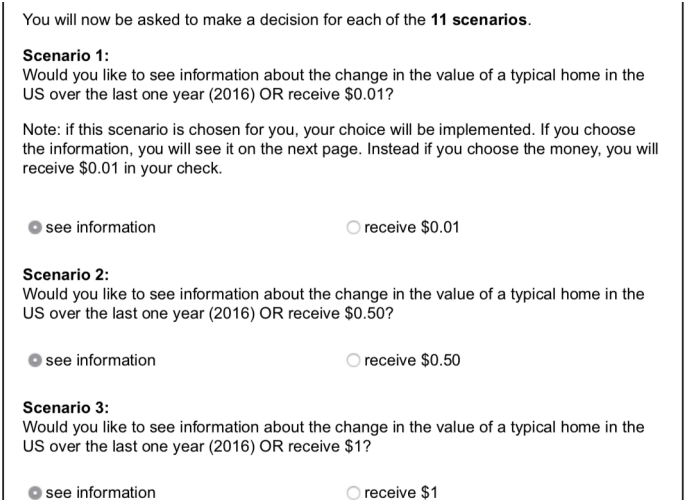


You will now be asked to make a decision for each of the **11 scenarios**.

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?

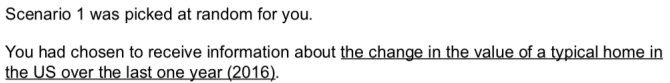
◉ see information ○ receive $0.50

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



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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

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- Signals $j \in \{1, 2, ...N\}$ provide noisy signal about θ: $x_j = \theta + \varepsilon_j$
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- Posterior beliefs follow from Bayesian updating, taking into account $\sigma^2_{\varepsilon,j}(i)$ and $\sigma^2_\psi(i)$

Model solution and assumptions

Individuals make choices to maximize their expected payoff:

- Choose whether to buy a signal j at cost c
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Two assumptions about heterogeneity to rationalize empirical results:

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    - Extension: common prior; expend cognitive effort on learning precision

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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 significantly negative.

Model implications

Back

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- (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

Back

	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 precisions	Yes	Negative	No
Heterogeneous priors about precisions	No	Negative	No
Heterogeneous priors about precisions & attention costs	No	(Can be) positive	Yes

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Heterogeneous priors about precisions & attention costs	No	(Can be) positive	Yes

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