Memory and Beliefs: Evidence from the Field

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We Still Don't Understand Beliefs Formation

- Measuring and Understanding Beliefs formation halted for decades
  - Simon (1955): Need to understand real-life mechanisms driving choice
  - Rational-expectations Revolution: Beliefs are model determined
    - Economists lost interest in studying beliefs/beliefs formation
    - Those with irrational beliefs will die, not marginal/price setters

- BUT, evidence points to aggregate effects of beliefs distortions
  - Early 2000s: dot.com bubble, Irrational Exuberance (Shiller 2000)
  - 2008-2009 Fin. Crisis: A Crisis of Beliefs (Gennaioli and Shleifer 2018)
  - Widespread deviation from FIRE (Coibion & Gorodnichenko 2012/15, Landier et al. 2019)
  - Most consumers heavily biased expectations, act on them (D'Acunto, Hoang, Paloviita, Weber 2019)
  - Consumers' uncertainty nature price changes, aggregate implications (Gaballo and Paciello 2021)

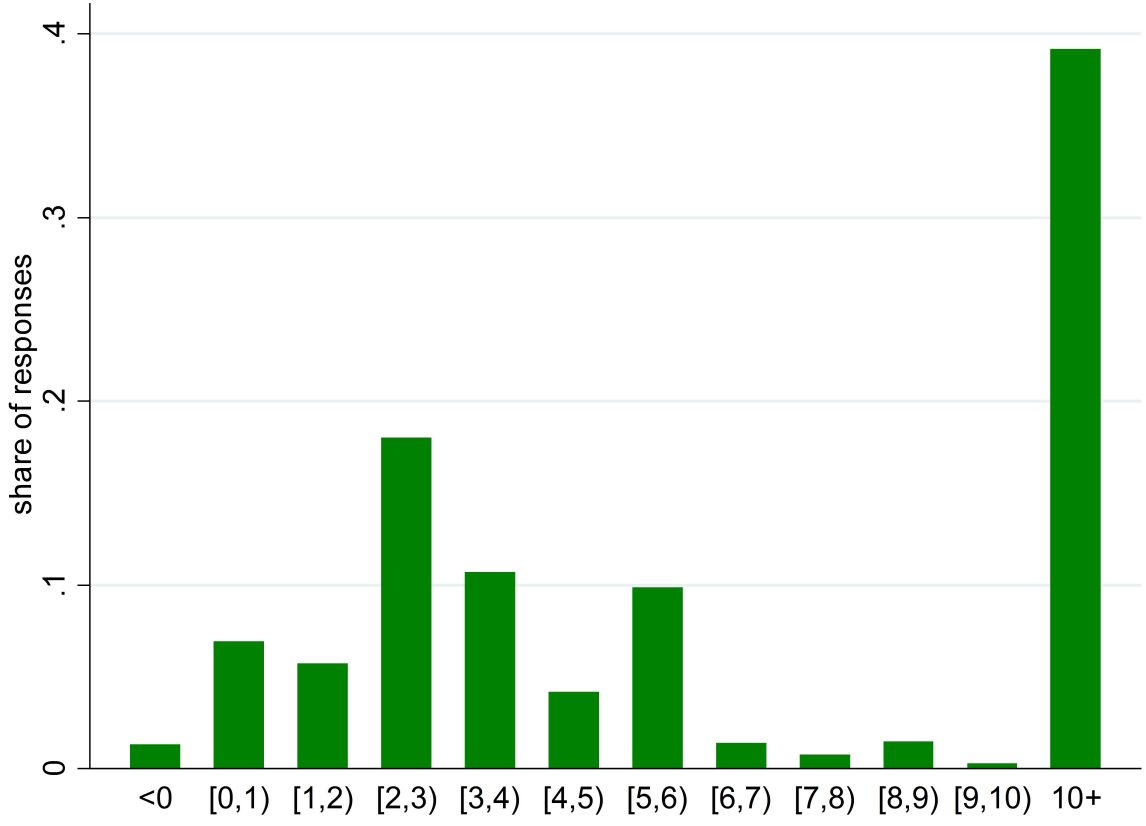
A Role for Memory? Evidence from the Lab

- Cognitive Psychology: Imperfect Memory (Kahana, 2012)
  - Long-Term Memory vs. Short-term Memory
  - Imperfect memory: Selective Recall, Interference
- From Cognitive Psychology to Economics
  - Economic Theory
    (Bordalo et al. 2020; Enke, Schwerter, Zimmermann 2020)
  - Color-based Cues in Lab
    (Bordalo, Coffman, Gennaioli, Schwerter 2020;
  - Economic Beliefs in Lab
    (Enke, Schwerter, Zimmermann 2020)
  - Overreaction Beliefs
    (Thesmar et al. 2020)
  - Asset Pricing
    (Kahana and Wachter 2019)

This Paper: Memory & Beliefs in the Field

- Aim: Testing predictions memory framework in field data
- Setting: Prices of consumption goods
  - Observe prices agents saw while shopping (Nielsen Homescan)
  - Observe recall & beliefs about prices (Booth Expectations Survey)
  - Randomly cue interfering contexts (lab-in-the-field experiment)
- Caveats: non-controlled environment
  - We cannot control all relevant details of setting as in lab
  - Cannot design/use most lab experimental paradigms

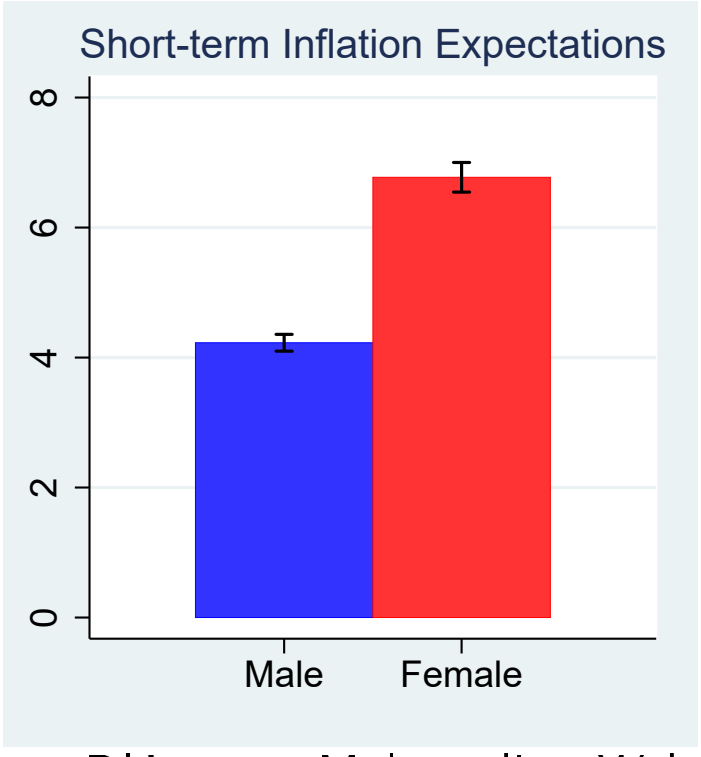
Households have Limited Knowledge about Basic Facts



Source: Coibion, Gorodnichenko, Weber, JPE (2022):
"Monetary Policy Communication and Households' Inflation Expectations"

- Expectations react to info and determine consumption choices

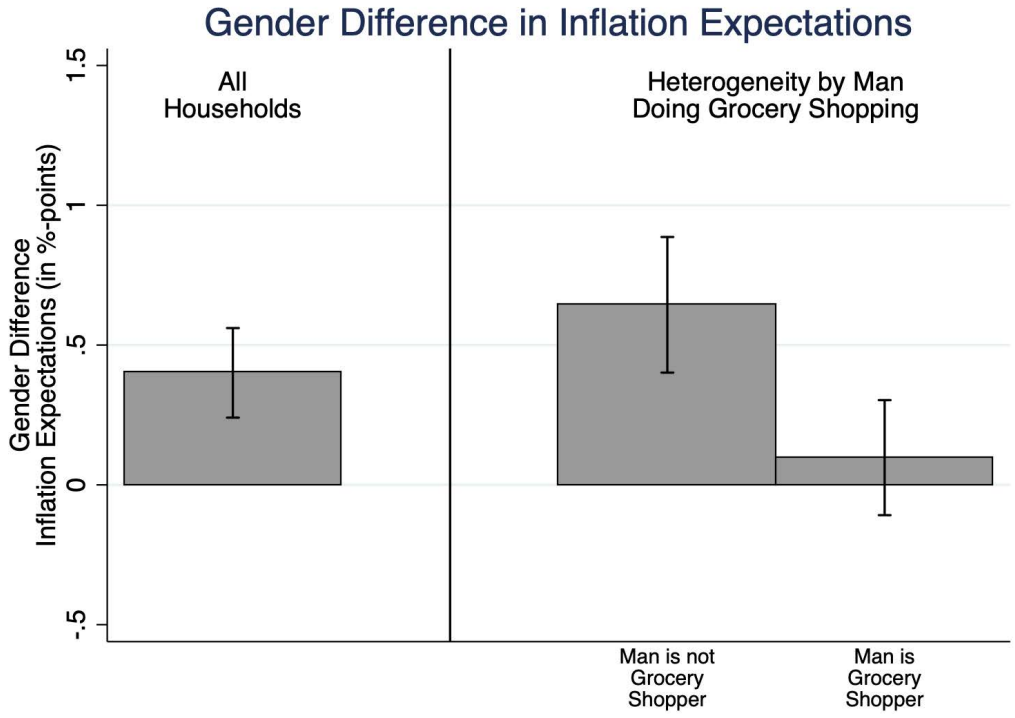
Within-Household Inflation Expectations: Gender Gap



Source: D'Acunto, Malmendier, Weber, PNAS (2021):
"Gender Roles Produce Divergent Economic Expectations"

- Women have (more) positively biased inflation expectations

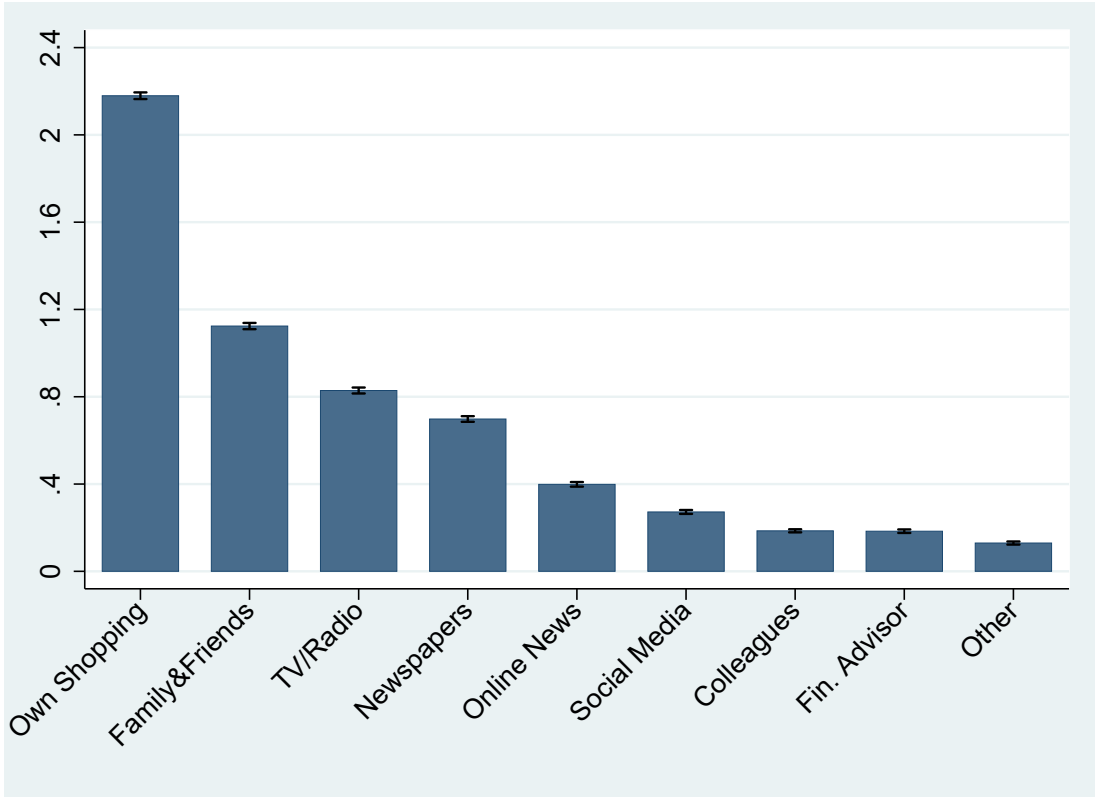
Why Are Women (More) Biased? They Do the Groceries!



Source: D'Acunto, Malmendier, Weber, PNAS (2021):
"Gender Roles Produce Divergent Economic Expectations"

- Large difference in inflation expectations by gender *within* household
- Unconditional difference driven by differences in grocery shopping

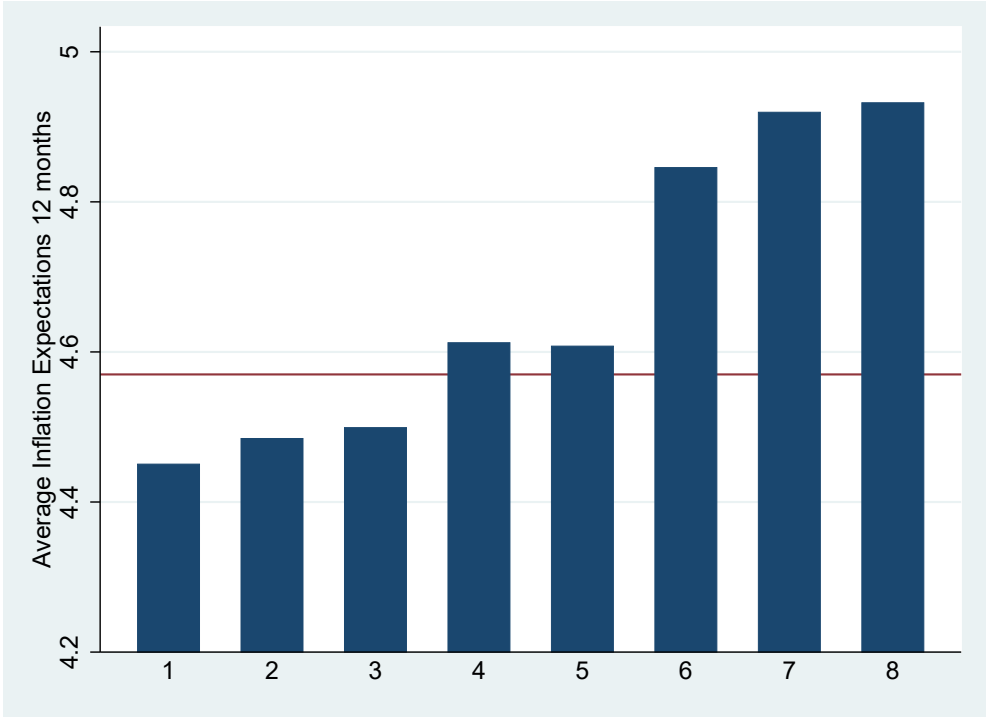
Shopping is the Most Important Source of Information



Source: D'Acunto, Malmendier, Ospina, Weber, JPE (2021):
"Exposure to Grocery Prices and Inflation Expectations"

- Most relevant sources of information when we asked their inflation expectations
- Own (and family) shopping much more common than media, other sources

Motivation: Past Observed Prices → Inflation Expectations



Source: D'Acunto, Ospina, Malmendier, Weber, JPE 2021

- Sort agents into bins by household own inflation (grocery bundle prices)
- Monotonic correlation with aggregate inflation expectations

Data Sources

- **Grocery bundles AND Expectations at the HH level**
  - Information set: paid prices, ask about info seen elsewhere
- Nielsen-Kilts Homescan Database
  - Purchase file: quantities and prices at the UPC level
  - Trips file: expenditure growth
  - Panelist file: demographics
- Chicago Booth Expectations and Attitudes Survey
  - Customized survey on all households members in panel
  - Expectations: inflation, interest rates, income, employment
  - Direct questions on sources info, what comes to mind

Chicago Booth Expectations and Attitudes Survey

- (Additional) Demographics

  Education, employment, industry, looking for job

- Other expenditures and income

  Income growth, mortgage, rent, college tuition, gas, health care, restaurants

- Prices, inflation, and house prices

  Short- & long-run, point estimate & distribution, prices of goods vs. inflation

- (General) economic outlook

  Aggregate & personal outlook, interest & mortgage rates, short- & long-run

- Consumption and savings

  Good time to consume & save, savings rate, portfolio allocation

Summary Statistics

- Full Nielsen panel: 92,511 unique households
- Survey: 49,383 individuals from 39,809 HHs (43% response rate)
- 40 questions with average response time of 14 min 49 sec
  - 67% women
  - Mean age: 53
  - Modal income: USD 80k
  - 28% with college degree

Measures: Rational Inattention vs. Frequency Bias/Salience

Construct household-level measures of *perceived* inflation

- *Size of Exposure*:

  proportion of overall budget spent on each good purchased matters

  e.g., Cavallo, Cruces, Perez-Truglia (2015); Armantier et al. (2016)

  $\rightarrow$ weigh price changes by expenditure shares: **Household CPI**

- *Frequency of Exposure*:

  frequency of exposure to goods' prices should matter

  Watanabe (2016): frequent stimuli recalled more, even if agent pays no attention

  In Economics: de Bruin et al. (2011); Bordalo, Gennaioli, & Shleifer (2013, 2019)

  $\rightarrow$ weigh price changes by frequency of purchases: **Frequency CPI**

Definition of Household-level Inflation

- Chained Laspeyres price index
- Base period for wave 1: June 2013 to May 2014
- Prices: volume-weighted average within year

$$CPI_{i,t} = \frac{\sum_{n=1}^{N} \Delta p_{n,i,t} \times \omega_{n,i}}{\sum_{n=1}^{N} \omega_{n,i}}$$

- $p_{n,i,t}$: log price of good n faced by household i at time t
- $\omega_{n,i}$: weight of good n in inflation rate for household i
- **Household CPI**: $\omega_{n,i} = p_{n,i,0} \times q_{n,i,0}$
- **Frequency CPI**: $\omega_{n,i} = f_{n,i,0}$ (frequency of purchases in base period)

Grocery Price Changes and $\mathbb{E}$(Inflation)

$$\mathbb{E}\,\pi_{i,t:t+1} = \alpha + \beta \times \mathit{CPI}\ \pi_{i,t-1:t} + X_i'\gamma + Y_i'\gamma + \eta_I + \eta_t + \epsilon_i,$$

- Regress expected inflation, $\mathbb{E}\,\pi_{i,t:t+1}$, on observed price changes
  - Size of Exposure: Household CPI
  - Frequency of Exposure: Frequency CPI
- Demographics X: income, age, education, gender, employment, home owner, marital status, household size, race, risk aversion, patience
- Expectations Y: income, economic outlook, financial outlook
- Fixed effects: county, survey wave, question type, individual (η_I)
- Cluster standard errors at household level

Grocery Price Changes and $\mathbb{E}$(Inflation): *Household CPI*

$$\mathbb{E}\,\pi_{i,t:t+1} = \alpha + \beta \times \textit{Observed}\ \pi_{i,t-1:t} + X_i'\gamma + Y_i'\gamma + \eta_I + \eta_t + \epsilon_i,$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Household CPI	0.17***	0.17***	0.21***				0.05	0.03	0.09
	(0.04)	(0.04)	(0.07)				(0.06)	(0.06)	(0.09)
Frequency CPI				0.20***	0.20***	0.31***	0.16***	0.18***	0.23**
				(0.04)	(0.04)	(0.09)	(0.06)	(0.06)	(0.12)
Nobs	59,126	57,730	57,730	59,126	57,730	57,730	59,126	57,730	57,730
R^2	0.0279	0.0952	0.7905	0.0281	0.0954	0.7905	0.0281	0.0954	0.7905
Demographics		X	X		X	X		X	X
Expectations		X	X		X	X		X	X
County FE		X	X		X	X		X	X
Individual FE			X			X			X

Standard errors in parentheses
$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

- 1 $\sigma \uparrow$ Household CPI: expect 0.2 pp. $\uparrow$ inflation next 12 months
- Similar magnitude within individual

Grocery Price Changes and $\mathbb{E}$(Inflation): *Frequency CPI*

$$\mathbb{E}\,\pi_{i,t:t+1} = \alpha + \beta \times \textit{Observed}\ \pi_{i,t-1:t} + X_i'\gamma + Y_i'\gamma + \eta_I + \eta_t + \epsilon_i,$$

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Expectations		X	X		X	X		X	X
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Individual FE			X			X			X

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

- Coefficient about 20% to 50% higher with Frequency CPI
- Similar magnitude within individual

Grocery Price Changes and $\mathbb{E}$(Inflation): *Both Measures*

$$\mathbb{E}\,\pi_{i,t:t+1} = \alpha + \beta \times \textit{Observed}\ \pi_{i,t-1:t} + X_i'\gamma + Y_i'\gamma + \eta_I + \eta_t + \epsilon_i,$$

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Demographics		X	X		X	X		X	X
Expectations		X	X		X	X		X	X
County FE		X	X		X	X		X	X
Individual FE			X			X			X

Standard errors in parentheses

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

- Frequently-observed price changes drive association with expectation inflation

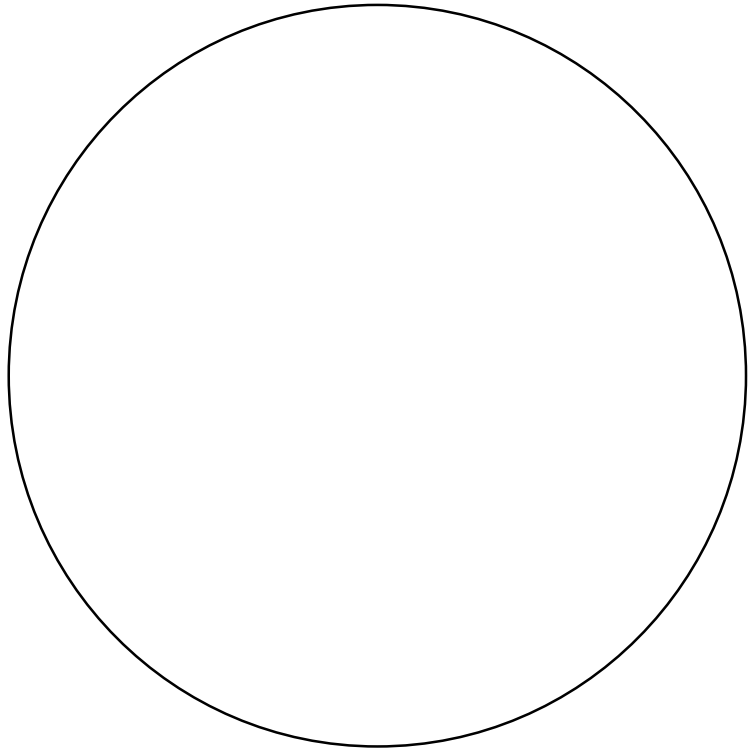
Memory, Selective Recall, and Beliefs

- Memory Database
  - Agents store price signals in a "memory database" (Watanabe, 2016)
  - Long-term memory: Recall signal when needed to form beliefs

- Selective Recall and Beliefs Formation
  - Selective Recall: (Kahana, 2012)
    can't recall ALL signals, draw some from memory database
  - Prices of goods purchased more often represent a higher fraction of signals in memory database, more likely to be recalled

Memory Database

Memory Database (Watanabe, 2016)



- Observe signals, add them to memory database, retrieve when needed
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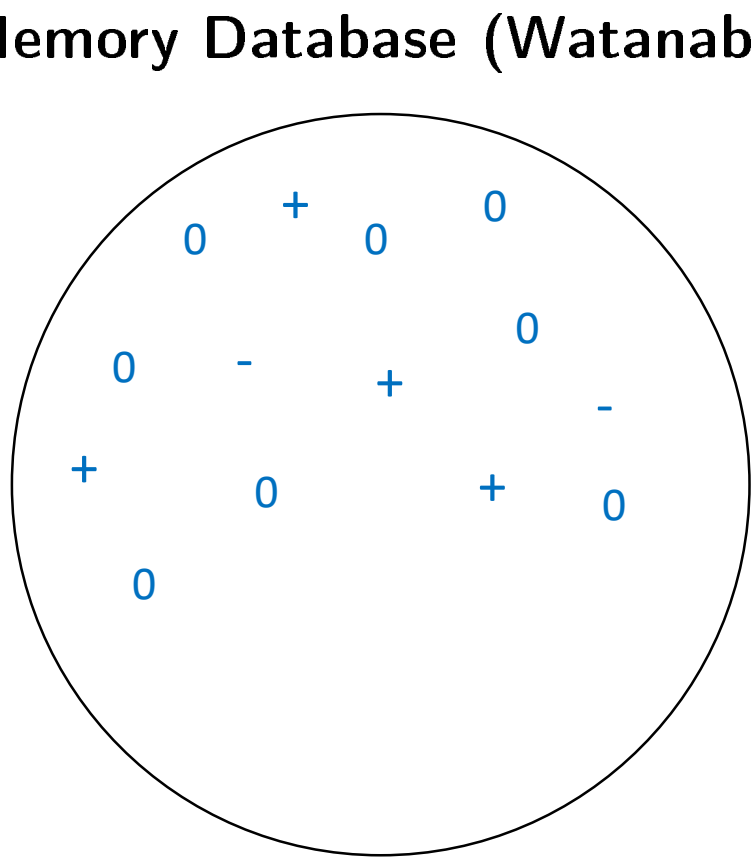
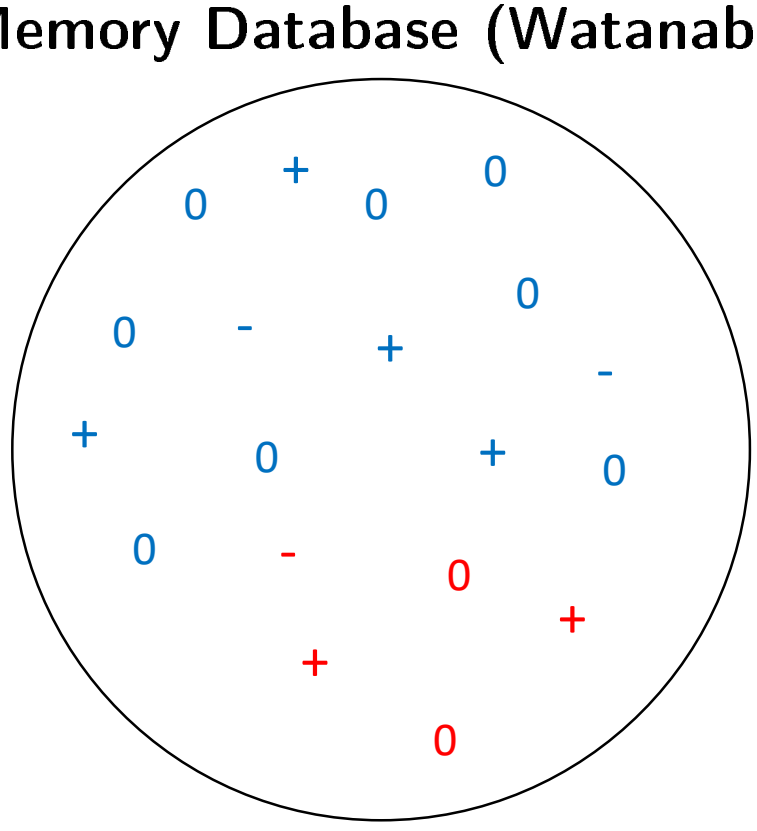
Memory Database



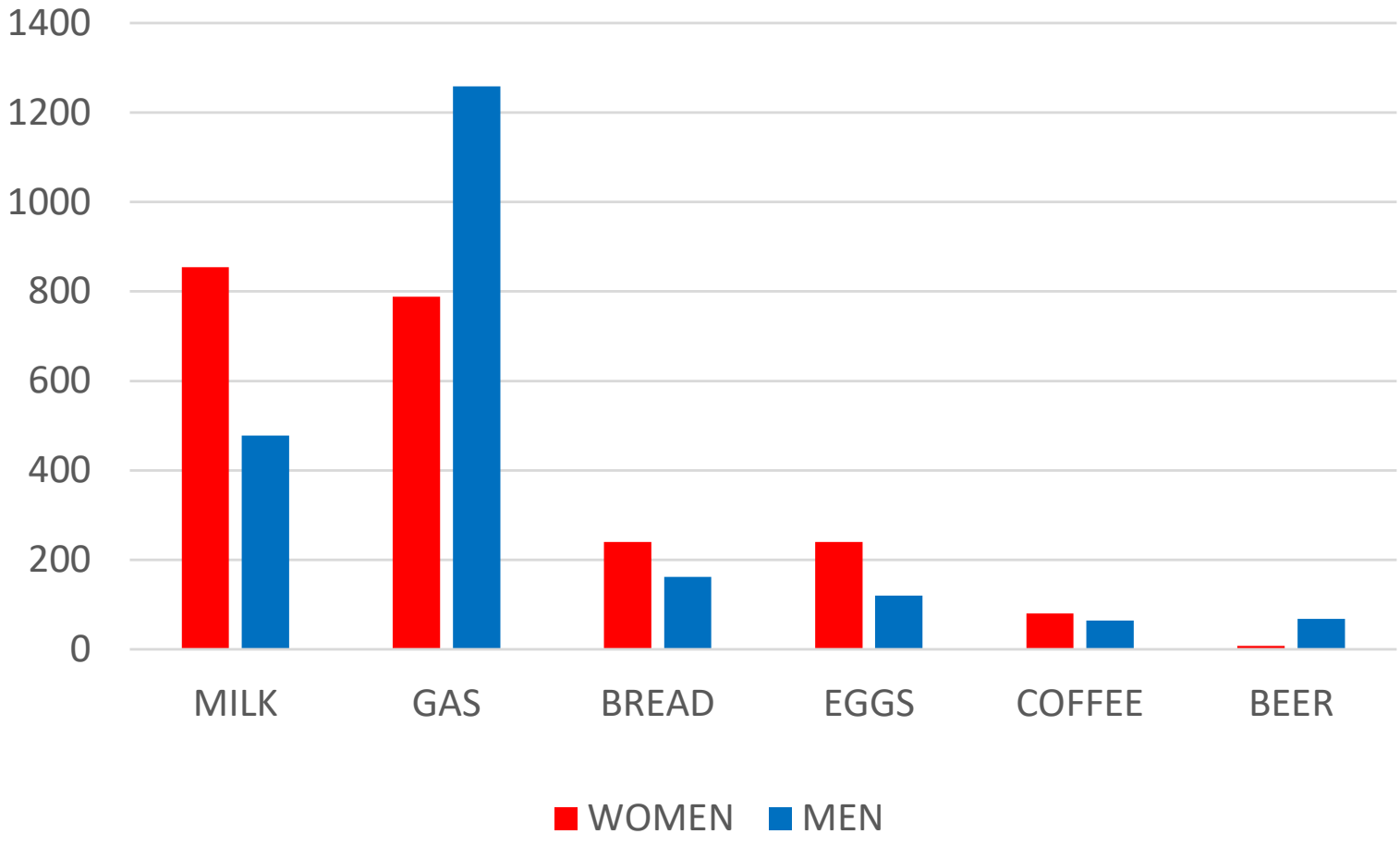
- Observe signals, add them to memory database, retrieve when needed
- Many price signals from frequently-purchased goods (e.g. milk)
-

Memory Database



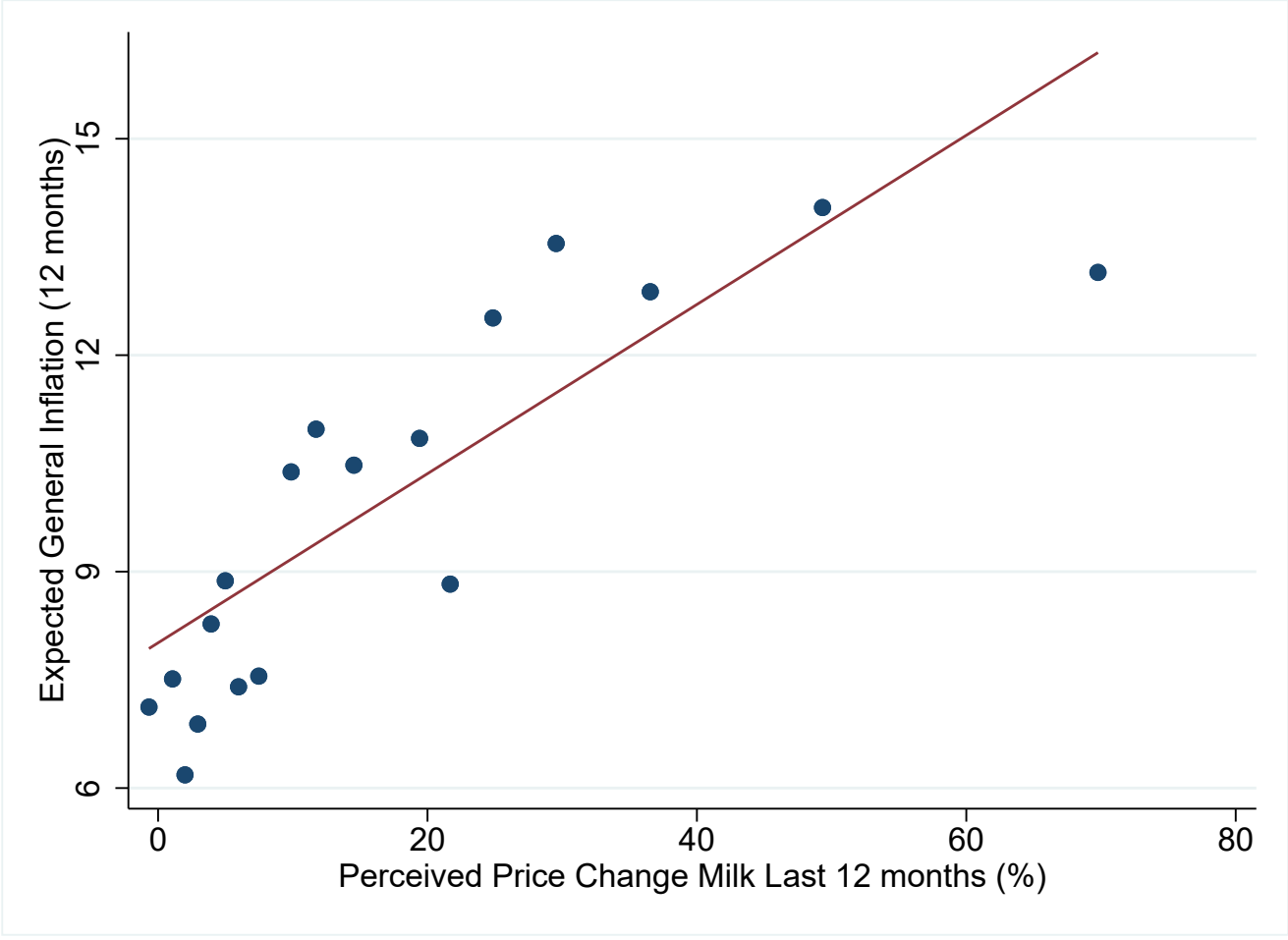
- Learn signals, add them to memory database, recall when needed
- Many price signals from frequently-purchased goods (e.g. milk)
- Fewer price signals from other goods (e.g., Wagyu steaks)

Whose Prices Come to Mind When Forming Beliefs?



- Earlier survey wave:
  Which goods' prices came to mind when forming expectations, if any?
- Prices of goods purchased more frequently recalled more

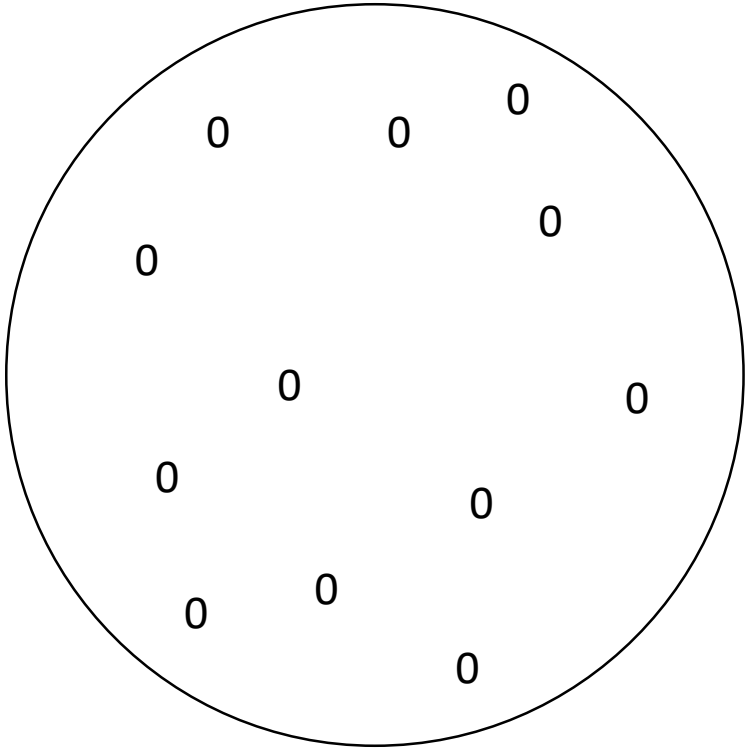
From Recalled Good-Specific Signals to Aggregate Beliefs?



- January 2022 survey wave: Elicit recalled milk prices, milk inflation
- Perceived milk inflation correlates with general inflation expectations
- Potential caveat: anchoring. Will tackle in a few slides

More Selective Recall: Size Changes & Shopping Frequency

Frequent Shopper



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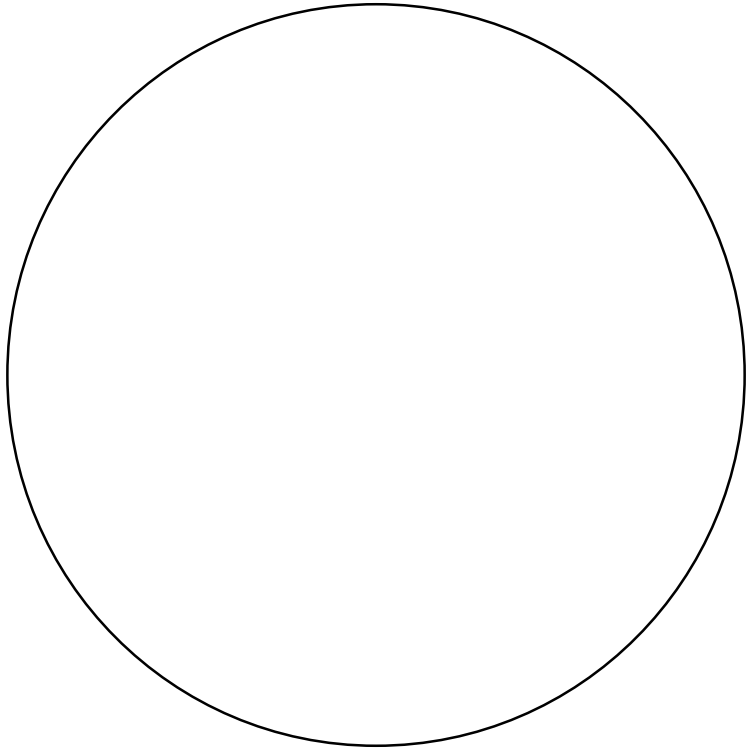

- Most times should store in memory zero price changes
-
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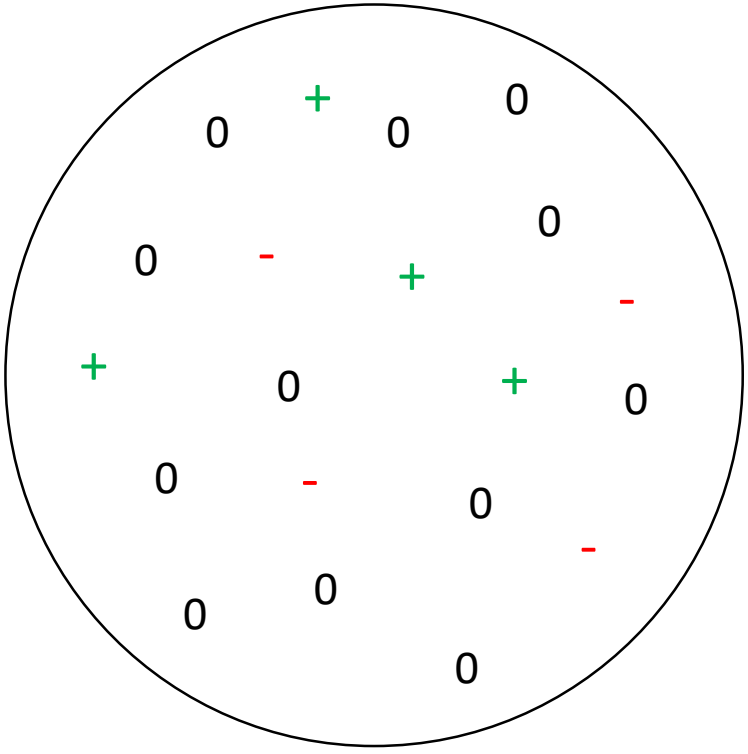
More Selective Recall: Size Changes & Shopping Frequency

Frequent Shopper



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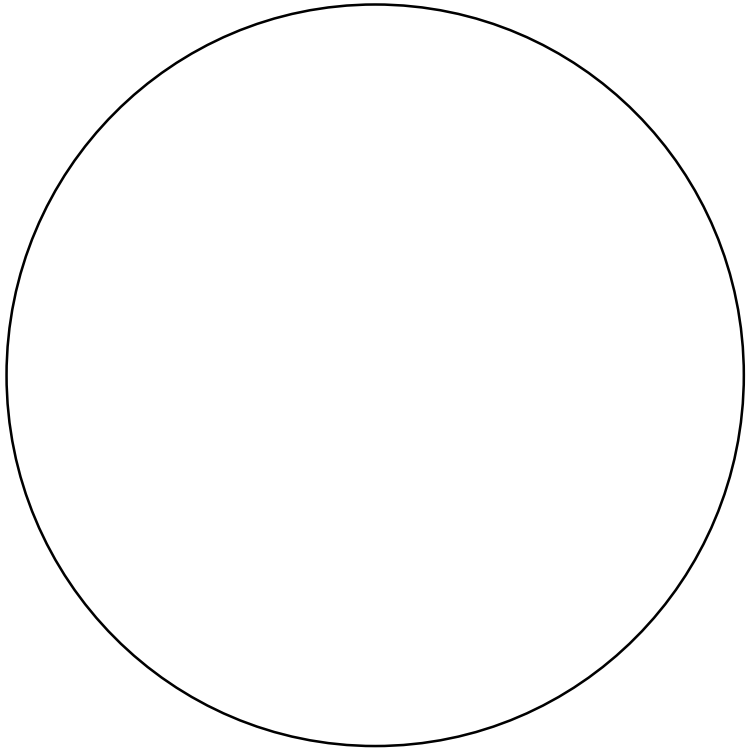
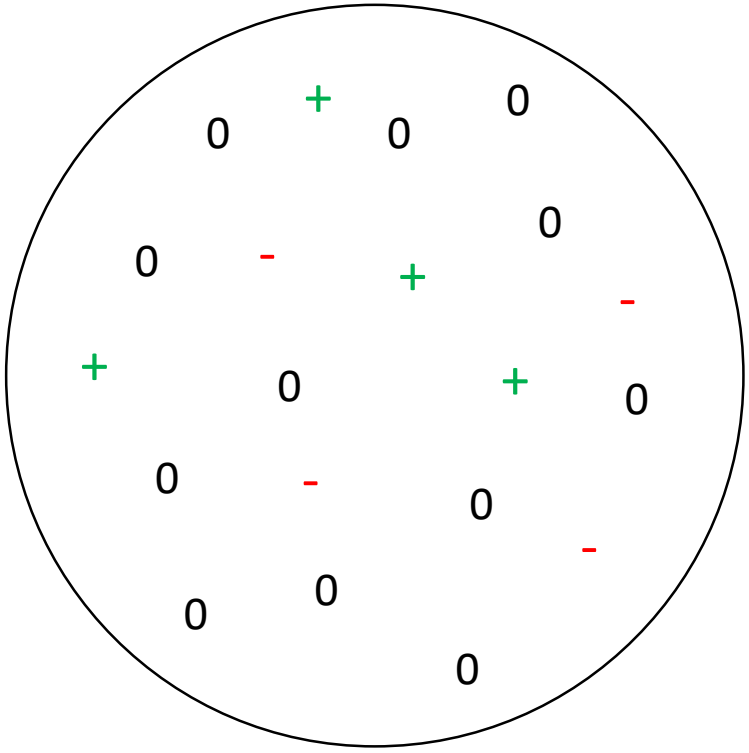


- Most times should store in memory zero price changes
- Sometimes, small price increases
- Sometimes, small price decreases (e.g., discounts)

More Selective Recall: Size Changes & Shopping Frequency

Frequent Shopper



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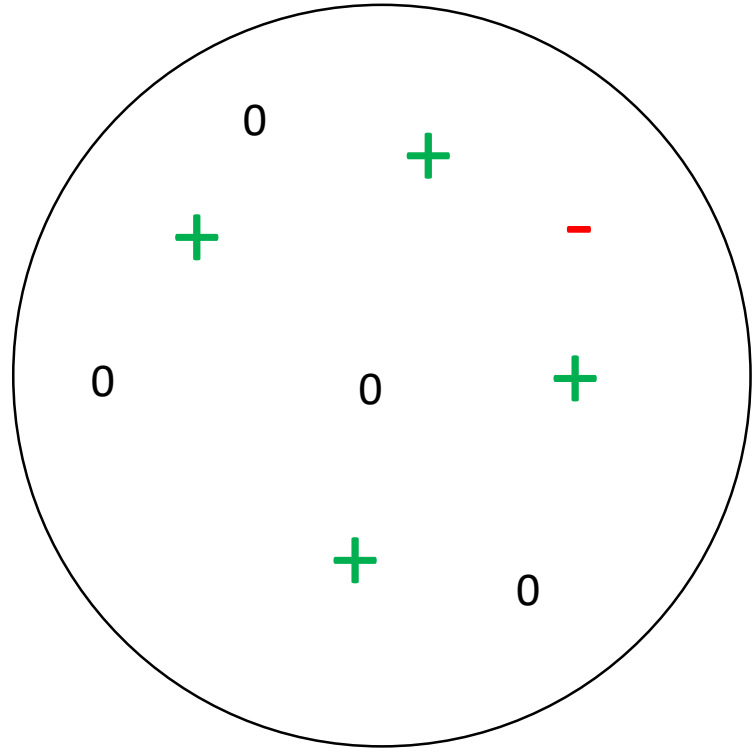


- Infrequent shoppers should store in memory database:
  - Fewer price changes
  - Lower proportion of zero price changes
  - Larger price changes (in absolute value)

More Selective Recall: Size Changes & Frequency

- Example: How fast is Francesco's nephew (Marco) growing?

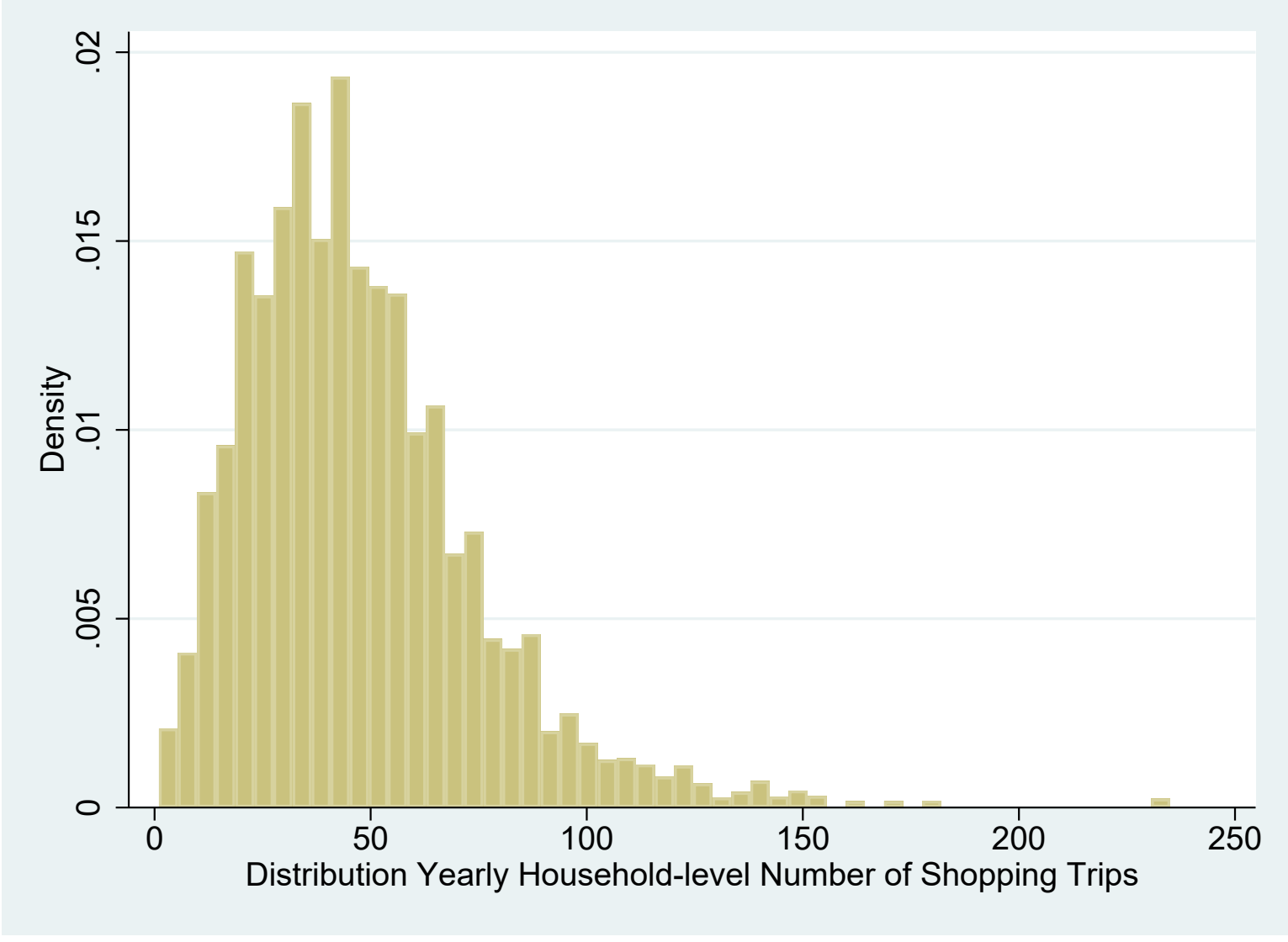
- Francesco's sister, Giulia, sees Marco every day
  - Most days no change in height
  - Once in a while, small (noticeable) increase

  $\rightarrow$ Giulia thinks Marco grows slowly, observations not salient

- Francesco sees Marco twice a year (well... before COVID-19)
  - Each time, large increase
  - Few observations, very memorable

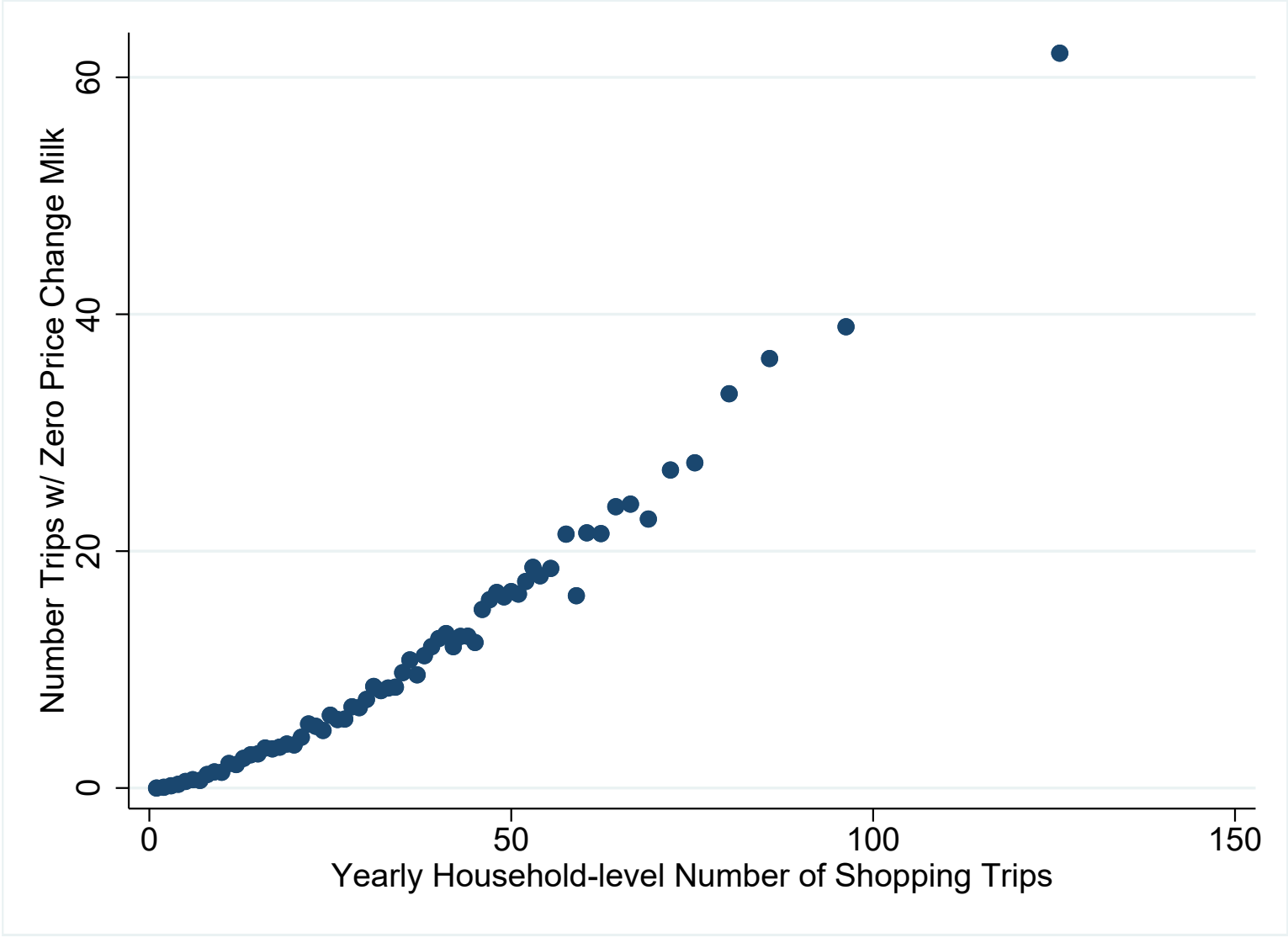
  $\rightarrow$ Francesco thinks Marco grows fast, each observation very salient

Variation in Yearly Shopping Frequency



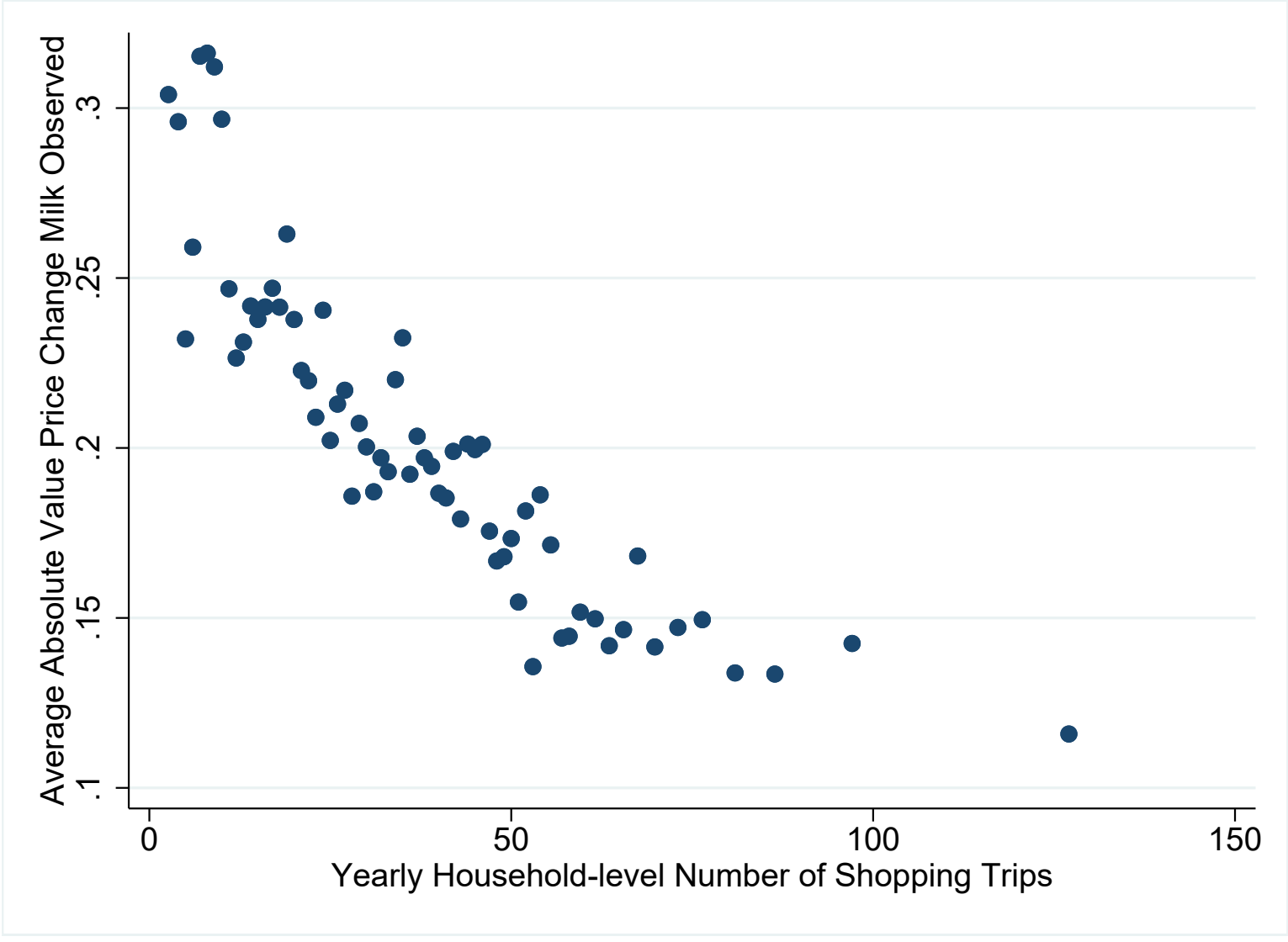
- Substantial (endogenous) variation in yearly number shopping trips across HH

Shopping Frequency and Number of Zero Price Changes



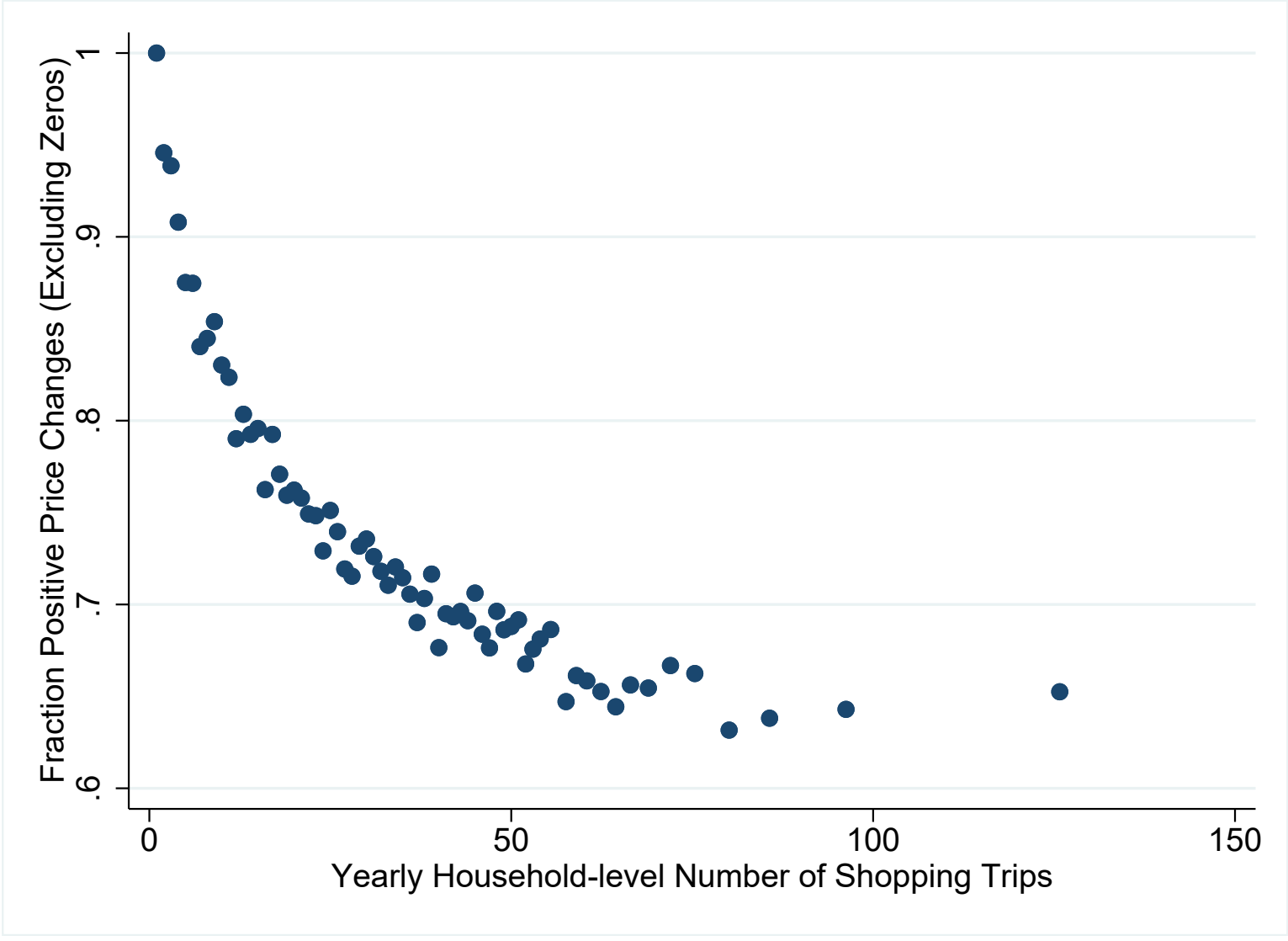
- Infrequent shoppers store more non-zero price changes in memory database

Shopping Frequency and Size of Price Changes



- Infrequent shoppers do store larger price changes in memory database

Shopping Frequency and Fraction of Positive Price Changes



- Everybody sees more positive than negative price changes
- Fraction of positive changes declines with shopping frequency

From Selective Recall to Beliefs Formation

1. Larger price changes (in any direction) affect beliefs by more

   Large price changes are more salient, surprising

2.

▶ ▶

Large Price Changes and Inflation Expectations

	Bottom Frequency CPI		Intermediate Frequency CPI		Top Frequency CPI	
	(1)	(2)	(3)	(4)	(5)	(6)
Frequency CPI	0.30**	0.32**	0.09	−0.01	0.16**	0.20**
	(0.15)	(0.15)	(0.28)	(0.33)	(0.08)	(0.08)
Range Frequency CPI	[-0.117, -0.009]		[-0.009, 0.028]		[0.028, 0.231]	
Nobs	19,706	18,568	19,707	18,903	19,713	18,749
R^2	0.0230	0.1002	0.0293	0.1038	0.0314	0.1122
Demographics		X		X		X
Expectations		X		X		X
County FE		X		X		X

Standard errors in parentheses

- Split the sample in 3 equal-sized group by size grocery price changes
- Reaction fully driven by larger price changes, in either direction

From Selective Recall to Beliefs Formation

1. Larger price changes (in any direction) should matter more

Large price changes are more salient

- Irrespective of expenditure share on goods

2. Less frequent shoppers should react more to price changes

If shop frequently, most prices do not change & small changes (+ / -)

- If shop infrequently:

(i) fewer price changes observed in general;

(ii) larger price changes on average

Less Frequent Shoppers and Inflation Expectations

Three proxies for frequency of grocery shopping:

- Primary Grocery Shopper for the Household
  - YES: 0.17^{***} NO: 0.27^{***}
- Shopping Frequency
  - Once a week or more: 0.17^{***} Less than once a week: 0.28^{***}
- Distance from Primary Shopping Outlet
  - $<$20m: 0.14^{***} 20m$>$t$>$60m: 0.27^{***} $>$60m: 0.80^{***}

Overall, effect larger for less frequent shoppers

Imperfect Recall: The Role of Interference

- Proactive Interference:
  older memories formed in same context crowd out newer memories
  - If recall price 12 months before, earlier stored price signals recalled
  - Prices grow over time→underestimate price 12 months before
  - Potential driver of systematic upward bias inflation expectations
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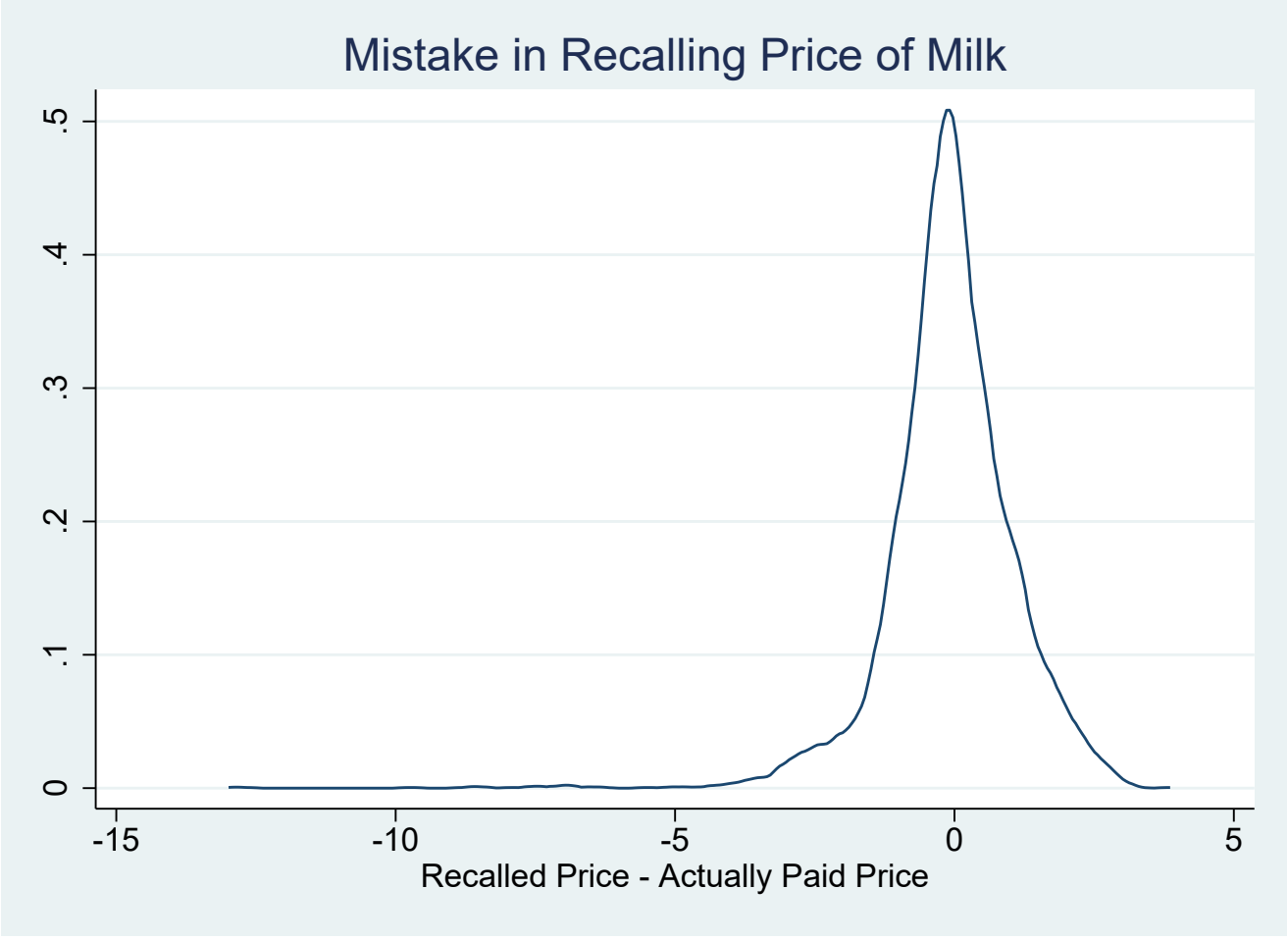
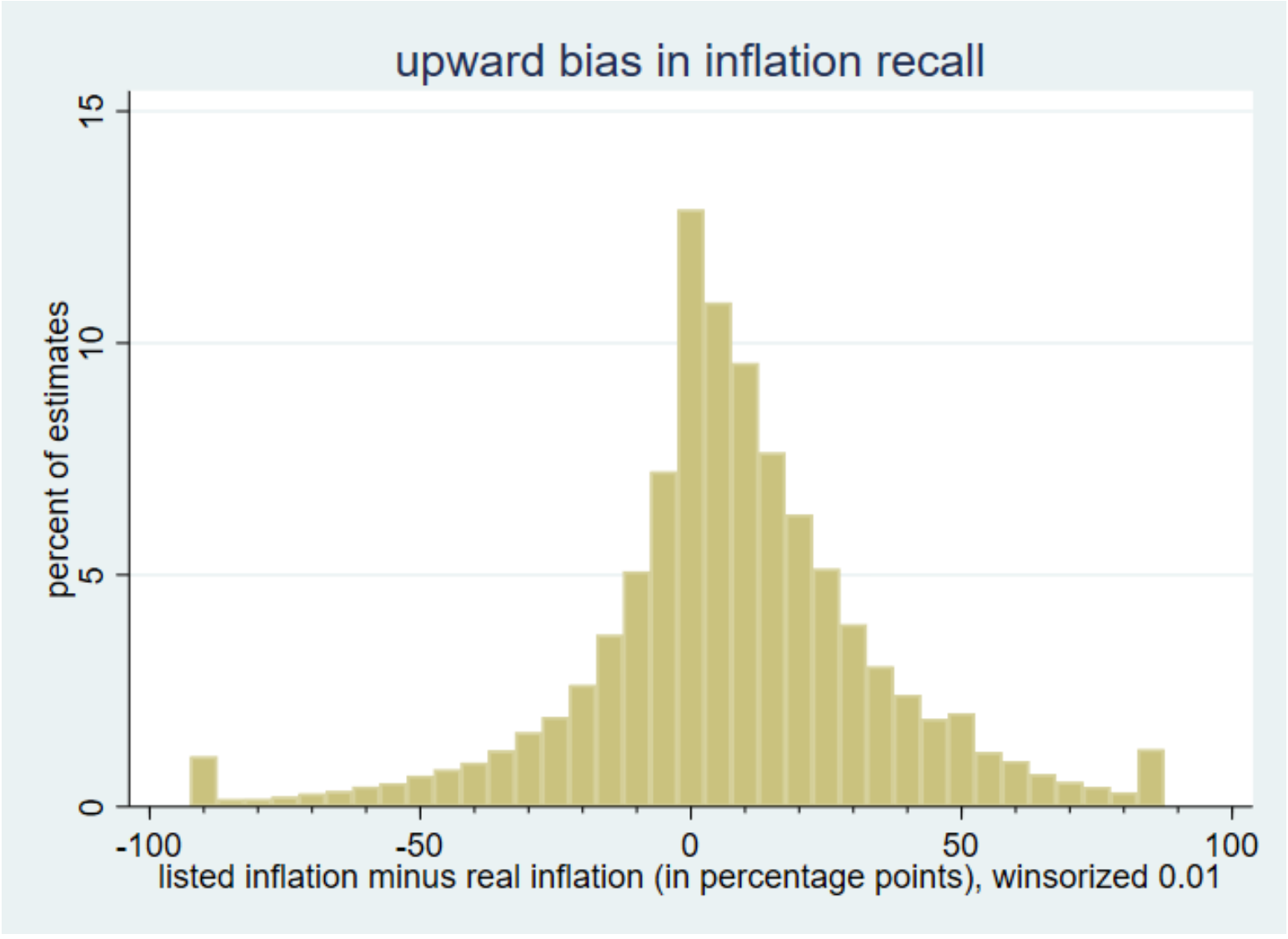
Proactive Interference: Recalling Lower Past Prices



- Many agents recall past prices of milk that are lower than actual prices they paid
- Do we observe an upward bias in perceived milk inflation?

Proactive Interference: Recalling Higher Past Inflation



- Indeed, upward bias in perceived milk inflation
- Could help explain upward bias in aggregate perceived/expected inflation

Imperfect Recall: The Role of Interference

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  - Prices grow over time→underestimate price 12 months before
  - Potential driver of systematic upward bias inflation expectations

- Retroactive Interference:
  newly cued memories crowd out otherwise recalled memories
  - Cue half pool randomly non-grocery price change signal

    "As far as you can recall, is there a gas station close to your home or where you work?"

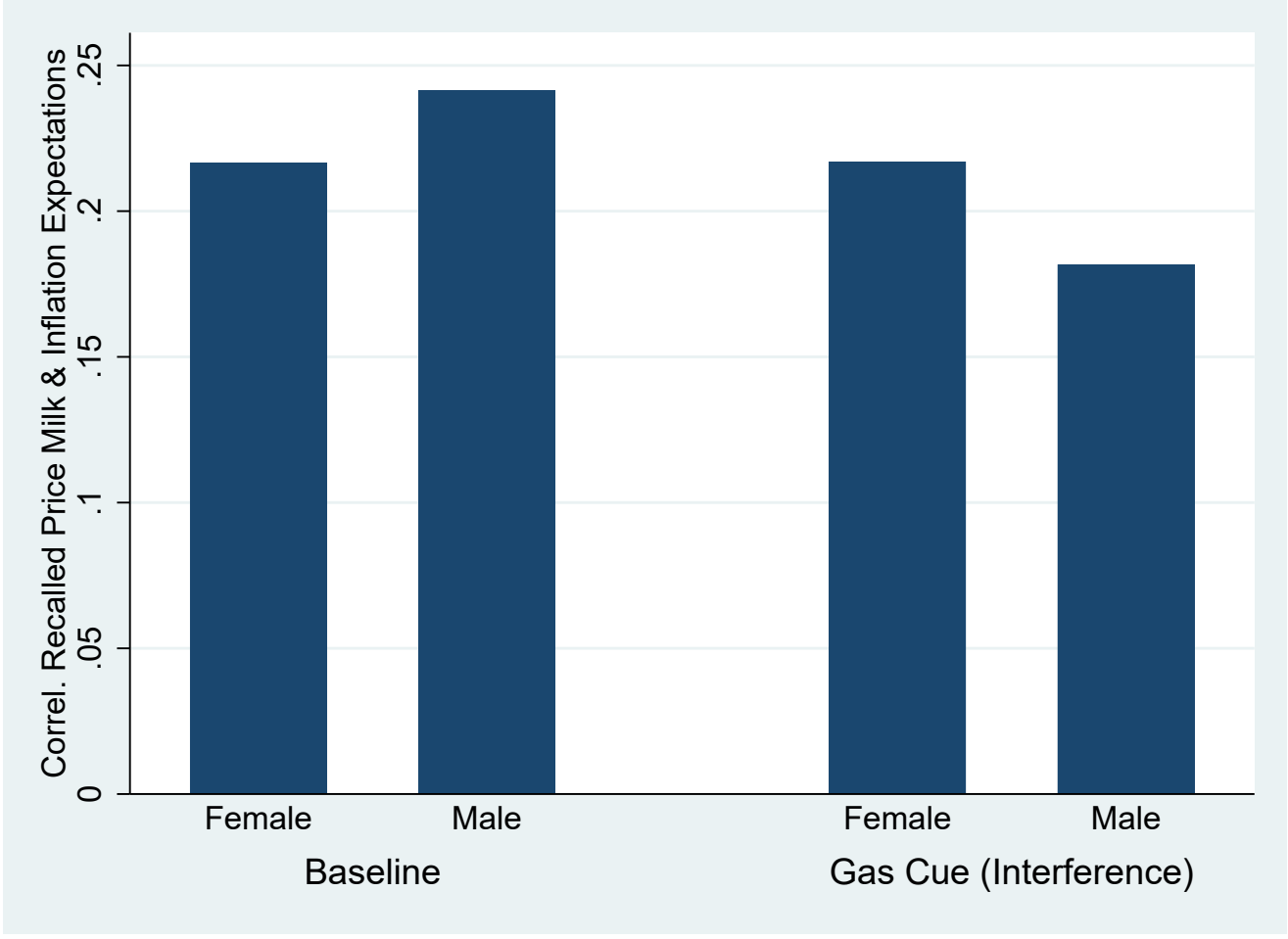
  - Are expectations less sensitive to recalled grocery price changes?
  - Aside: also helps with anchoring of reported values within survey

Retroactive Interference and Inflation Expectations

	(1)	(2)	(3)
Recalled π_{MILK}	0.03^{***}	0.04^{***}	0.04^{***}
	(3.58)	(4.18)	(3.78)
Recalled π_{MILK}		-0.03^{**}	-0.03^{**}
$\times$ Interfered		(-1.97)	(-2.10)
Interfered		-0.01	0.03
		(-0.01)	(0.08)
Nobs	4,618	4,618	4,618
R^2	0.787	0.802	0.802
Demographics			X
Expectations			X

- Recalled milk inflation predicts 12-month-ahead general π expectations
- Correlation substantially lower for subjects that faced interference gas prices

Variation in Interference: Men vs. Women



- Recall from above: men attend to gas prices more than women
- Gas price interference crowds out men's milk inflation recall by more than women's

Variation in Interference: Reliance on Price Recall for Beliefs

	(1) Women	(2) Men	(3) Media	(4) No Media	(5) Literate	(6) Illiterate
Recalled π_{MILK}	0.03*	0.04***	0.02*	0.04***	0.02*	0.07***
	(1.68)	(3.36)	(1.77)	(2.98)	(1.76)	(4.21)
Recalled π_{MILK}	−0.01	−0.04*	−0.00	-0.04*	−0.01	−0.07**
× Interfered	(−0.49)	(−1.80)	(−0.30)	(-1.93)	(−0.34)	(−2.10)
Interfered	−0.47	0.28	0.05	-0.116	−0.08	−0.08
	(−0.92)	(0.57)	(0.08)	(-0.25)	(−0.18)	(−0.13)
Nobs	1,314	3,299	1,727	2,891	2,162	2,456
R^2	0.874	0.826	0.894	0.824	0.834	0.845
Demographics	X	X	X	X	X	X
Expectations	X	X	X	X	X	X

- Recalled milk prices used in aggregate beliefs more if female, no info from media, financially illiterate

Conclusions

- Memory framework in the field
  - Memory Database of recalled price signals
  - Selective recall of stored signals
  - Recalled prices used in forming beliefs
  - Interference in recall of price signals
- Many agents recall systematically lower past prices than reality
- Bottom line:
  Facts inform theory & field experiments for channels