

Inflation Expectations, Learning and Supermarket Prices

Evidence from Field Experiments

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Cleveland Federal Reserve, Sept. 2016

Outline

- 1 Introduction
- 2 Experimental Design
- 3 Online Experiments
- 4 Supermarket Experiment
- 5 Conclusions

Introduction

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 - ▶ Key for consumption decisions and real effects of monetary policy. E.g.: Bernanke, 2007; Bachmann et al., 2012; Coibion and Gorodnichenko, 2011

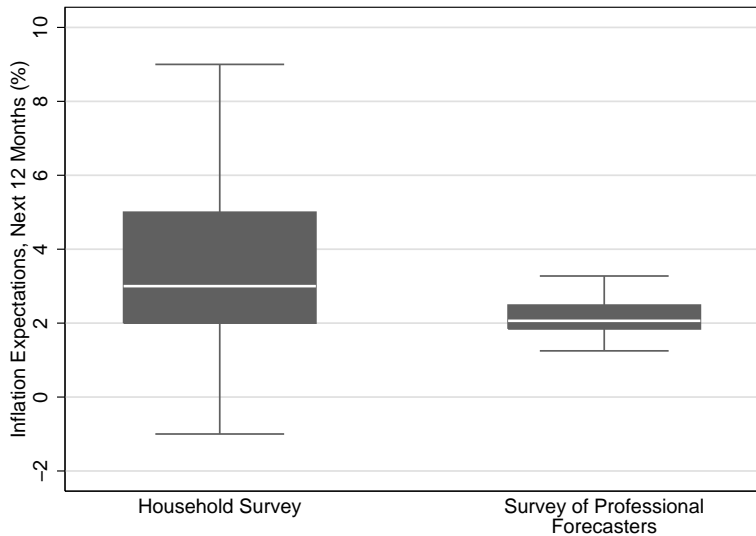
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 - ▶ No consensus in the literature. E.g.: Raynard et al., 2012.

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 - ▶ No consensus in the literature. E.g.: Raynard et al., 2012.
- Households' expectations are more dispersed than those of professional forecasters. E.g.: Ranyard et al., 2008; Armantier et al., 2013.

Households' Exp. more Dispersed (2012 U.S. Data)



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 - ▶ Personal Experience / Irrational Learning. E.g.: Bruine de Bruin et al., 2011; Malmendier and Nagel, 2013; Armantier et al., 2016.
- Large literature, but hard to distinguish them with observational data

Our Contribution

- We run survey experiments to find evidence of inattention and learning
 - ▶ Online and Supermarket surveys:
 - ★ ask about past (perceptions), provide randomized information about past, ask about future (expectations)
 - ▶ In both US (low-inflation) and Argentina (high-inflation)
 - ▶ Using both aggregate statistics and individual supermarket prices
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- Reduced-form evidence: effect of treatment on distribution of post-treatment beliefs.
- Structural approach: use Bayesian model to estimate “learning rates” and quantify the contribution of each source of information

Summary of Findings

- Rational inattention test.
 - ▶ Individuals have stronger priors in higher inflation contexts.
- Irrational learning test.
 - ▶ Individuals over-weight supermarket prices.
- Spurious learning test.
 - ▶ Half of the reaction is spurious.
- Remembered prices test.
 - ▶ Individuals use their price memories, but they are inaccurate and biased.

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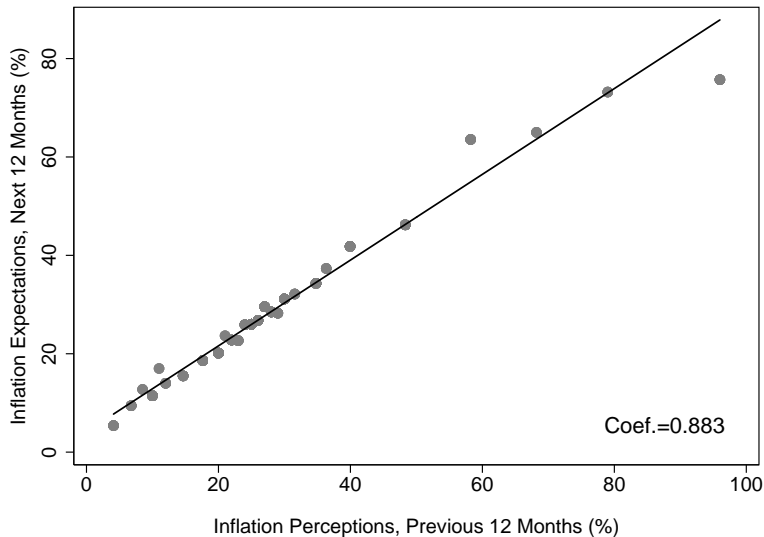
Expectations Equation

- Goal: quantify the rate of learning.
- $\pi_{i,t}$: perceptions about inflation over the past 12 months.
- $\pi_{i,t+1}$: expectations about inflation over the next 12 months.
- Expectations equation:

$$\pi_{i,t+1} = \mu + \beta \cdot \pi_{i,t} + \epsilon_{i,t}$$

- Can take it as purely statistical model, but can accommodate:
 - ▶ Adaptive learning (e.g., Sargent, 1993).
 - ▶ Rational expectations (e.g., Barr and Campbell, 1997; Atkeson and Ohanian, 2001).
- Consistent with lots of empirical evidence (eg. Jonung ,81 and others)

Expectations Equation (Argentina)



Learning Equation

- $\pi_{i,t}^0$: prior belief about inflation over the past 12 months.
- $\pi_{i,t}^T$: signal about inflation over the past 12 months.
- If prior and signal are normally distributed, posterior is also normal:

$$\pi_{i,t} = (1 - \alpha) \pi_{i,t}^0 + \alpha \pi_{i,t}^T$$

- α is the weight placed on signal (a function of relative precision between prior and signal)

Inferring Learning Rates

- Combine learning and expectation equations:

$$\pi_{i,t+1} = \gamma_0 + \underbrace{\gamma_1}_{\beta} \pi_{i,t}^0 + \underbrace{\gamma_2}_{\alpha \cdot \beta} (\pi_{i,t}^T - \pi_{i,t}^0) + \varepsilon_{i,t+1}$$

- Experiment collects data on $\{\pi_{i,t}^0, \pi_{i,t}^T, \pi_{i,t+1}\}$,
- So we can estimate both β (pass-through perception to expectation) and α (weight on signal or “learning rate”) with a single regression.
- We also test other predictions of Bayesian learning.

Disentangling Genuine and Spurious Learning

- Important concern is spurious learning.
 - ▶ E.g.: desirability bias (Goffman, 1963); numerical anchoring (Tversky and Kahneman, 1974).
- Strategy: define “true learning” as reactions that are “consistent.”
 - ▶ Over time.
 - ▶ Across beliefs.
- Boils down to estimating model with alternative dependent variables (e.g., $\pi_{i,t+1}^{\text{follow-up}}$, $i_{i,t+1}$).

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Subject Pools

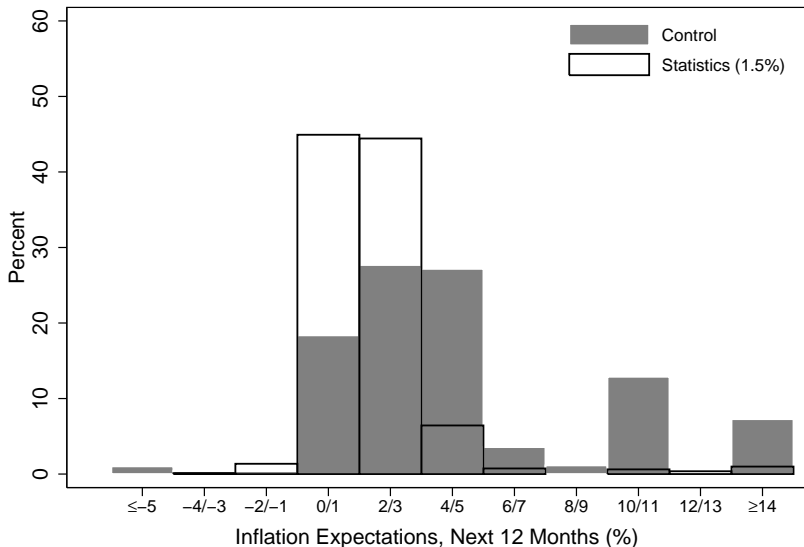
- Online experiments conducted in 2013.
- United States (inflation stable around 2%).
 - ▶ 3,945 individuals recruited from Amazon Mechanical Turk.
 - ▶ Inflation expectations similar to *Michigan Survey of Consumers*.
- Argentina (inflation stable around 25%).
 - ▶ 3,653 individuals recruited from regular online poll.
 - ▶ Inflation expectations similar to (equivalent of) *Michigan Survey of Consumers*.

Treatment Arm: Statistics (1.5%), U.S.

Official Statistic	Average Annual Change in Prices
Consumer Price Index ¹	2.0%
Personal Consumption Expenditures Price Index ²	1.1%
Gross Domestic Product Deflator ³	1.5%
Average of the three statistics:	1.5%

Sources: 1 Bureau of Labor Statistics, 2 and 3: Bureau of Economic Analysis.

Treatment Arm: Statistics (1.5%), U.S.



Note: ES test p-value: <0.01

Treatment Arm: Products, U.S.

- Table of 6 products with the following message:
 - ▶ *“The six products that appear in the following table were randomly selected from a database containing hundreds of products. All prices were obtained from the same supermarket.”*
- Prices scraped from largest supermarkets in each country.
- No suggestion that prices were representative.
- Algorithm chose products to hold constant other characteristics.

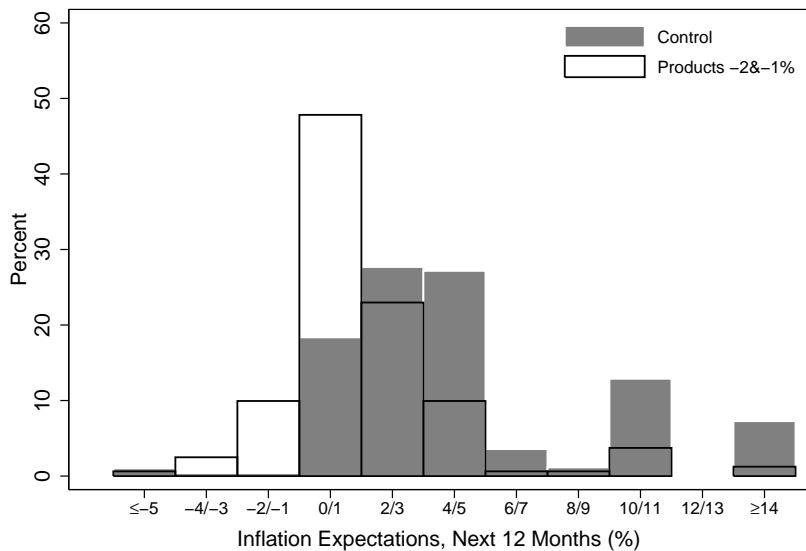
Products (-2%), U.S.

Product	Price on August 1, 2012	Price on August 1, 2013	Price change in %
Infant Formula (Enfamil Gentlease)	\$18 ⁶⁹	\$18 ⁶⁹	0.0%
Bread (Anzio & Sons Sub Rolls)	\$3 ⁵⁹	\$3 ⁵⁹	0.0%
Pasta Sauce (Barilla Marinara)	\$2 ⁷⁹	\$2 ⁸⁰	0.4%
Cereal (Cheerios Honey Nut)	\$5 ²⁹	\$4 ⁹⁹	-5.7%
Soda (Schweppes Ginger Ale)	\$1 ⁷⁹	\$1 ⁶⁷	-6.7%
Body Wash (Dial Spring Water)	\$6 ⁰⁹	\$6 ⁰⁹	0.0%
Average change:			-2.0%

Products (2%), U.S.

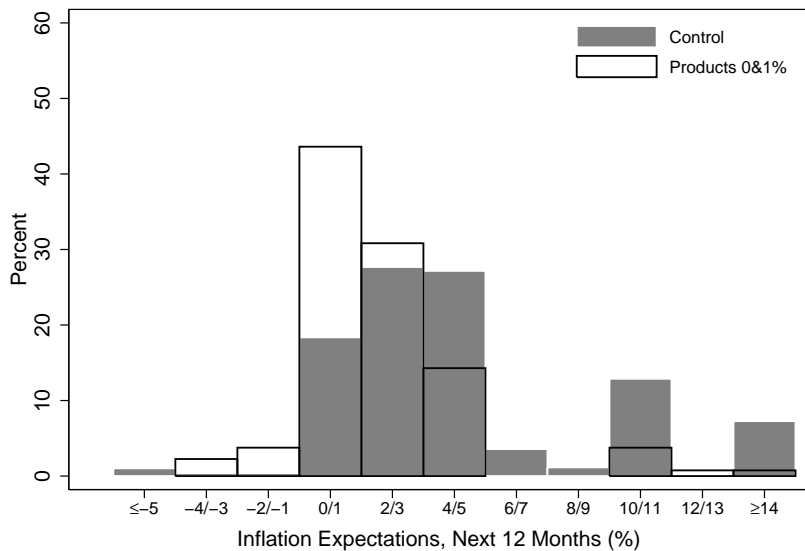
Product	Price on August 1, 2012	Price on August 1, 2013	Price change in %
Infant Formula (Similac with Iron)	\$7 ²⁹	\$7 ⁵⁹	4.1%
Bread (Pepperidge Farm Sliders)	\$3 ⁰⁰	\$2 ⁹⁹	-0.3%
Noodles (No Yolks)	\$2 ⁷⁹	\$2 ⁷⁹	0.0%
Cereal (Natures Path Envirokidz)	\$4 ⁹⁹	\$5 ³⁹	8.0%
Soda (Dr Pepper)	\$1 ⁷⁹	\$1 ⁷⁹	0.0%
Body Wash (Dial Spring Water)	\$6 ⁰⁹	\$6 ⁰⁹	0.0%
Average change:			2.0%

Products (-2% | -1%), U.S.



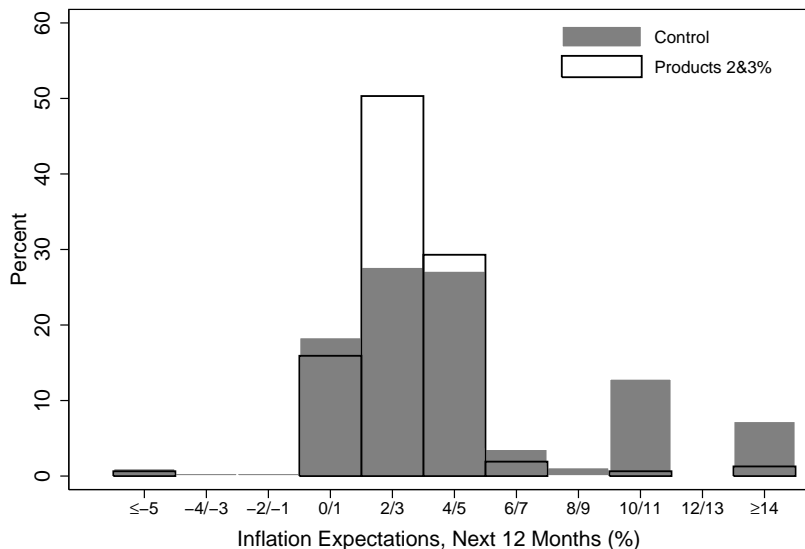
Note: ES test p-value: <0.01

Products (0% | 1%), U.S.



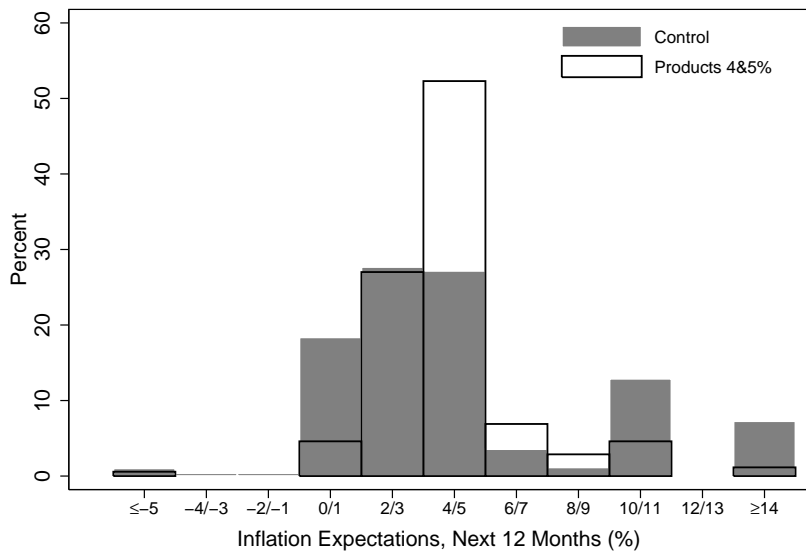
Note: ES test p-value: <0.01

Products (2% | 3%), U.S.



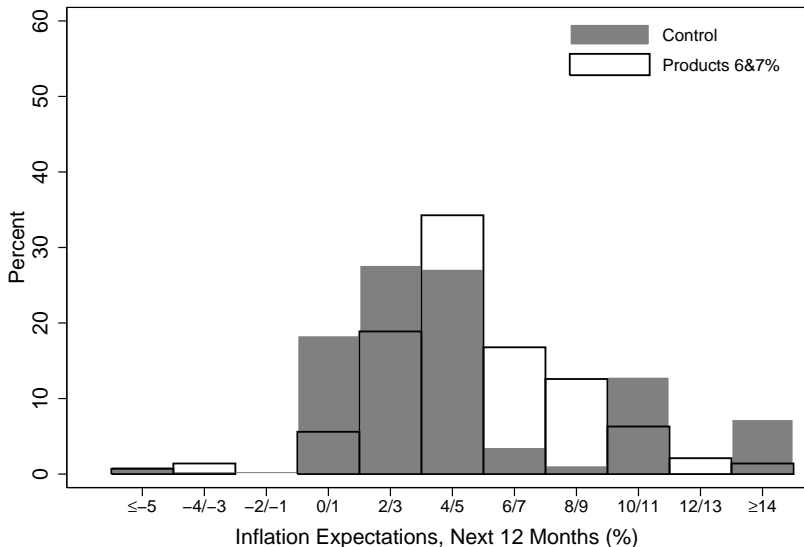
Note: ES test p-value: <0.01

Products (4% | 5%), U.S.



Note: ES test p-value: < 0.01

Products (6% | 7%), U.S.



Note: ES test p-value: <0.01

Table 1: Estimates of Learning Rates, Online Experiments

a. United States

	(1)	(2)	(3)	(4)	(5)
	$\pi_{i,t+1}$	$\pi_{i,t+1}$	$\pi_{i,t+1}$	$\pi_{i,t+1}^{follow-up}$	$i_{i,t+1}$
β	0.757*** (0.033)	0.817*** (0.058)	0.814*** (0.046)	0.438*** (0.055)	0.291*** (0.040)
α -Products	0.689*** (0.036)	0.449*** (0.050)	0.697*** (0.045)	0.336** (0.150)	0.499*** (0.135)
α -Statistics	0.838*** (0.034)	0.283*** (0.063)	0.799*** (0.058)	0.360*** (0.138)	0.314 (0.212)
α -Hypothetical	0.232*** (0.027)		0.215*** (0.046)	-0.021 (0.092)	0.131 (0.112)
Observations	3,141	1,587	1,073	1,073	3,141
Simultaneous treatments	No	Yes	No	No	No

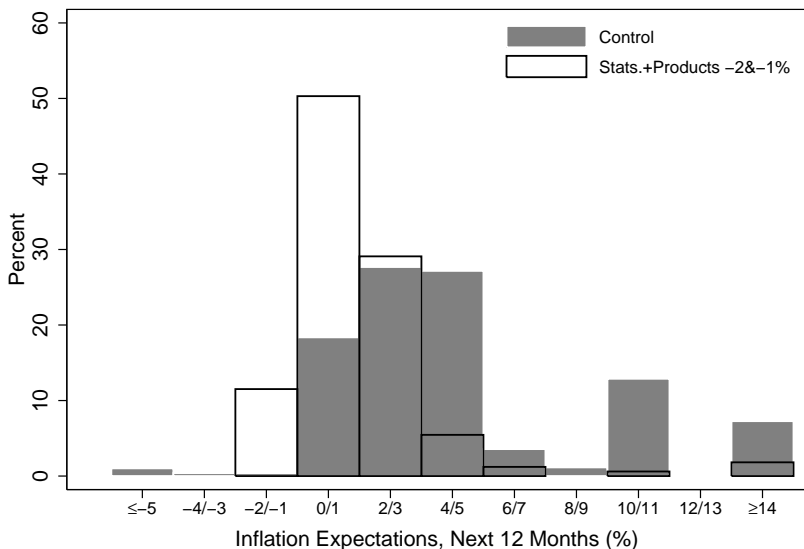
First Test: Rational Inattention

- Comparing learning rates (α):
 - ▶ United States: 0.84 from statistics, 0.70 from supermarket prices.
 - ▶ Argentina: 0.43 from statistics, 0.46 from supermarket prices.
- Learning rates 55%-95% larger in United States.
 - ▶ Suggest that rational inattention is important.

Second Test: Irrational Learning

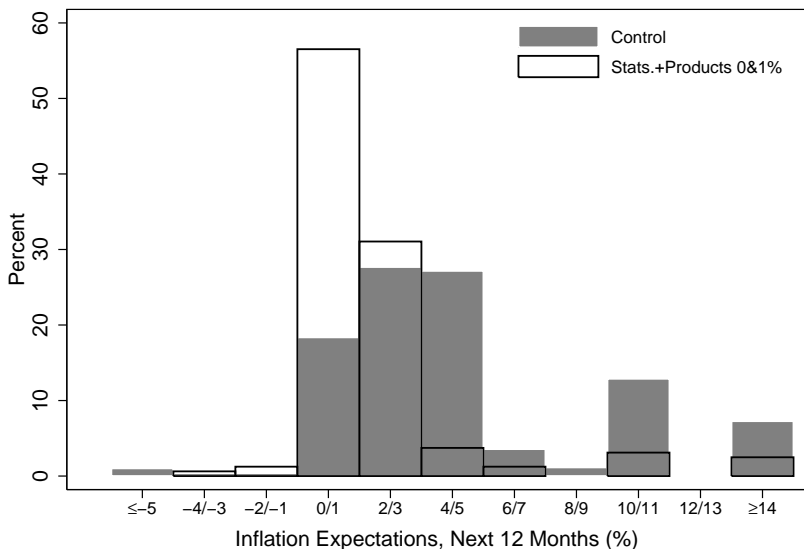
- Provide two sources of information simultaneously:
 - ▶ Inflation statistics (e.g., CPI).
 - ▶ A few supermarket prices (\sim consumer experience).
- Rational learning hypothesis: conditional on statistics, individual goods should not matter.

Statistics (1.5%) + Products (-2% | -1%), U.S.



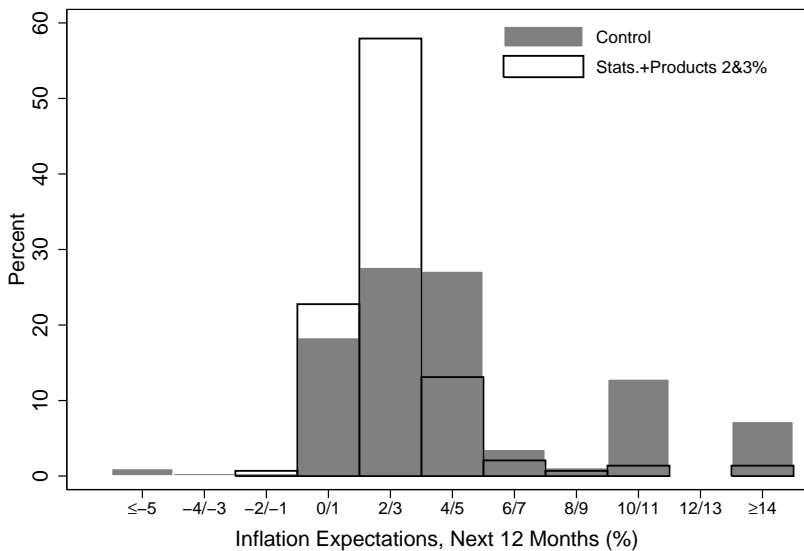
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Statistics (1.5%) + Products (0% | 1%), U.S.



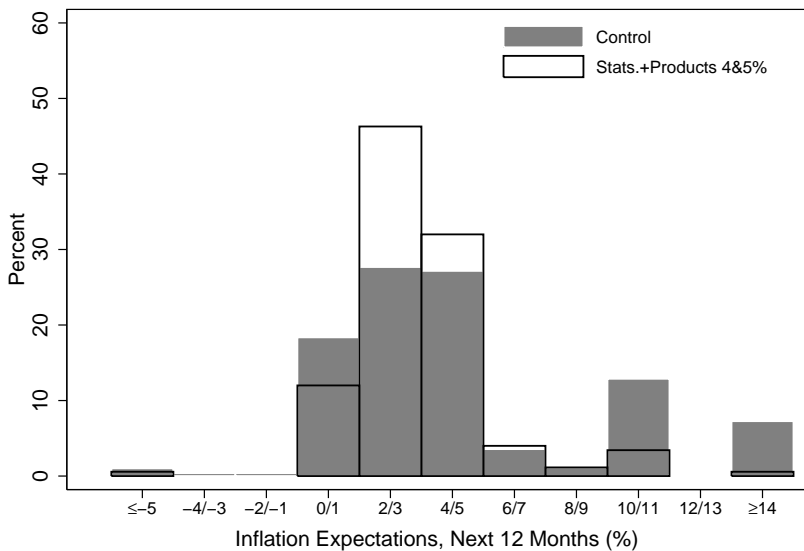
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Statistics (1.5%) + Products (2% | 3%), U.S.



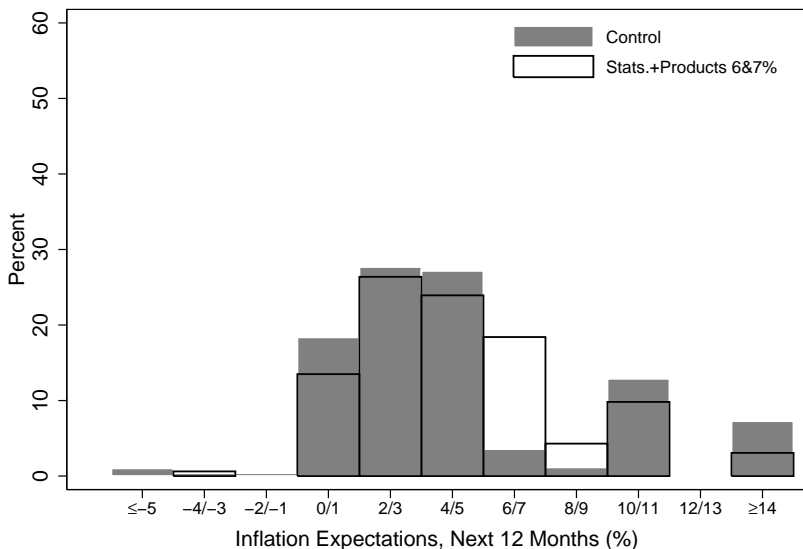
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Statistics (1.5%) + Products (4% | 5%), U.S.



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Third Test: Spurious Learning

- Individuals may respond to information due to:
 - ▶ Experimenter demand effect.
 - ▶ Numerical anchoring.
- Suggestive evidence: hypothetical treatment arm.

Spurious Learning: Hypothetical (10%), U.S.

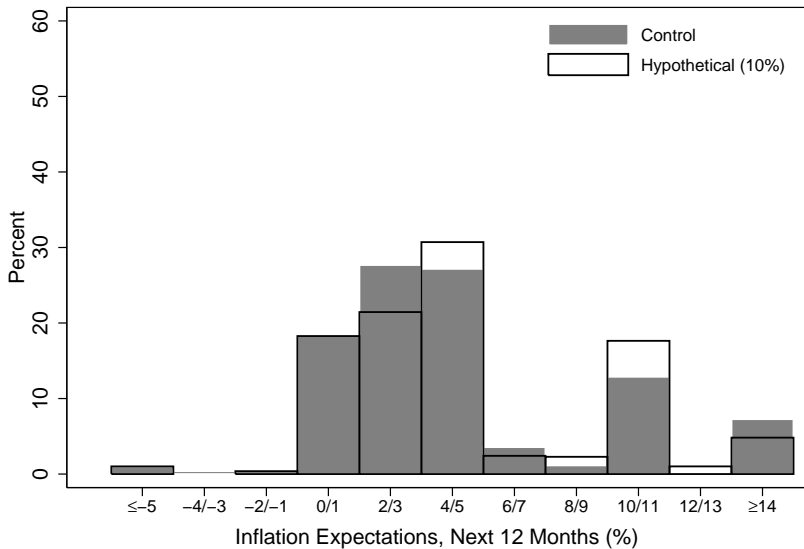
Please consider the following prices of a hypothetical product at two different moments.

Price on January 1st 2012:	\$9.99
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What is the approximate price change for this product over this period? Please do not use a calculator, pen, or pencil to calculate the exact figure. We want your best guess from eyeballing these prices.

- About 1%
- About 5%
- About 10%
- About 100%

Hypothetical (10%), U.S.



Note: ES test p-value: <0.01

Third Test: Spurious Learning

- Method 1: using follow-up survey.
 - ▶ Spurious learning about 50%.
- Method 2: using nominal interest rate expectations.
 - ▶ Spurious learning about 50%.
- Nevertheless, qualitative evidence is robust.
 - ▶ E.g.: priors still much stronger in Argentina.

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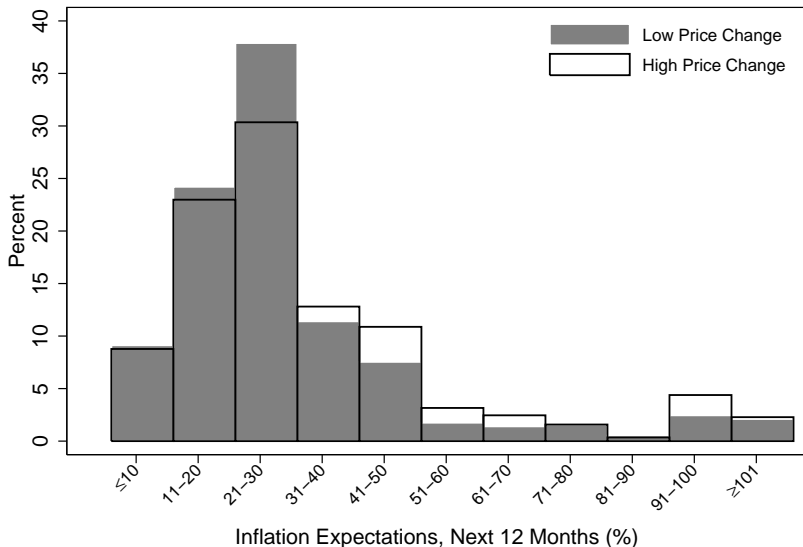
Remaining Hypotheses

- Evidence that individuals give much weight to supermarket prices.
- However:
 - ▶ Does it mean that individuals would use their own price memories?
 - ▶ How misleading can those memories be?

A Consumer Intercept Survey

- We surveyed people outside a large Supermarket in Argentina
- Collected data on:
 - ▶ Items purchased from supermarket receipt (scan)
 - ▶ Actual historical prices for those same items (scraped data)
 - ▶ Remembered prices.
 - ▶ Expected/perceived inflation.
- Randomize set of products for price-elicitation exercise.
 - ▶ Generate experimental variation in salience of price memories.

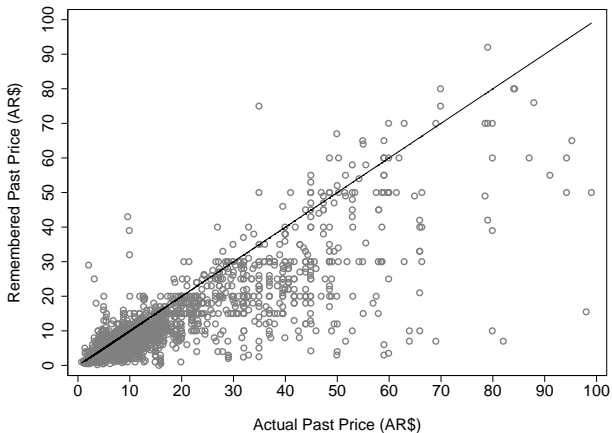
Price Memories Matter for Expectations



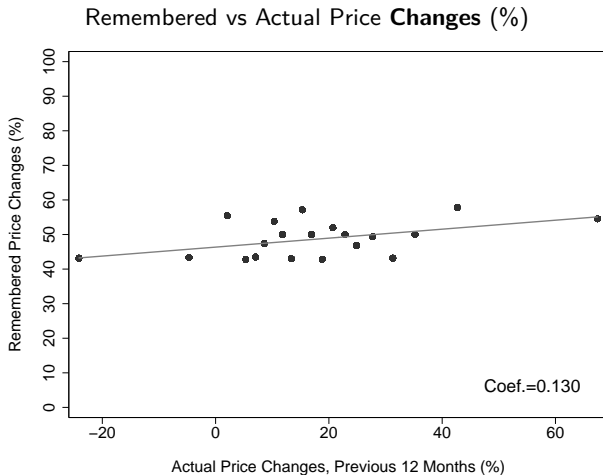
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Price Memories are Inaccurate

Remembered vs Actual **Past Price Levels** (Arg. Pesos)



Price Memories are Inaccurate



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- Policy implication: educate consumers about aggregate statistics and also highlight examples of individual goods.
- Can governments affect expectations by manipulating statistics or using price controls?
 - ▶ Related paper: “Learning from Potentially-Biased Statistics”, Brookings PEA Spring 2016
 - ▶ Short answer is no. People adjust for the perceived bias. Generates an asymmetry in response that makes things worse.

Additional Slides

Argentina Results

b. Argentina

	(1)	(2)	(3)	(4)	(5)
	$\pi_{i,t+1}$	$\pi_{i,t+1}$	$\pi_{i,t+1}$	$\pi_{i,t+1}^{follow-up}$	$i_{i,t+1}$
β	1.138*** (0.118)	0.902*** (0.042)	0.963*** (0.041)	0.754*** (0.086)	0.155*** (0.035)
α -Products	0.458*** (0.062)	0.494*** (0.027)	0.456*** (0.037)	0.208** (0.094)	0.468*** (0.133)
α -Statistics	0.432*** (0.098)				
Observations	691	3,653	1,320	1,320	3,373
Sample (experts, online)	I	II	II	II	II

Disentangling Genuine and Spurious Learning

- Important concern is spurious learning. E.g.: desirability bias of Goffman (1963), numerical anchoring of Tversky and Kahneman (1974).
- Strategy: define “true learning” as reactions that are consistent:
 - ▶ Over time: i.e., experimental effects must persist at the same rate than the prior belief.
 - ▶ Across beliefs: i.e., experimental effects must “spillover” to other nominal beliefs at the same rate than the prior belief.
- In practice, estimating same equation but with alternative dependent variables:
 - ▶ $\pi_{i,t+1}^{\text{follow-up}}$: inflation expectations measured months after information provision.
 - ▶ $i_{i,t}$: expected nominal interest rate over the next 12 months.
- We also run a “hypothetical” treatment to explore numerical anchoring.

Treatment Arm: Hypothetical (10%)

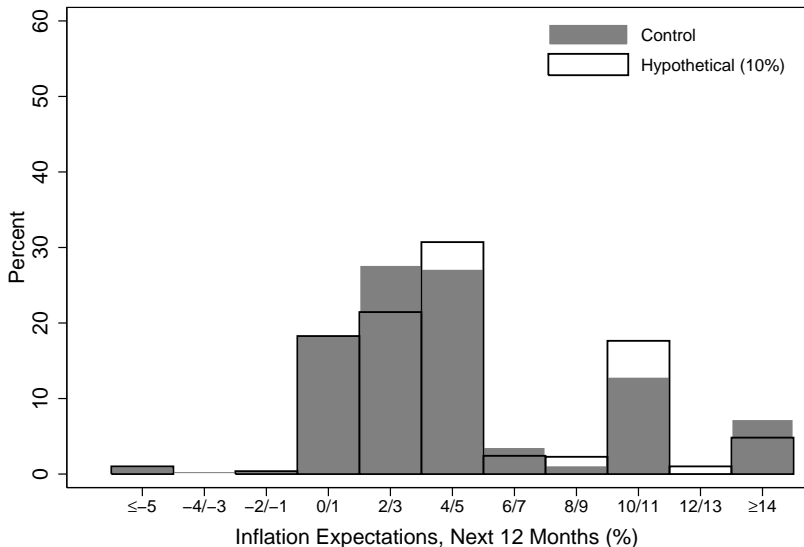
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What is the approximate price change for this product over this period? Please do not use a calculator, pen, or pencil to calculate the exact figure. We want your best guess from eye-balling these prices.

- About 1%
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Hypothetical (10%)

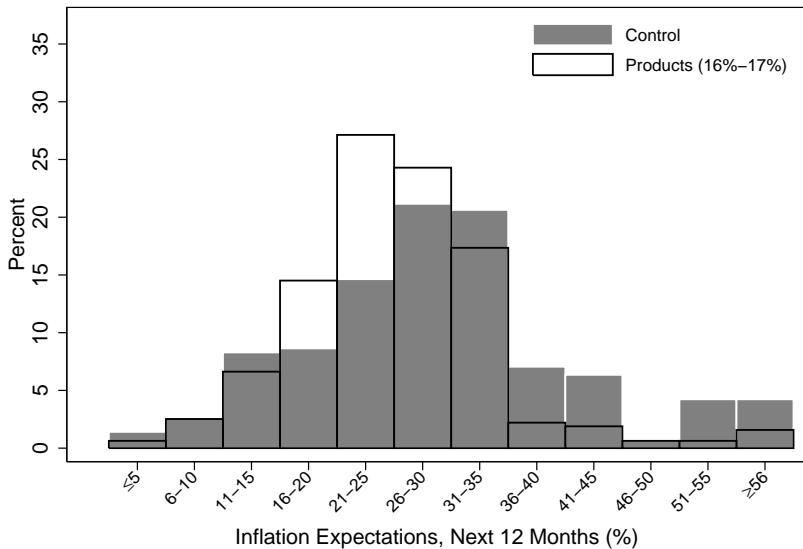


Note: ES test p-value: <0.01

Treatment Arm: Products

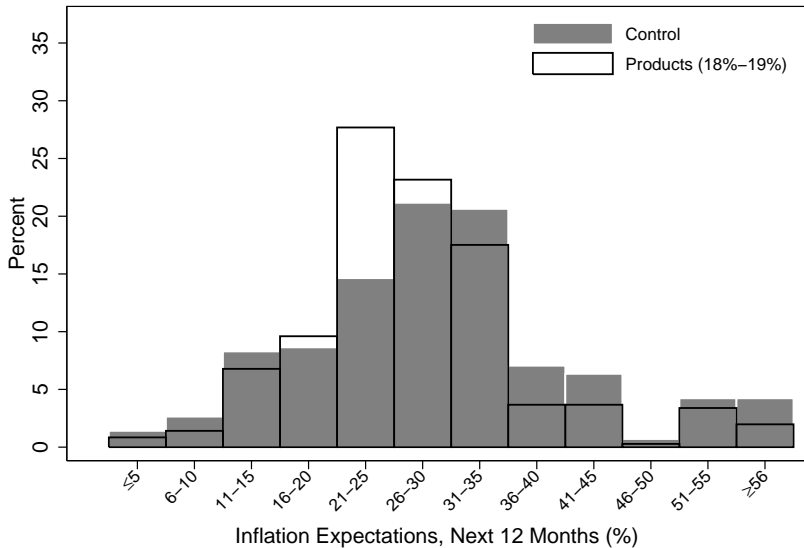
- Prices scraped from largest supermarkets in each country.
- We presented a table of prices with the following message:
 - ▶ *“The six products that appear in the following table were randomly selected from a database containing hundreds of products. All prices were obtained from the same supermarket.”*
- No suggestion that prices were representative.
- Created an algorithm that chooses varieties (e.g., pulp vs. no-pulp juice) to produce continuum of price changes holding constant other characteristics.

Products (16%-17%)



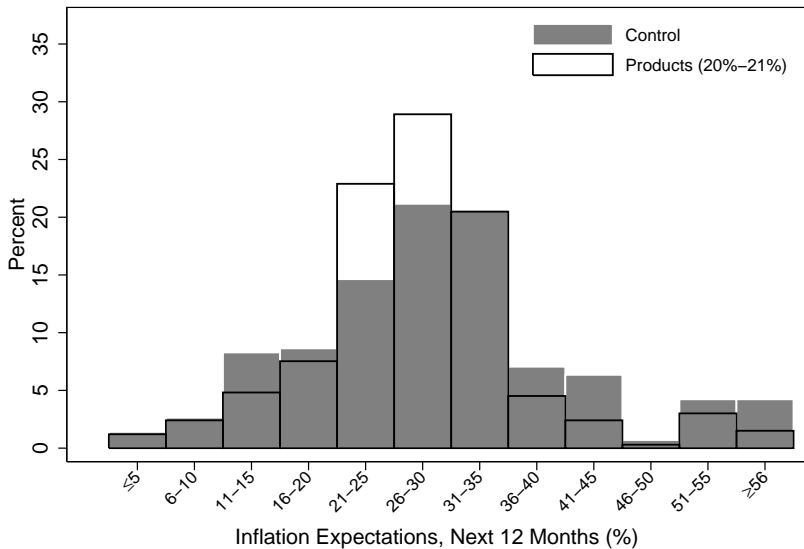
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Products (18%-19%)



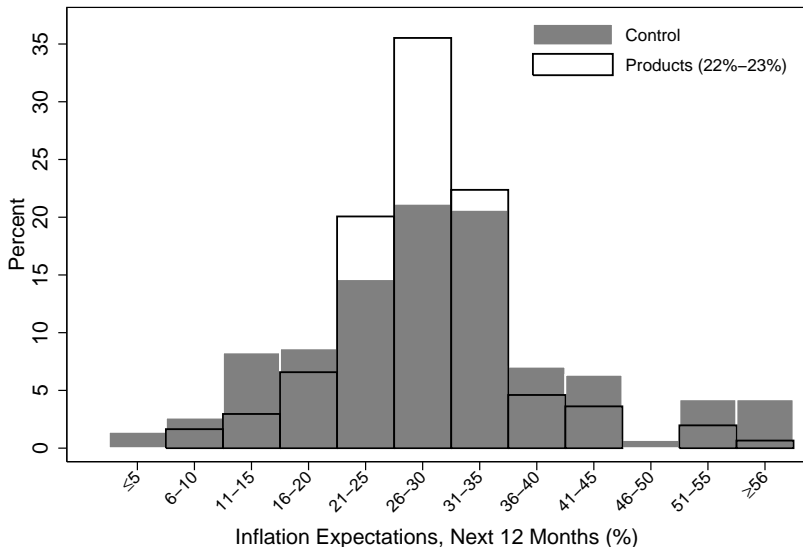
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Products (20%-21%)



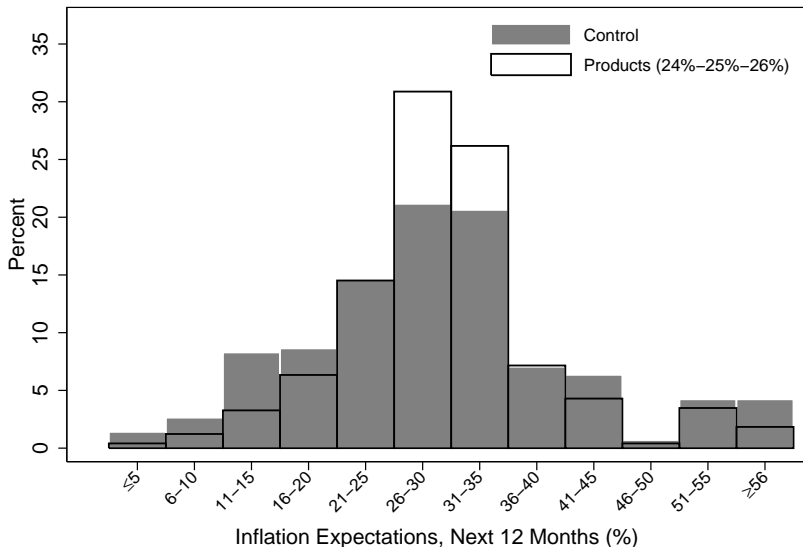
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Products (22%-23%)



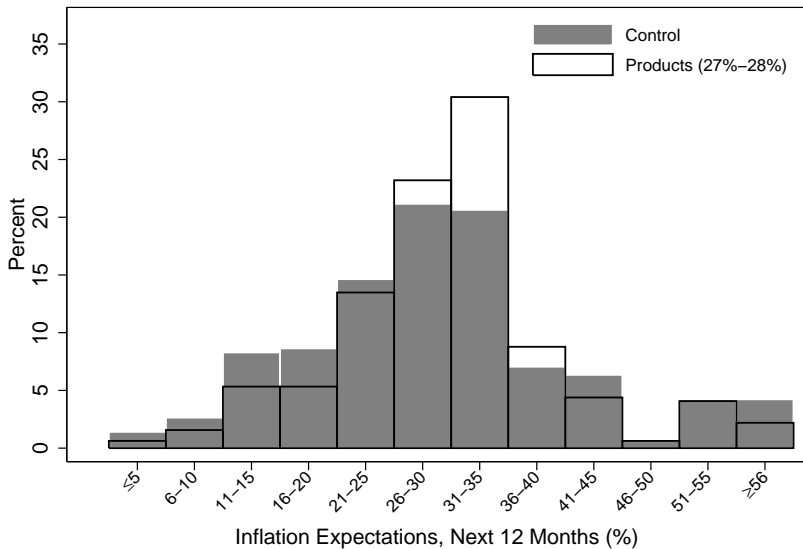
Note: ES test p-value: <0.01

Products (24%-26%)



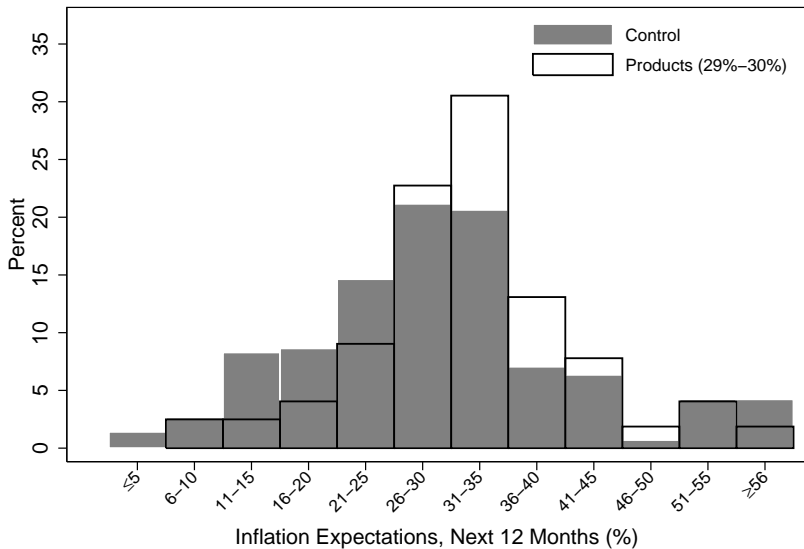
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Products (27%-28%)



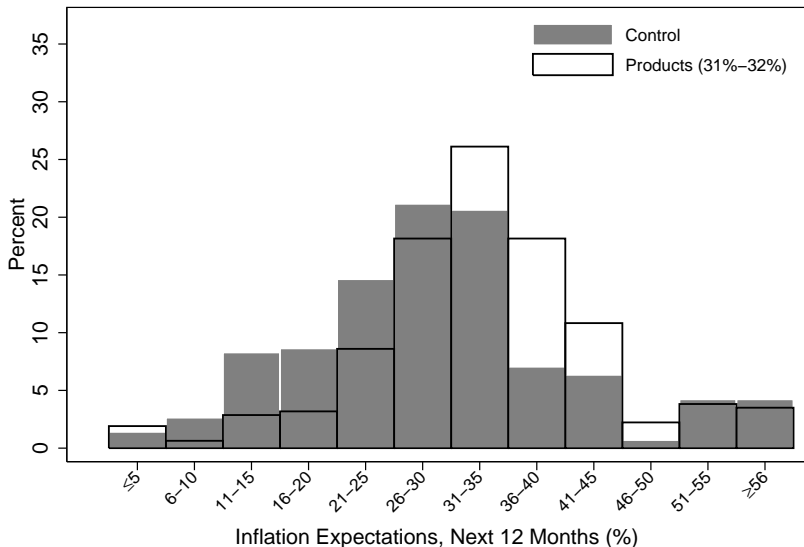
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Products (29%-30%)



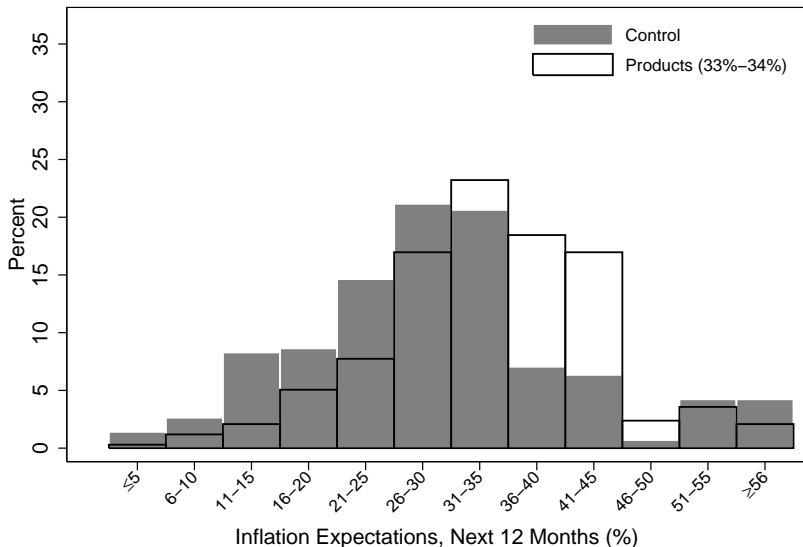
Note: ES test p-value: <0.01

Products (31%-32%)



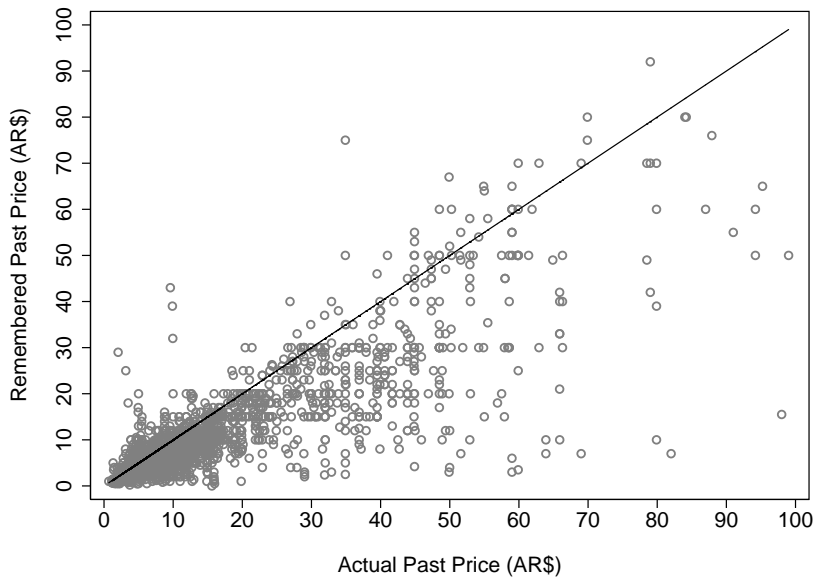
Note: ES test p-value: <0.01

Products (33%-34%)



Note: ES test p-value: <0.01

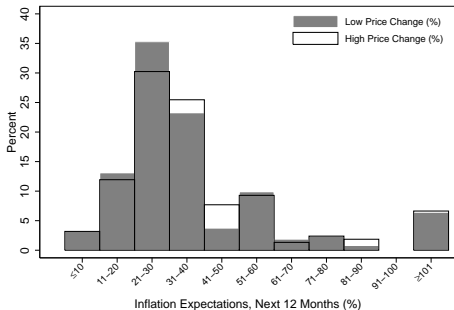
Remembering Past Prices



Effect of Experienced and Remembered Price Changes

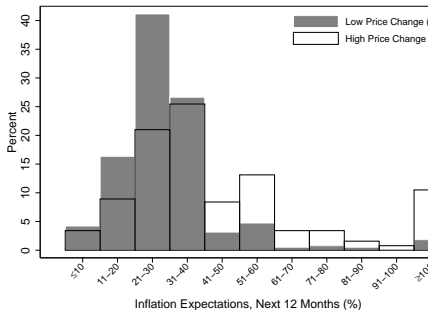
- Actual (experienced) price changes do not affect expectations, but “remembered” price changes do.

a) Actual Price changes



Note: ES test p-value: 0.51

a) Remembered price changes



Note: ES test p-value: <0.01