Price Selection in the Microdata

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  - Low frequency implies rigid price level

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- Prices change infrequently (Bils and Klenow, 2004)
- In standard price-setting models (Calvo, 1983)
  - Low frequency implies rigid price level
- In models microfounded by fixed (menu) costs of adjustment (Golosov and Lucas, 2007)
  - Price level stays flexible even if a small fraction adjusts, because
  - *Large* price changes are selected

Selection of large price changes

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- Menu costs: optimal to concentrate on the products with the largest price misalignment
- When an aggregate shock hits
  - The most misaligned prices get adjusted,
  - They change by a lot, and
  - This raises the flexibility of the price level.

What do we do and find?

- Revisit the Golosov and Lucas (2007)-critique to price-rigidity

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- We measure price misalignment and identify aggregate shocks to show
  1. State-dependence: Probability of price adjustment increases with price misalignment unconditionally
  2. No selection: conditional on an aggregate shock, misalignment is immaterial
  3. Active gross extensive margin: Uniform shift between price increases versus price decreases

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  1. State-dependence: Probability of price adjustment increases with price misalignment unconditionally
  2. No selection: conditional on an aggregate shock, misalignment is immaterial
  3. Active gross extensive margin: Uniform shift between price increases versus price decreases
- Provides guidance for model choice and policy implications
  - Consistent with mildly state-dependent models with linear and flat price-adjustment hazard and sizable monetary non-neutrality

Plan of talk

- Framework
- US supermarket data (IRi) (robust to PPI)
- Price-gap proxy: competitor's-price-gap (robust to competitors'-reset-price and reset-price gaps)
- Aggregate credit shock (robust to monetary policy shock)
- Selection
- Robustness
- Selected literature

Conceptual framework (extending Caballero and Engel, 2007)

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  - Extensive margin: new adjusters; new channel in state dependent

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- Our contribution: generalize Caballero and Engel (2007)
  - Separate extensive margin into two channels
  - Gross extensive margin: shift between price increases vs decreases
  - Selection: large gaps adjust with higher probability, conditional on shock

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  - Separate extensive margin into two channels
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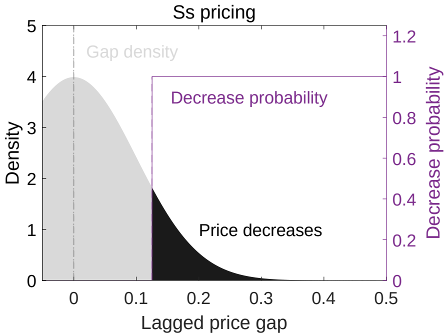
  - Selection: large gaps adjust with higher probability, conditional on shock
- Sufficient to concentrate on the impact effect (dynamics $\sim$ same, Auclert et al., 2022)

Conceptual framework (extending Caballero and Engel, 2007)

- Price adjustment frictions: lumpy price adjustment
- Price gap $x_{it} = p_{it} - p^*_{it}$
  - p_{it} (log) price of product i: adjusts occasionally
  - p^*_{it} (log) optimal price: influenced continuously by both product-level and aggregate factors
- Inflation decomposition

$$\pi = \int -x\Lambda(x)f(x)dx$$

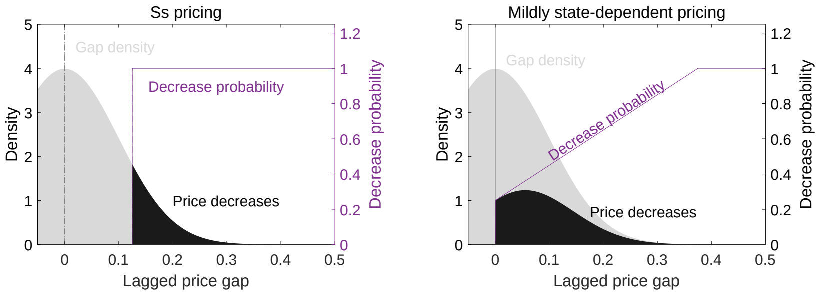
- π: inflation; $f(x)$ density; $\Lambda(x)$ hazard; $-x$: desired change (-gap)



State dependence (extending Caballero and Engel, 2007)

- Concentrate on π^-: inflation from positive gaps (π^+ analogous, $\pi = \pi^- + \pi^+$)
- Focus: shape of the adjustment hazard $\Lambda(x)$.
- Steep hazard: price changes are large unconditionally (state-dependence, not selection)

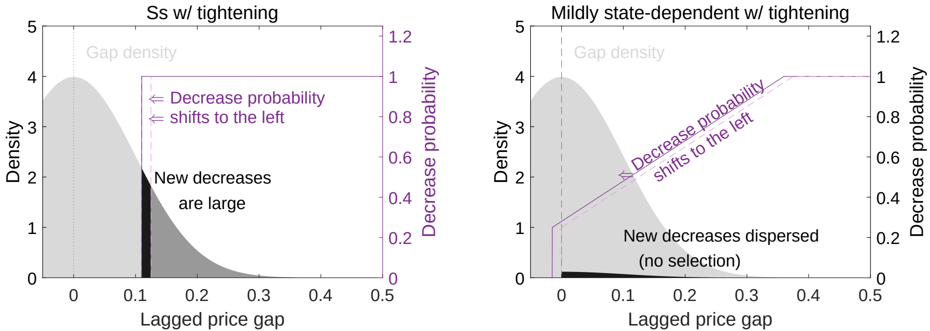
$$\pi^- = \int_{x \geq 0} -x\Lambda(x)f(x)dx = -\bar{x}^-\bar{\Lambda}^- + \underbrace{\text{Cov}\left(-x, \Lambda(x)|x \geq 0\right)}_{\text{state-dependence}},$$



Selection (extending Caballero and Engel, 2007)

- Selection: position of new adjusters conditional on a permanent shock m
- Gross extensive: mass of new adjusters (shift from increases to decreases)

$$\frac{\partial \pi^-}{\partial m} = \underbrace{\bar{\Lambda}^-}_{\text{intensive}} + \overbrace{\underbrace{-\bar{x}^- \, \mathrm{E}\left[\Lambda'(x) | x \geq 0\right]}_{\text{gross extensive}} + \underbrace{\mathrm{Cov}\left(-x, \Lambda'(x) | x \geq 0\right)}_{\text{selection}}}^{\text{extensive}}$$



Conceptual framework (Caballero and Engel, 2007)

- Overview

	Time-dependent	(S,s) & Convex hazard	Linear hazard
Intensive margin	✓	✓	✓
Gross extensive margin	✗	✓	✓
Selection	✗	✓	✗

- Empirical goal
  - Measure the shape of the hazard function and gap density in the data
  - Assess the strength of the margins of adjustment unconditionally
  - Reassess the strength of the margins of adjustment conditional on an aggregate shock

Data

- IRi supermarket scanner data ($\approx$ 15% of CPI)
  - Very granular: 170 000 products
  - Wide coverage: 50 markets across the US, over 3000 stores
  - 12 years of weekly data (2001-2012)
- Suitable dataset
  - Granularity: high-quality information about close substitutes
  - Long time series: can identify aggregate fluctuations

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- Baseline data ▸ Data cleaning ▸ Expenditure weights ▸ Price Indexes
  - Reference prices: filter out temporary discounts ▸ Sales filtering
  - Time-aggregation: monthly mode

Price gap: Empirics

- A relevant component of the gap is observable
  - Distance from the average price of close competitors,
  - Controlling for store fixed effects (regional variation, amenities)
  - Stores wants to avoid price misalignments; higher: low demand; lower: low markup

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- Competitors' reference-price gap

$$x_{pst} = p^f_{pst} - \bar{p}^f_{pt} - \hat{\alpha}_s,$$

where p^f_{pst} is the sales-filtered reference price and $\hat{\alpha}_s$ is the store-FE in $p^f_{pst} - \bar{p}^f_{pt} = \alpha_s$.

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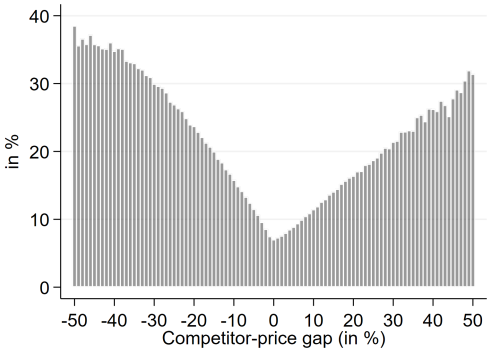
- Control for unobserved heterogeneity Matters
  - Deduct estimated product-store FE
  - Raise all estimates with the average product-store FE

Competitors' price gap, frequency

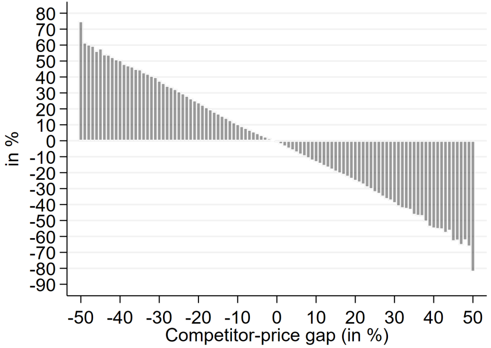
- Adjustment hazard in the data:
  - Increases with distance from 0
  - Approximately (piecewise) linear
  - Positive at 0, mildly asymmetric
- In line with empirical literature

▸ Eichenbaum et al, 2014 ▸ All



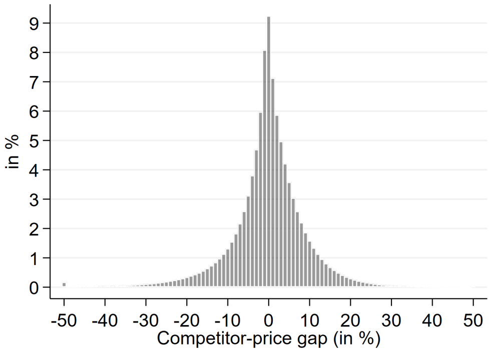
Competitors' price gap, size

- Size
  - Almost (inverse) one-on-one btw gap and size, on average
  - Relevant component of the gap



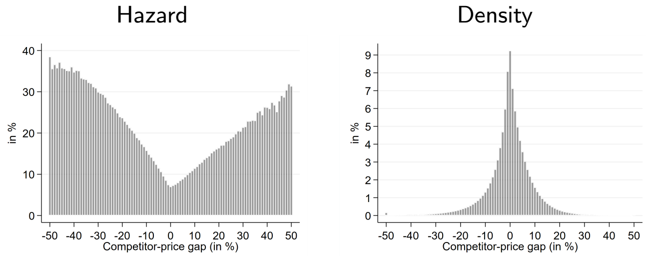
Competitors' price gap, density

- Density:
  - Sizable dispersion, fat tails
  - Despite sales-filtering and store-FE



Unconditional decomposition

- We use empirical hazard and density



- Sufficient for decomposition (if hazard and density are representative)

$$\frac{\partial \pi^-}{\partial m} = \underbrace{\bar{\Lambda}^-}_{\text{intensive}} + \overbrace{\underbrace{-\bar{x}^- \,\mathrm{E}\left[\Lambda'(x) | x \geq 0\right]}_{\text{gross extensive}} + \underbrace{\mathrm{Cov}\left(-x, \Lambda'(x) | x \geq 0\right)}_{\text{selection}}}^{\text{extensive}}$$

Unconditional decomposition, cont

- Relative contributions of channels

Intensive margin	Gross extensive margin	Selection effect
73.4%	26.5%	0.2%

- Result
  - Extensive margin effective
  - Selection miniscule

- Next: reassess the same, conditional on an aggregate shock

Impulse response to a credit shock

- Sizable, exogenous tightening of credit conditions

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- Sizable, exogenous tightening of credit conditions
- Identified with timing restrictions (Gilchrist and Zakrajšek, 2012)
  - Increase in the excess bond premium (default-free corporate spread)
  - No contemporaneous effect on activity, prices and interest rate

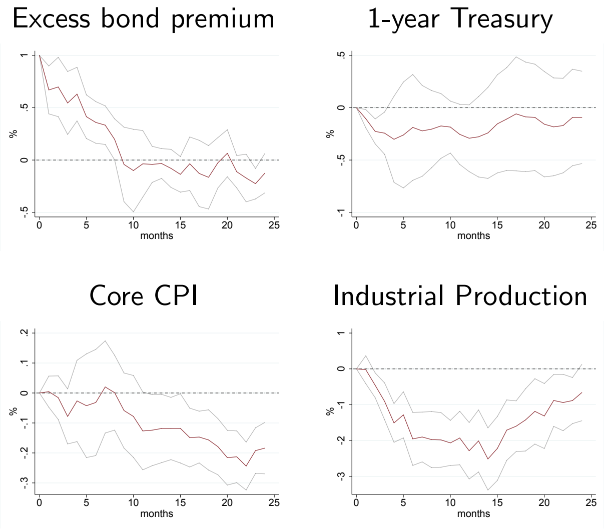
Local projections

- Run a series of OLS regressions h (Jordà, 2005)

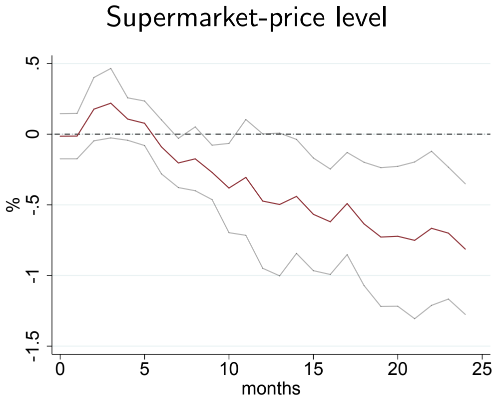
$$x_{t+h} - x_t = \alpha_h + \text{ebp}_t + \mathit{\Gamma}_h \mathit{\Psi}(L) X_t + u_{t,h},$$

  - x: variable of interest, e.g. (log) price level
  - ebp_t: credit shock
  - $\mathit{\Gamma}_h \mathit{\Psi}(L) X_t$: set of controls: contemporaneous cpi, ip, 1y and 1-12m lags of cpi, ip, 1y, ebp
  - Monthly aggregates, seasonally adjusted
  - 95% confidence bands

Credit shock, 2001-2012



Response of the supermarket-price index



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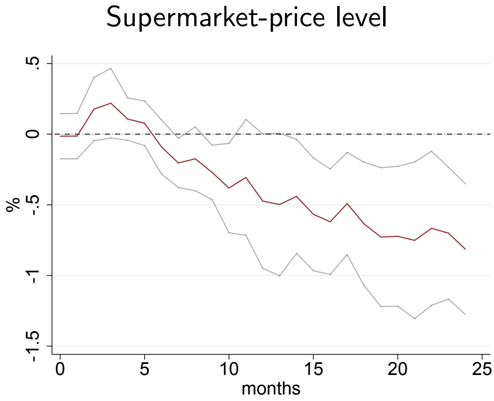

- Gradual response, not unlike core CPI
- Peak effect not before 24 months

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- Approach: Selection is an interaction between
  - Aggregate shock and
  - Product-level proxy.
- Framework: Linear probability model of price adjustment
  - Does the interaction term influences adjustment probability?

Linear probability model

$$I^{\pm}_{pst,t+h} = \beta^{\pm}_{xih} x_{pst-1} \hat{\text{ebp}}_t + \beta^{\pm}_{xh} x_{pst-1} + \beta^{\pm}_{ih} \text{ebp}_t + \gamma^{\pm}_{h} T_{pst-1} + \Gamma^{\pm}_{h} \Phi(L) X_t + \alpha^{\pm}_{psh} + \alpha^{\pm}_{mh} + \varepsilon^{\pm}_{psth},$$

- $I^{\pm}_{pst,t+h}$ indicator of price increase (resp. decrease) of product p in store s between t and $t+h$
- x_{pst-1}: price gap (to control for its regular effect)
- ebp_t is the aggregate shock (to control for its average effect)
- $x_{pst-1}\text{ebp}_t$ gap-shock interaction (selection: focus of analysis)

Linear probability model, cont.

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- T_{pst} (log) age of price (to control for time dependence)
- $\Gamma^{\pm}_h \Phi(L) X_t$ aggregate controls
- $\alpha \pm_{psh}$ product-store FE (to control for unexplained cross-sectional heterogeneity)
- $\alpha^{\pm}_{mh}$ are calendar-month FE (to control for seasonality)
- Standard errors are clustered across categories and time

Results, competitors' price gap, credit shock, h=24m

	(1) Price increase $\left(I^{+}_{pst,t+24}\right)$	(2) Price decrease $\left(I^{-}_{pst,t+24}\right)$
Gap (x_{pst-1})	-1.75^{***}	1.55^{***}
Shock (ebp_t)	-0.03^{***}	0.03^{***}
Selection ($x_{pst-1}\hat{\text{ebp}}_t$)	-0.00	0.01
Age (T_{pst-1})	0.02^{***}	0.00^{**}
Product x store FE	✓	✓
Calendar-month FE	✓	✓
Time FE	✗	✗
N	$16.1M$	$16.1M$
within R^2	18.5%	17.3%

Implications

- State dependence: Gap raises frequency Spec.
  - Probability of price increase 26 pp. lower btw 1st and 3rd quartile (decrease 23 pp higher)

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  - Probability of price increase 26 pp. lower btw 1st and 3rd quartile (decrease 23 pp higher)
- Adjustment on the (gross) extensive margin: aggregate shock shifts the probability of price increases vs price decreases
  - Probability of price increase 1pp lower after a 1sd credit tightening (30 bps)
  - Probability of price decrease 1pp higher after a similar tightening

Implications, cont.

- No selection: Specification
  - No evidence of significant interaction
  - Conditional on the shock, not adjusting the prices with larger gap

Implications, cont.

- No selection: Specification
  - No evidence of significant interaction
  - Conditional on the shock, not adjusting the prices with larger gap
- Time dependence
  - Older prices are changed with higher probability

Margins of adjustment

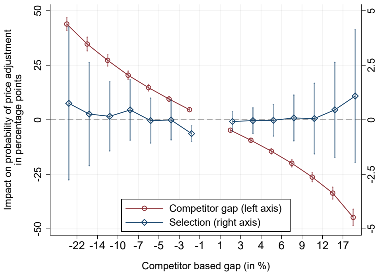
	Data	Time-dependent	(S,s) & Convex hazard	Linear hazard
Intensive margin	✓	✓	✓	✓
Gross extensive margin	✓	✗	✓	✓
Selection	✗	✗	✓	✗

- Evidence consistent with linear hazard models with no selection
- Inconsistent with time-dependent (constant hazard) models (Calvo, 1983)
- Inconsistent with (S,s) and convex hazard models (Golosov and Lucas, 2007)

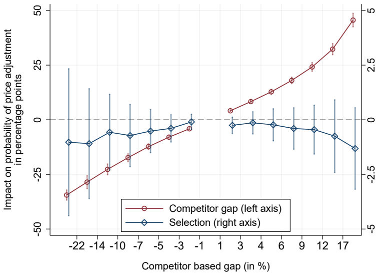
Robustness

- Relax linearity restriction: 15 gap groups, regressions with group dummies

Price increases



Price decreases



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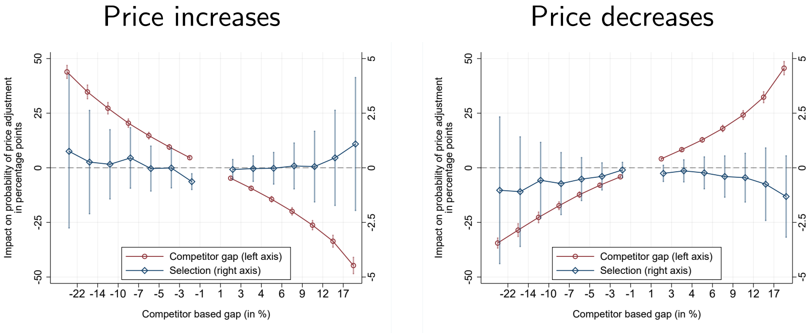

- Robustness to non-linearity, alternative gap, shock, data

Probit | Heterogeneity across product categories | Competitors' reset-price gap | PPI dataset | Monetary policy shock | No FE | Posted prices | 2001-2007

Selected literature

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- Us: Empirical question

Selected literature, cont.

- Implicit hazard-function (Caballero and Engel, 2007; Alvarez et al., 2022)
  - Estimate density and hazard function by matching moments
  - Quadratic hazard function (result in Alvarez et al., 2022)
  - Sizable selection (Berger and Vavra, 2018; Petrella, Santoro and Simonsen, 2019)
  - Weak selection (Luo and Villar, 2021; Alvarez et al., 2022)

Selected literature, cont.

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  - Weak selection (Luo and Villar, 2021; Alvarez et al., 2022)
- Explicit hazard function
  - Relative to competitors' prices (Campbell and Eden, 2014; Gagnon, López-Salido and Vincent, 2012): ∼linear, flat, no selection
  - Relative to wholesale prices/cost (Eichenbaum et al., 2011; Gautier et al., 2022): ∼linear, steeper, no selection
  - Us: competitors' prices, multiple retailers, control for heterogeneity

Selected literature, cont.

- Construct informative moments that reveals selection
  - Carvalho and Kryvtsov (2021): preset-price-relative vs. inflation
  - Dedola et al. (2019): selection bias in Danish PPI
  - Us: shock-gap interaction on frequency

Conclusion

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- We have found that
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Conclusion

- Use granular supermarket and PPI data to measure selection
- We have found that
  1. State dependence: Adjustment probability increases linearly with gap
  2. No selection: Conditional on shock adjustment independent of price gap
  3. Gross extensive margin: key adjustment channel
- Consistent with linear-hazard state-dependent models

Conclusion, cont.

- Implications
  - Evidence inconsistent with standard time-dependent (Calvo, 1983) or state-dependent (Golosov and Lucas, 2007) models
  - Shift between increases versus decreases determines the extensive-margin effect Data
  - Slope of the hazard function is informative about the strength of this shift
  - Flat hazard implies sizable monetary non-neutrality

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IRi: data cleaning

- Posted prices:

$$P_{psw} = \frac{TR_{psw}}{Q_{psw}},$$

  - TR is the total revenue
  - Q is the quantity sold for each product
  - p in store s in week w

Back

IRi: data cleaning

- Posted prices:

$$P_{psw} = \frac{TR_{psw}}{Q_{psw}},$$

  - TR is the total revenue
  - Q is the quantity sold for each product
  - p in store s in week w

- Cleaning
  - Round to the nearest penny (8.7%)
  - Private label products: new products at relabeling
  - Drop products that are not available the whole year

Back

IRi: sales-filtering

- Sales: high-frequency noise (Anderson et al., 2017)

Back

IRi: sales-filtering

- Sales: high-frequency noise (Anderson et al., 2017)
- Modal-price filter of **?**

Back

IRi: sales-filtering

- Sales: high-frequency noise (Anderson et al., 2017)
- Modal-price filter of **?**
- Reference prices P^f_{psw} on weekly data
  - 13-week two-sided modal price
  - Iterative updating to align the change of P^f_{psw} with P_{psw}
  - Reference price changes less than a third of posted price changes

Back

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- Results are robust to using posted prices

Back

IRi: sales-filtering

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  - Iterative updating to align the change of P^f_{psw} with P_{psw}
  - Reference price changes less than a third of posted price changes
- Results are robust to using posted prices
- Monthly prices P_{pst}: mode of weekly prices

Back

IRi: Expenditure weights

- Fixed-weight index (as CPI). Annual weights $t \in y$

$$\omega_{psy} = \frac{TR_{psy}}{\sum_p \sum_s TR_{psy}}$$

Back

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Back

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$$\omega_{psy} = \frac{TR_{psy}}{\sum_p \sum_s TR_{psy}}$$

- Posted and reference-price inflation ($i = p, f$)

$$\pi_t^i = \sum_s \sum_p \omega_{pst} \left(p_{pst}^i - p_{pst-1}^i \right)$$

Back

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Back

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- Sales-price inflation

$$\pi_t^s = \pi_t^p - \pi_t^f$$

- Seasonal adjustment using monthly dummies

Back

Specification, cont.

- Focus: aggregate shock – price-gap interaction term

Back

Specification, cont.

- Focus: aggregate shock – price-gap interaction term
- Price increases I^{+}_{pst}: expected sign is positive
  - Driven by products with negative gap ($x_{pst-1} \leq 0$)
  - Credit tightening ($\hat{\text{ebp}}_t \geq 0$): less price increases
  - Credit easing ($\hat{\text{ebp}}_t < 0$): more price increases

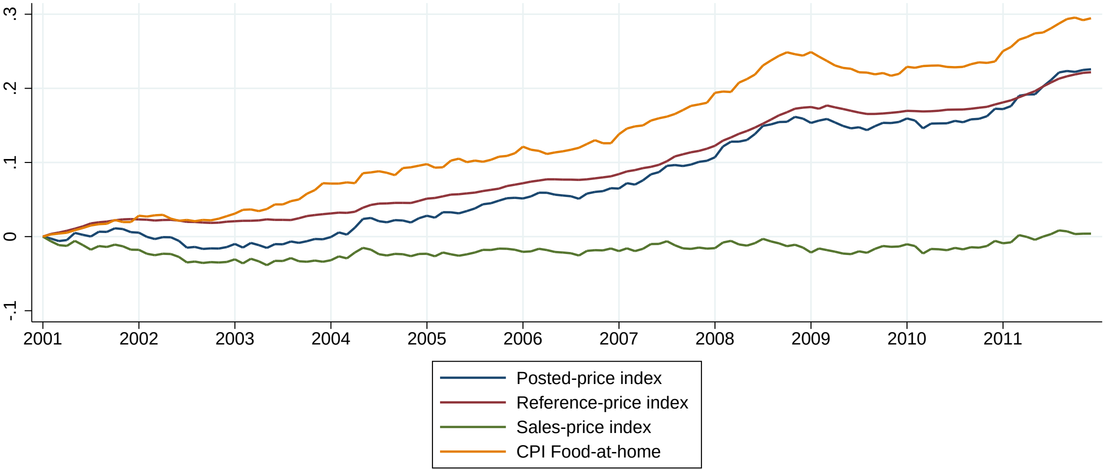
Back

Specification, cont.

- Focus: aggregate shock – price-gap interaction term
- Price increases I^{+}_{pst}: expected sign is positive
  - Driven by products with negative gap ($x_{pst-1} \leq 0$)
  - Credit tightening ($\hat{\text{ebp}}_t \geq 0$): less price increases
  - Credit easing ($\hat{\text{ebp}}_t < 0$): more price increases
- Price decreases I^{-}_{pst}: expected sign is positive
  - Driven by products with positive gap ($x_{pst-1} \geq 0$)
  - Credit tightening ($\hat{\text{ebp}}_t \geq 0$): more price decreases
  - Credit easing ($\hat{\text{ebp}}_t < 0$): less price decreases

Back

Posted, reference and sales-price indices



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IRi supermarket index

- Similar business-cycle fluctuations as CPI food-at-home

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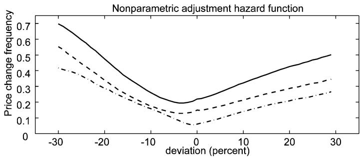
IRi supermarket index

- Similar business-cycle fluctuations as CPI food-at-home
- Trend inflation lower than CPI food-at-home
  - Main reason: new products
  - Higher-quality - higher-price than existing products
  - CPI takes this into account - we only use surviving products

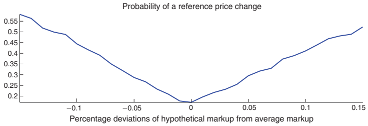
Back

Estimated empirical hazards

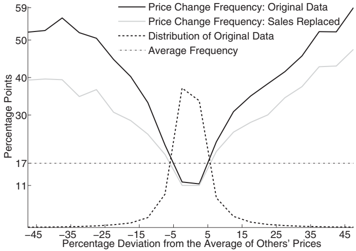
Gagnon et al. (2012)



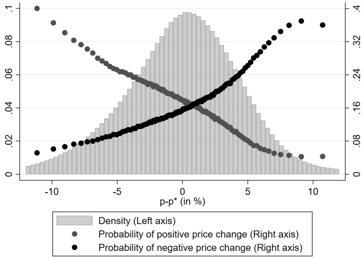
Eichenbaum et al. (2011)



Campbell and Eden (2014)



Gautier et al. (2022)



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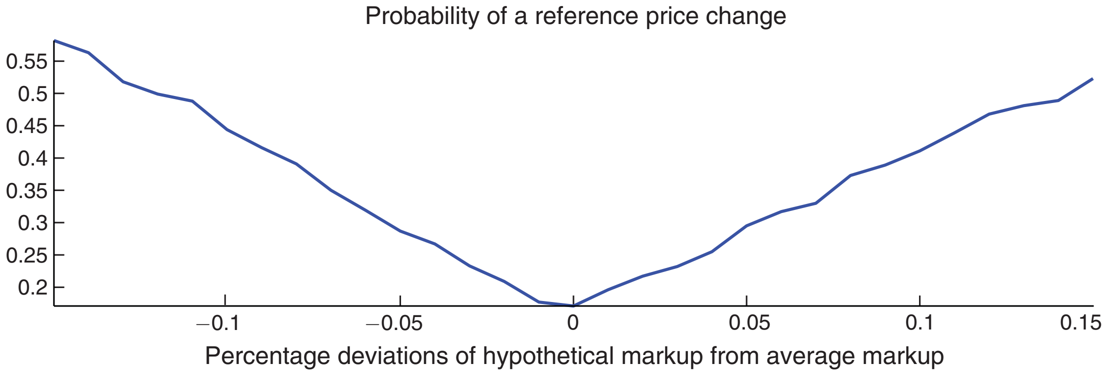
Estimated empirical hazard: Eichenbaum et al. (2011)



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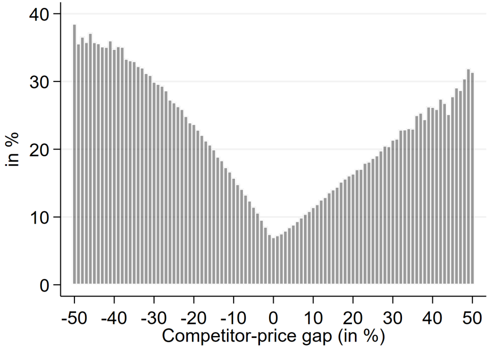
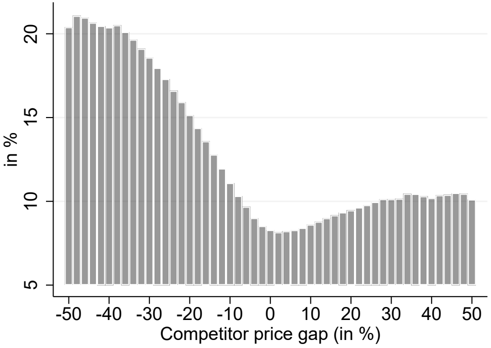
Competitors' price gap, frequency, with and without heterogeneity

W/o heterogeneity



Pooled



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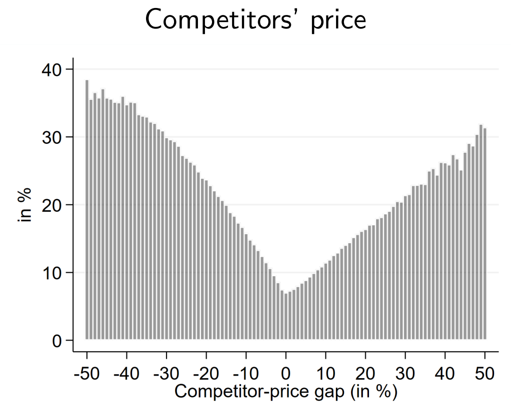
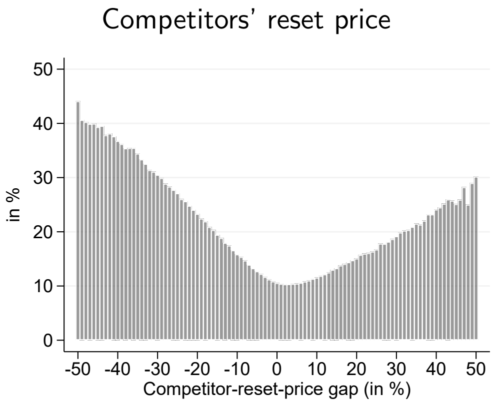
Competitors' price gap vs. competitors' reset-price gap, frequency





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Specification, cont.

- Additional interest

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Specification, cont.

- Additional interest
- Impact of the price gap β_{xh}: expected sign: negative for I^{+}_{pst} (positive for I^{-}_{pst})
  - More negative gap: more price increases
  - (More positive gap: more price decreases)

Back

Specification, cont.

- Additional interest
- Impact of the price gap β_{xh}: expected sign: negative for I^{+}_{pst} (positive for I^{-}_{pst})
  - More negative gap: more price increases
  - (More positive gap: more price decreases)
- Impact of aggregate shock β_{ih}: expected sign: negative for I^{+}_{pst} (positive for I^{-}_{pst})
  - Credit tightening ($\hat{\text{ebp}}_t > 0$) less increases, more decreases
  - Credit easing ($\hat{\text{ebp}}_t < 0$) more increases, less decreases

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Specification, cont.

- 2 additional specifications for robustness

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Specification, cont.

- 2 additional specifications for robustness
- Time-fixed effects (drop the direct impact of shock)

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Specification, cont.

- 2 additional specifications for robustness
- Time-fixed effects (drop the direct impact of shock)
- Separate coefficients for positive and negative gaps

Back

Results, competitors' price gap, credit shock, h=24m

	(1)	(2)	(3)	(4)	(5)	(6)
	Price increase $\left(I^{+}_{pst,t+24}\right)$			Price decrease $\left(I^{-}_{pst,t+24}\right)$		
Gap (x_{pst-1})	-1.75^{***}	-1.75^{***}		1.55^{***}	1.55^{***}	
Shock (ebp_t)	-0.03^{***}			0.03^{***}		
Selection ($x_{pst-1}\hat{\text{ebp}}_t$)	-0.00	-0.00		0.01	0.01	
Age (T_{pst-1})	0.02^{***}	0.02^{***}		0.00^{**}	0.01^{***}	
Pos. gap (x^{+}_{pst-1})						
Neg. gap (x^{-}_{pst-1})						
Pos. sel. ($x^{+}_{pst-1}\hat{\text{ebp}}$)						
Neg. sel. ($x^{-}_{pst-1}\hat{\text{ebp}}$)						
Product x store FE	✓	✓		✓	✓	
Calendar-month FE	✓	✗		✓	✗	
Time FE	✗	✓		✗	✓	
N	$16.1M$	$16.1M$		$16.1M$	$16.1M$	
within R^2	18.5%	16.6%		17.3%	16.4%	

Back

Results, competitors' price gap, credit shock, h=24m

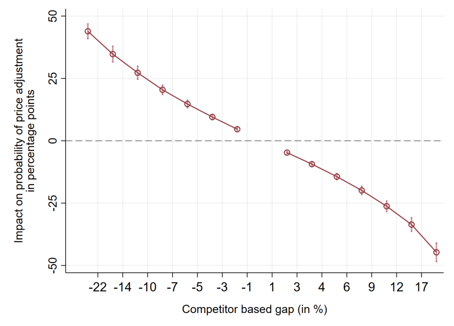
	(1)	(2)	(3)	(4)	(5)	(6)
	Price increase $\left(I^{+}_{pst,t+24}\right)$			Price decrease $\left(I^{-}_{pst,t+24}\right)$		
Gap (x_{pst-1})	-1.75^{***}	-1.75^{***}		1.55^{***}	1.55^{***}	
Shock (ebp_t)	-0.03^{***}		-0.04^{***}	0.03^{***}		0.03^{***}
Selection ($x_{pst-1}\hat{\text{ebp}}_t$)	-0.00	-0.00		0.01	0.01	
Age (T_{pst-1})	0.02^{***}	0.02^{***}	0.02^{***}	0.00^{**}	0.01^{***}	0.01^{***}
Pos. gap (x^{+}_{pst-1})			-2.26^{***}			2.29^{***}
Neg. gap (x^{-}_{pst-1})			-1.44^{***}			1.10^{***}
Pos. sel. ($x^{+}_{pst-1}\hat{\text{ebp}}$)			0.04			-0.04
Neg. sel. ($x^{-}_{pst-1}\hat{\text{ebp}}$)			-0.03			0.04
Product x store FE	✓	✓	✓	✓	✓	✓
Calendar-month FE	✓	✗	✓	✓	✗	✓
Time FE	✗	✓	✗	✗	✓	✗
N	$16.1M$	$16.1M$	$16.1M$	$16.1M$	$16.1M$	$16.1M$
within R^2	18.5%	16.6%	18.9%	17.3%	16.4%	18.2%

Back

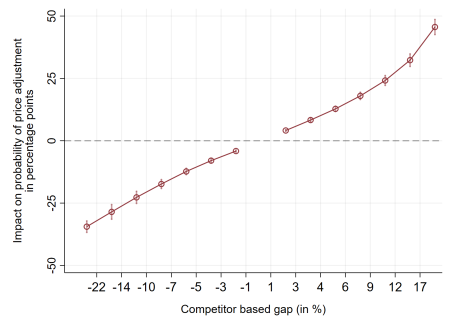
Gap group-dummies, within product-store, 24m

- Hazard close to linear and quite symmetric
  - Heterogeneity is controlled for (item, time FEs)
  - Predicted frequency in 24 months

Price increases



Price decreases



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Average moments

Annualized inflation		Frequency	
Posted	Reference	Posted	Reference
1.84 %	1.75%	36.2%	10.8%

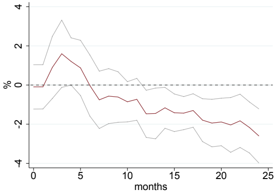
Reference frequency		Reference size	
Increase	Decrease	Increase	Decrease
6.6%	4.2%	12.5%	-15.1%

Back

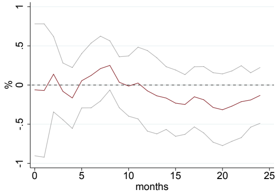
Data: response from shift from increases to decreases

Expressions

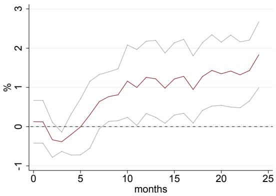
Frequency (increases)



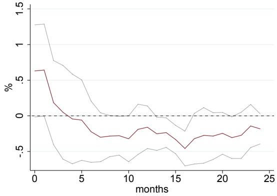
Size (increases)



Frequency (decreases)



Size (decreases)



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Gross extensive margin

- Micro-data: how do standard moments adjust to aggregate shocks Average moments

Back

Gross extensive margin

- Micro-data: how do standard moments adjust to aggregate shocks Average moments

- Frequency:

$$\xi^{\pm}_{t,t+h} = \sum_i \bar{\omega}_{it,t+h} I^{\pm}_{it,t+h},$$

Back

Gross extensive margin

- Micro-data: how do standard moments adjust to aggregate shocks ▸ Average moments
- Frequency:

$$\xi^{\pm}_{t,t+h} = \sum_i \bar{\omega}_{it,t+h} I^{\pm}_{it,t+h},$$

- Size

$$\psi^{\pm}_{t,t+h} = \frac{\sum_i \bar{\omega}_{it,t+h} I^{\pm}_{it,t+h} (p_{it+h} - p_{it-1})}{\xi^{\pm}_{t,t+h}}.$$

◂ Back

Gross extensive margin

- Micro-data: how do standard moments adjust to aggregate shocks ▸ Average moments
- Frequency:

$$\xi^{\pm}_{t,t+h} = \sum_i \bar{\omega}_{it,t+h} I^{\pm}_{it,t+h},$$

- Size

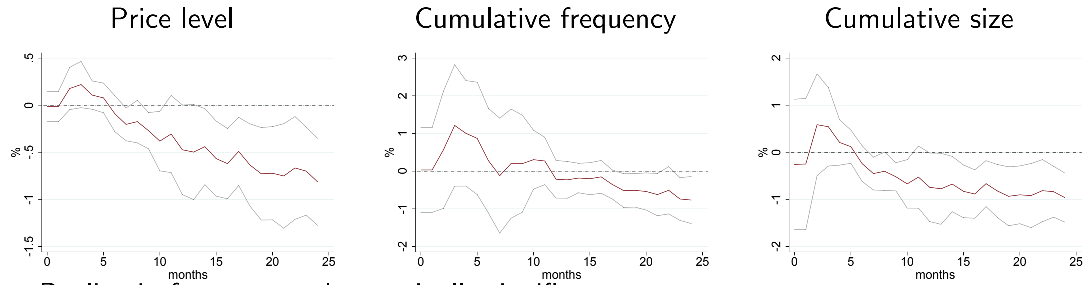
$$\psi^{\pm}_{t,t+h} = \frac{\sum_i \bar{\omega}_{it,t+h} I^{\pm}_{it,t+h}(p_{it+h} - p_{it-1})}{\xi^{\pm}_{t,t+h}}.$$

- Decomposition

$$p_{t+h} - p_{t-1} = \pi_{t,t+h} = \xi^{+}_{t,t+h}\psi^{+}_{t,t+h} + \xi^{-}_{t,t+h}\psi^{-}_{t,t+h},$$

◂ Back

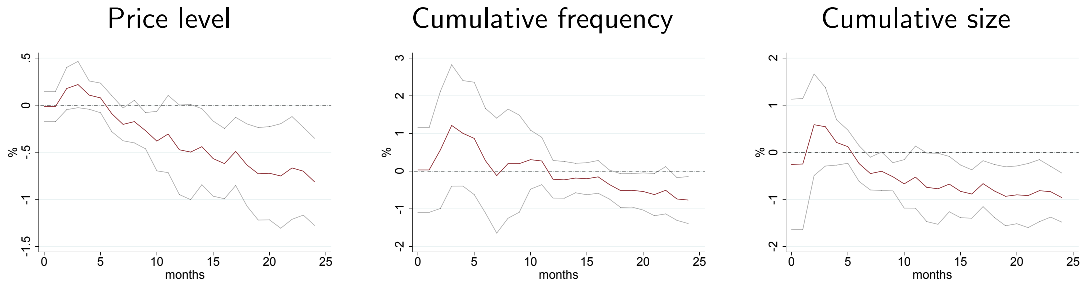
Price changes



- Decline in frequency only marginally significant

Back

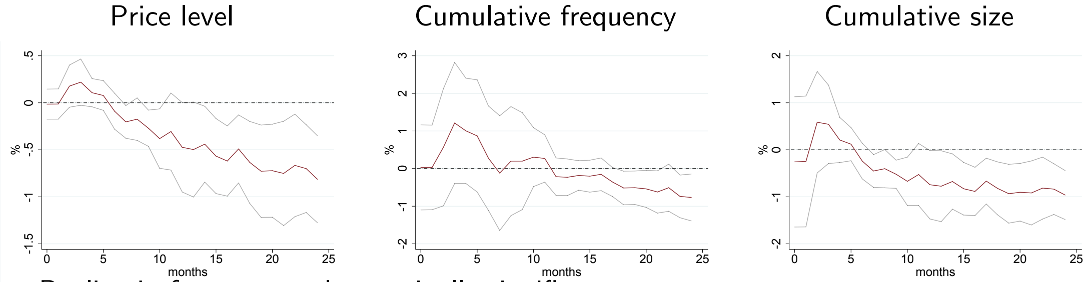
Price changes



- Decline in frequency only marginally significant
- Average size declines

Back

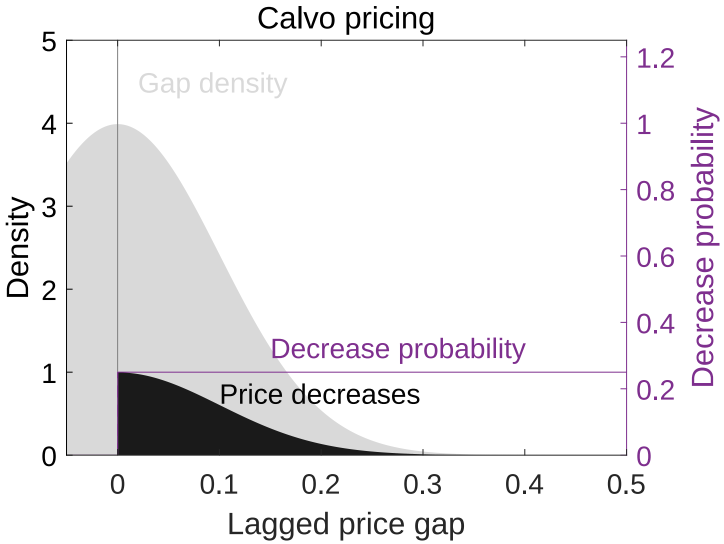
Price changes



- Decline in frequency only marginally significant
- Average size declines
- In line with both time-dependent (Calvo, 1983) and state-dependent (Golosov and Lucas, 2007) models

Back

Time-dependent model (Calvo, 1983)



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Nonlinearity II: Probit

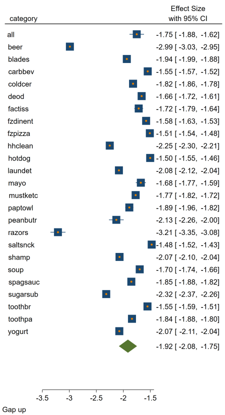
	(1)	(2)	(3)
	Multinomial probit		Ordered probit
	Incr. $\left(I^{+}_{pst,t+24}\right)$	Decr. $\left(I^{-}_{pst,t+24}\right)$	Change $(I_{pst,t+24})$
Gap (x_{pst-1})	-3.15^{***}	3.37^{***}	-4.24^{***}
Shock (ebp_t)	-0.11^{***}	0.05^{***}	-0.10^{***}
Selection $(x_{pst-1}\hat{\text{ebp}}_t)$	-0.05	-0.21^{**}	0.04
Age (T_{pst-1})	0.01^{*}	-0.03^{***}	0.02^{***}
Freq. incr. (ξ^{+}_{psM})	5.17^{***}	2.91^{***}	1.79^{***}
Freq. decr. (ξ^{-}_{psM})	3.02^{***}	5.84^{***}	-1.33^{***}
Product x store FE	✗	✗	✗
Calendar-month FE	✓	✓	✓
Time FE	✗	✗	✗
N	$16.1M$	$16.1M$	$14.3M$

Back

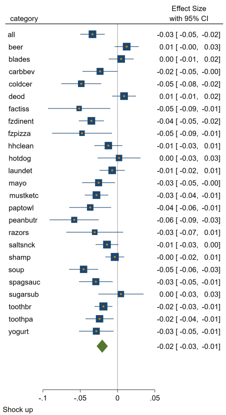
Heterogeneity across product categories

- Heterogeneous demand elasticities might bias our baseline

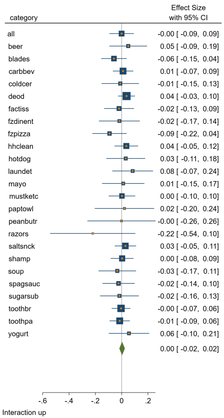
Gap



Shock



Selection



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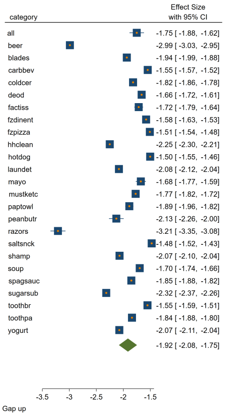
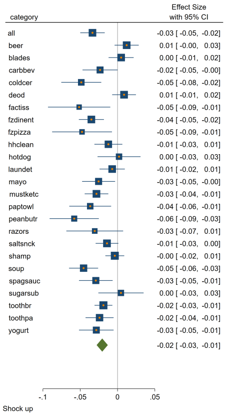
Heterogeneity across product categories

- Heterogeneous demand elasticities might bias our baseline
- Separate estimates across product categories: price increases

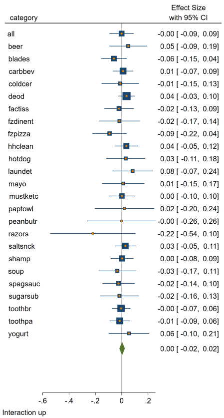
Gap



Shock



Selection



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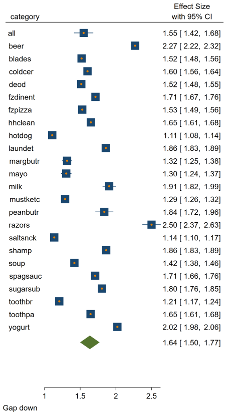
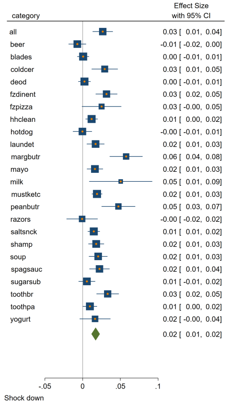
Heterogeneity across product categories, cont.

- Separate estimates across product categories: price decreases

Gap



Shock



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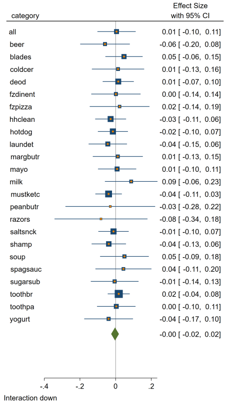

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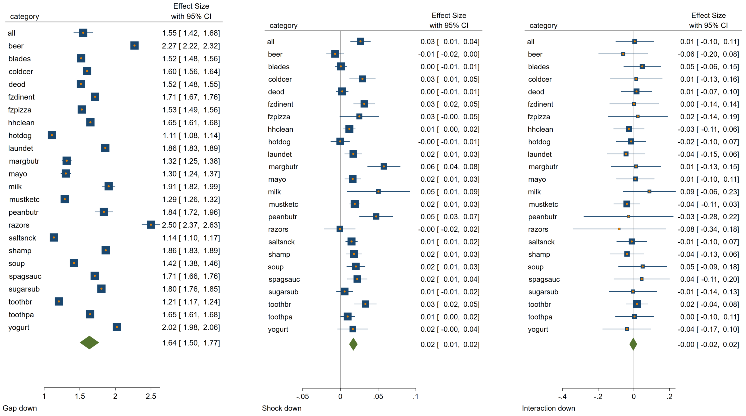
Heterogeneity across product categories, cont.

- Separate estimates across product categories: price decreases

Gap Shock Selection



- Robust results

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Competitors' reset-price gap

- Alternative price-gap proxy

Back

Competitors' reset-price gap

- Alternative price-gap proxy
- For the optimal price, only use those competitors' prices that changed in t

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Competitors' reset-price gap

- Alternative price-gap proxy
- For the optimal price, only use those competitors' prices that changed in t
- Formally: Reference price-reset gap (x^r_{pst})

$$x^r_{pst} = p^f_{pst} - \overline{p}^{fr}_{pt} - \alpha_{sc}$$

  - p^f_{pst}: reference price
  - $\overline{p}^{fr}_{pt}$ average ref. price of changers
  - α_{sc} store and category fixed effect

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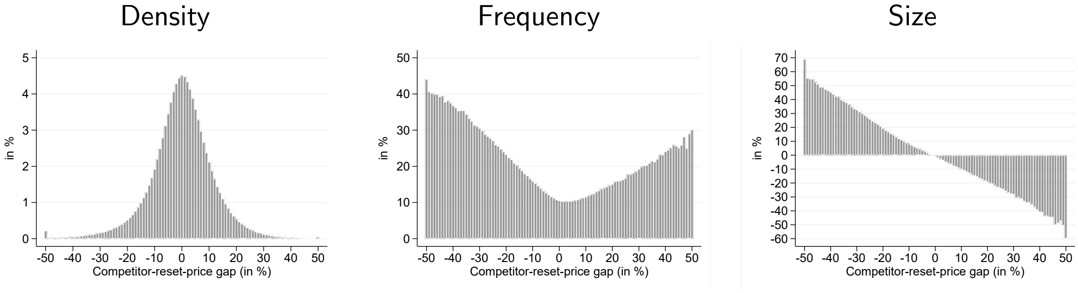
Competitors' reset price gap



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Results, competitors' reset-price gap, credit shock, h=24m

	(1)	(2)	(3)	(4)
	Increases $\left(I^{+}_{pst,t+24}\right)$		Decreases $\left(I^{-}_{pst,t+24}\right)$	
	Baseline	Competitor-reset-gap	Baseline	Competitor-reset-gap
Gap (x_{pst-1})	−1.75***	−1.29***	1.55***	1.19***
	(0.06)	(0.04)	(0.06)	(0.06)
Shock (ebp_t)	−0.03***	−0.05***	0.03***	0.04***
	(0.01)	(0.01)	(0.01)	(0.01)
Selection ($x_{pst-1}\widehat{\text{ebp}_t}$)	−0.00	−0.01	0.01	0.00
	(0.04)	(0.05)	(0.05)	(0.06)
Age (T_{pst-1})	0.02***	0.02***	0.00**	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Product x store FE	✓	✓	✓	✓
Calendar-month FE	✓	✓	✓	✓
Time FE	✗	✗	✗	✗
N	16.1M	9.3M	16.1M	9.3M
Within R^2	18.5%	15.2%	17.3%	14.5%

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PPI microdata

- Coverage
  - 1981-2012 monthly data
  - Representative of the US economy

Back

PPI microdata

- Coverage
  - 1981-2012 monthly data
  - Representative of the US economy
- No sales filtering

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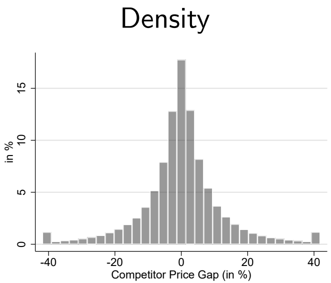
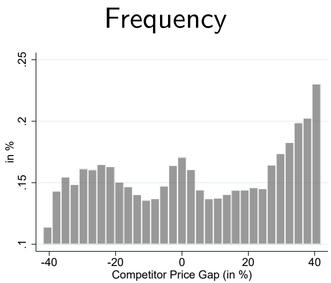
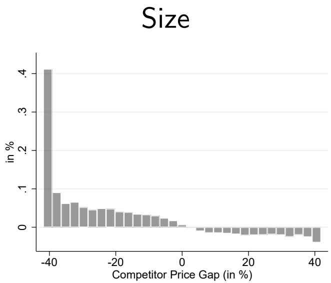
Competitors' price gap







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PPI: gaps

- Size: clear negative relationship with the gaps

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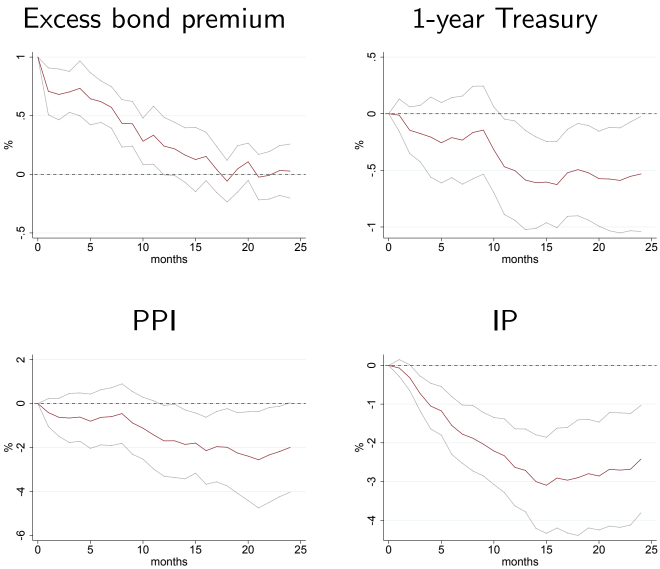
PPI: gaps

- Size: clear negative relationship with the gaps
- Frequency:
  - Increases with competitors' gap eventually
  - Initially decreases with higher gap

Credit shock



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Results, competitors' price gap, credit shock, h=24m, PPI

	(1)	(2)	(3)	(4)
	Increases $\left(I^{+}_{pst,t+24}\right)$		Decreases $\left(I^{-}_{pst,t+24}\right)$	
Gap (x_{pst-1})	-0.23^{***}	-0.23^{***}	0.22^{***}	0.22^{***}
Shock (ebp_t)	-0.023^{***}		0.021^{***}	
Selection ($x_{pst-1}\hat{\text{ebp}}_t$)	0.00	-0.00	-0.00	-0.00
Age (T_{pst-1})	0.035^{***}	0.035^{***}	0.01^{***}	0.01^{***}
Product x store FE	✓	✓	✓	✓
Calendar-month FE	✓	✗	✓	✗
Time FE	✗	✓	✗	✓
N	$9.7M$	$9.7M$	$9.7M$	$9.7M$
Within R^2	4.4%	3.5%	4.3%	3.7%

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PPI: selection

- Results are robust using longer and wider-coverage data

Back

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- Gap: significant unconditional impact on frequency

Back

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- Aggregate shock: shifts the probability of adjustment

Back

PPI: selection

- Results are robust using longer and wider-coverage data
- Gap: significant unconditional impact on frequency
- Aggregate shock: shifts the probability of adjustment
- No selection:
  - No evidence of interaction:
  - Conditional on the shock, not adjusting prices with larger gap

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Impulse responses to monetary policy shocks

- High-frequency identification of monetary policy shocks (Gertler and Karadi, 2015; Nakamura and Steinsson, 2018)
  - Intra-day financial market surprises around press statements
  - Control for information shocks using the co-movement of interest rates and stock prices (Jarociński and Karadi, 2020)

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Impulse responses to monetary policy shocks

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  - Control for information shocks using the co-movement of interest rates and stock prices (Jarociński and Karadi, 2020)
- Calculate relevant price-setting moments
- Estimate impulse responses using local projections (Jordà, 2005)

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High-frequency identification of monetary policy shocks

- Central bank announcements generate unexpected variation in interest rates: can be used to assess monetary non-neutrality.

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- Surprises
  - Measure change in interest rates in a 30-minute window around policy announcements
  - Only central bank announcements systematically impacts surprises

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High-frequency identification of monetary policy shocks

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- Surprises
  - Measure change in interest rates in a 30-minute window around policy announcements
  - Only central bank announcements systematically impacts surprises
- FOMC press statements (8 times a year)

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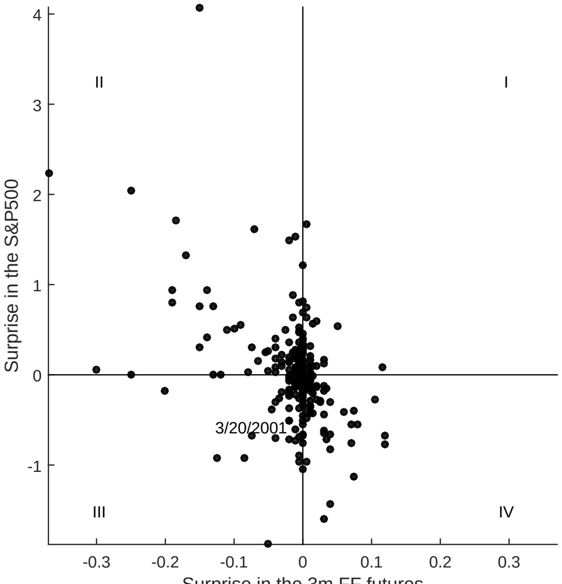
High-frequency surprises



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Interest rate

- Preferred interest rate: 3-months federal funds futures rate
    - Closely controlled by the FOMC
    - Incorporates next FOMC meeting: with near-term forward guidance
    - Does not affected by ‘timing’ surprises
    - It stays active after ZLB is reached

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Controlling for central bank information shocks

- Issue: announcements can reveal information
  - not just about policy,
  - but also about the central bank's economic outlook.

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Controlling for central bank information shocks

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- Use responses in stock markets (Jarociński and Karadi, 2020) Scatter
  - Negative co-movement in interest rates and stock prices: monetary policy shocks
  - Positive co-movement: central bank information shocks

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Controlling for central bank information shocks

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- Use responses in stock markets (Jarociński and Karadi, 2020) Scatter
  - Negative co-movement in interest rates and stock prices: monetary policy shocks
  - Positive co-movement: central bank information shocks
- 'Poor man's sign restriction': use events when the co-movement was negative

Back

Local projections

- Run a series of OLS regressions h (Jordà, 2005)

$$x_{t+h} - x_t = \alpha_h + \beta_h \Delta i_t + \Gamma_h \Psi(L) X_t + u_{t,h},$$

  - x: variable of interest, e.g. (log) price level
  - Δi_t: high-frequency monetary policy shock
  - $\Gamma_h \Psi(L) X_t$: set of controls: various lags of cpi, ip, de1y

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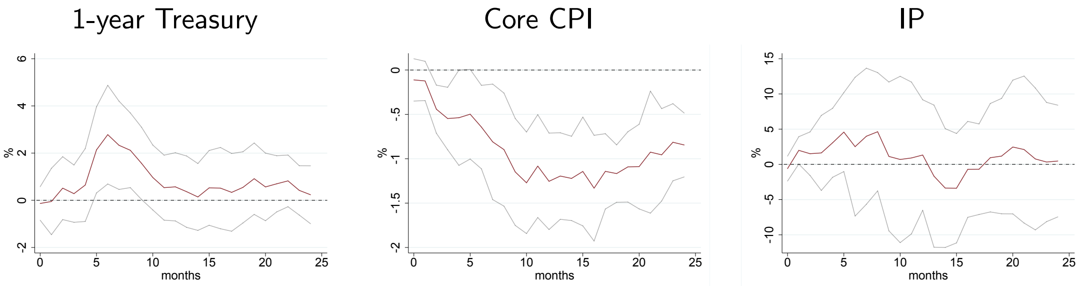
Impulse responses of key macroeconomic variables to a monetary policy tightening



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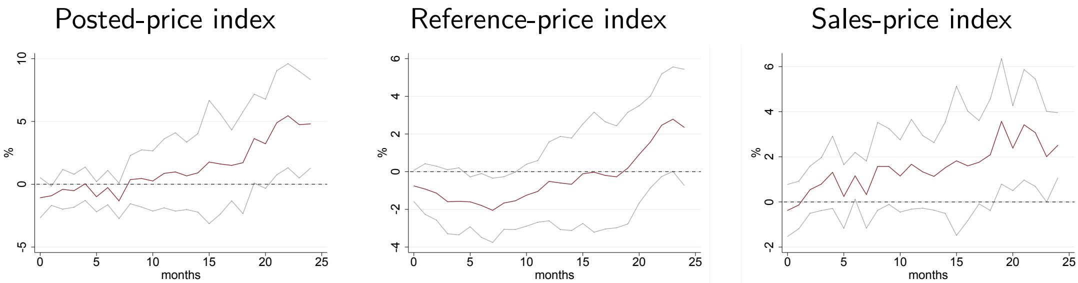
Impulse responses of key macroeconomic variables to a monetary policy tightening



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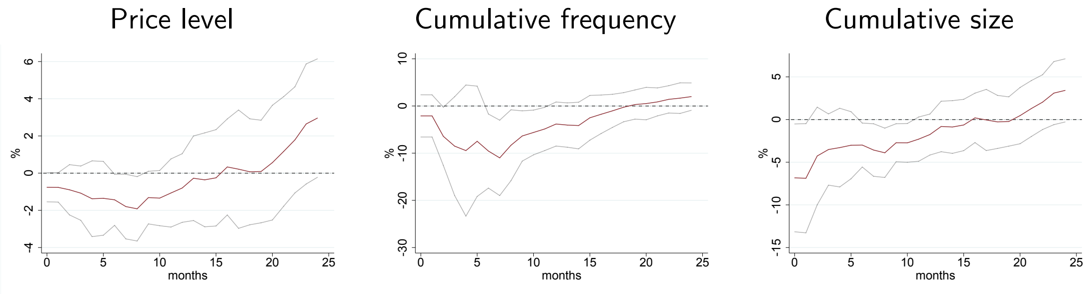
Price changes



- Aggregate frequency drops

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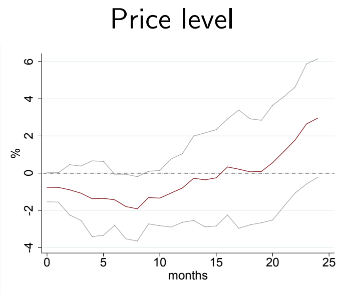
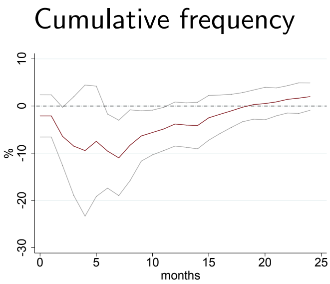
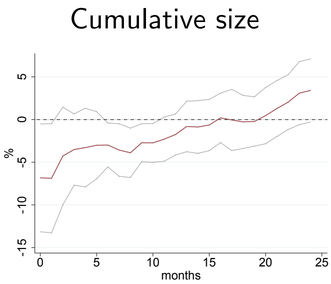
Price changes







- Aggregate frequency drops
- Size declines

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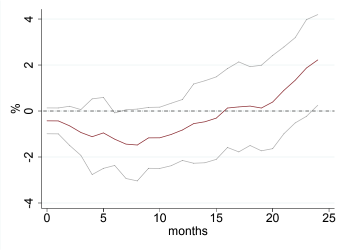
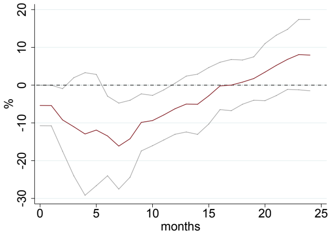
Less increases more decreases

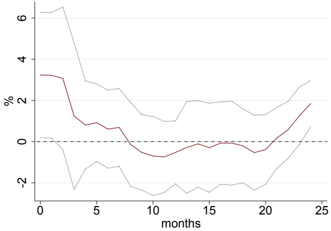
Price increase



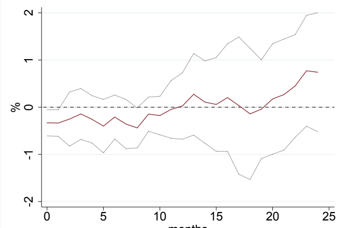
Cumulative frequency



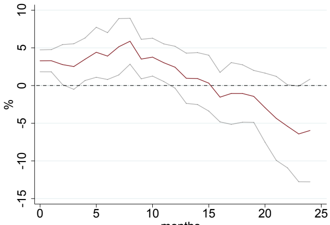
Cumulative size



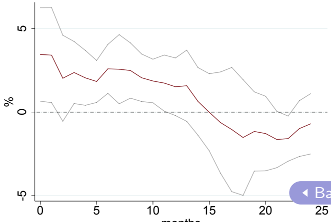
Price decrease



Cumulative frequency



Cumulative size



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Results, competitors' price gap, MP shock, h=12m

	(1)	(2)	(3)	(4)	(5)	(6)
	Price increases $\left(I^{+}_{pst,t+12}\right)$			Price decreases $\left(I^{-}_{pst,t+12}\right)$		
Gap (x_{pst-1})	-1.71^{***}	-1.71^{***}		1.36^{***}	1.36^{***}	
Shock (Δi_t)	-0.03^{*}		-0.03	0.01^{*}		0.01^{*}
Selection ($x_{pst-1}\Delta i_t$)	-0.07	-0.07		0.07	0.07	
Age (T_{pst-1})	0.03^{***}	0.03^{***}	0.03^{***}	0.01^{***}	0.01^{***}	0.01^{***}
Positive gap (x^{+}_{pst-1})			-1.92^{***}			1.93^{***}
Negative gap (x^{-}_{pst-1})			-1.58^{***}			1.01^{***}
Pos. selection ($x^{+}_{pst-1}\Delta i_t$)			-0.05			0.05
Neg. selection ($x^{-}_{pst-1}\Delta i_t$)			-0.08			0.08
Product x store FE	✓	✓	✓	✓	✓	✓
Calendar-month FE	✓	✗	✓	✓	✗	✓
Time FE	✗	✓	✗	✗	✓	✗
N	$23.7M$	$23.7M$	$23.7M$	$23.7M$	$23.7M$	$23.7M$
Within R^2	16.4%	14.7%	16.5%	13.3%	12.7%	13.8%

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MP shock: selection

- Robustly no evidence for selection

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MP shock: selection

- Robustly no evidence for selection
- Significant shift in adjustment probability in supermarket prices

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Robustness to dropping fixed effects

	(1)	(2)	(3)	(4)
	Increases $\left(I^{+}_{pst,t+24}\right)$		Decreases $\left(I^{-}_{pst,t+24}\right)$	
Gap (x_{pst-1})	-1.75^{***}	-0.99^{***}	1.55^{***}	0.90^{***}
Shock (ebp_t)	-0.03^{***}	-0.04^{***}	0.03^{***}	0.03^{**}
Selection ($x_{pst-1}\hat{\text{ebp}}_t$)	-0.00	-0.01	0.01	0.02
Age (T_{pst-1})	0.02^{***}	-0.01^{**}	0.00^{**}	-0.03^{***}
Product x store FE	✓	✗	✓	✗
Calendar-month FE	✓	✓	✓	✓
Time FE	✗	✗	✗	✗
N	$16.1M$	$16.1M$	$16.1M$	$16.1M$
Within R^2	18.5%	8.9%	17.3%	9.3%

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Robustness to using posted prices

	(1)	(2)	(3)	(4)
	Increases $\left(I^{+}_{pst,t+24}\right)$		Decreases $\left(I^{-}_{pst,t+24}\right)$	
	Reference	Posted	Reference	Posted
Gap (x_{pst-1})	-1.75^{***}	-1.46^{***}	1.55^{***}	1.25^{***}
Shock (ebp_t)	-0.03^{***}	-0.04^{***}	0.03^{***}	0.03^{***}
Selection ($x_{pst-1}\hat{\text{ebp}}_t$)	-0.00	-0.01	0.01	0.02
Age (T_{pst-1})	0.02^{***}	0.01^{***}	0.00^{**}	-0.01^{***}
Product x store FE	✓	✓	✓	✓
Calendar-month FE	✓	✓	✓	✓
Time FE	✗	✗	✗	✗
N	$16.1M$	$18.6M$	$16.1M$	$18.6M$
Within R^2	18.5%	17.6%	17.3%	14.8%

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Robustness to excluding the Great Recession

	(1)	(2)	(3)	(4)
	Increases $\left(I^{+}_{pst,t+24}\right)$		Decreases $\left(I^{-}_{pst,t+24}\right)$	
	2001-2012	2001-2007	2001-2012	2001-2007
Gap (x_{pst-1})	-1.75^{***}	-1.74^{***}	1.55^{***}	1.50^{***}
Shock (ebp_t)	-0.03^{***}	-0.03^{***}	0.03^{***}	0.02^{***}
Selection ($x_{pst-1}\hat{\text{ebp}}_t$)	-0.00	0.06	0.01	-0.06
Age (T_{pst-1})	0.02^{***}	0.02^{***}	0.00^{**}	0.01^{***}
Product x store FE	✓	✓	✓	✓
Calendar-month FE	✓	✓	✓	✓
Time FE	✗	✗	✗	✗
N	$16.1M$	$9.9M$	$16.1M$	$9.9M$
Within R^2	18.5%	17.7%	17.3%	16.5%

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