Price Selection

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The views expressed here are ours, and they do not necessarily reflect the views of the Bank of Canada.

Key trade-off for monetary policy: Phillips Curve

- Traditional view: New Keynesian DSGE models
  - Inflation stable and persistent, insensitive to shocks (flat Phillips Curve)
  - Simple "representative-firm" IO: one-product monopolistic producers, extensive imperfections in the goods market or factor markets, perfect information, centralized exchange, Calvo price adjustment

- Data: product-level price behavior is remarkably complex
  - Product-level prices are flexible, volatile and transient
  - Multi-product retailers, heterogeneity of p-adj across/within products, imperfect information, de-centralized exchange

- **Does micro price behavior wash out with aggregation?**

Price selection

- Selection exists when prices that change at any given point in time are not representative of the overall population

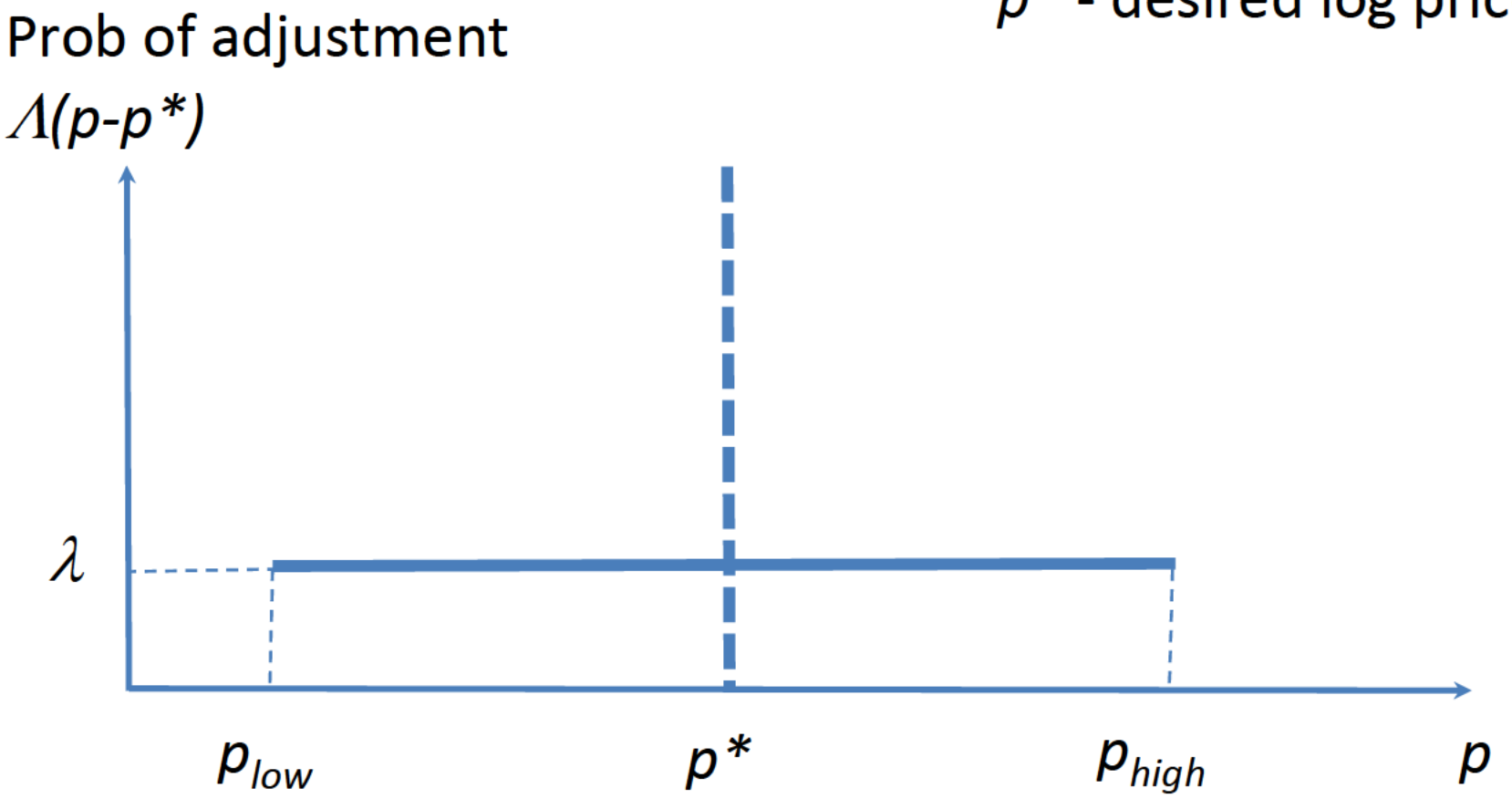
- Price selection makes inflation more sensitive to shocks
  - If prices that respond to a monetary expansion tend to be low, then price increases are larger, and inflation is more sensitive to shocks

- Two examples of price selection mechanisms:
  - Time-dependent adjustment (Calvo model): inflation less sensitive
  - State-dependent adjustment (Menu cost): inflation more sensitive

Time-dependent adjustment (Calvo, 1983)

p - firm's log price

p^* - desired log price



Probability of a price adjustment does not depend on $|p-p^*|$

Time-dependent adjustment (Calvo, 1983)

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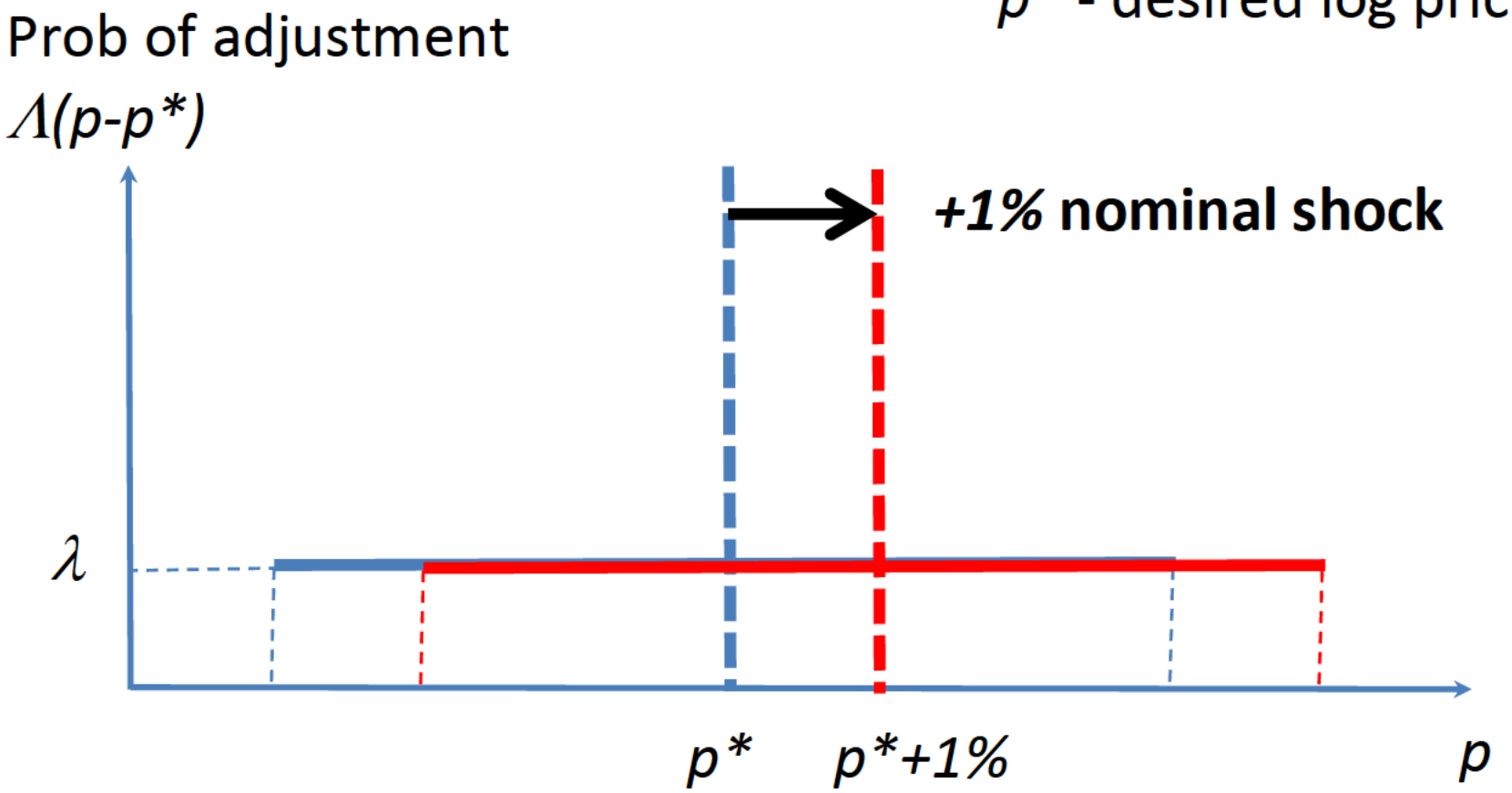

Conditional on aggregate nominal shock,
adjusting prices are representative of population

State-dependent adj-nt (Golosov-Lucas'07)

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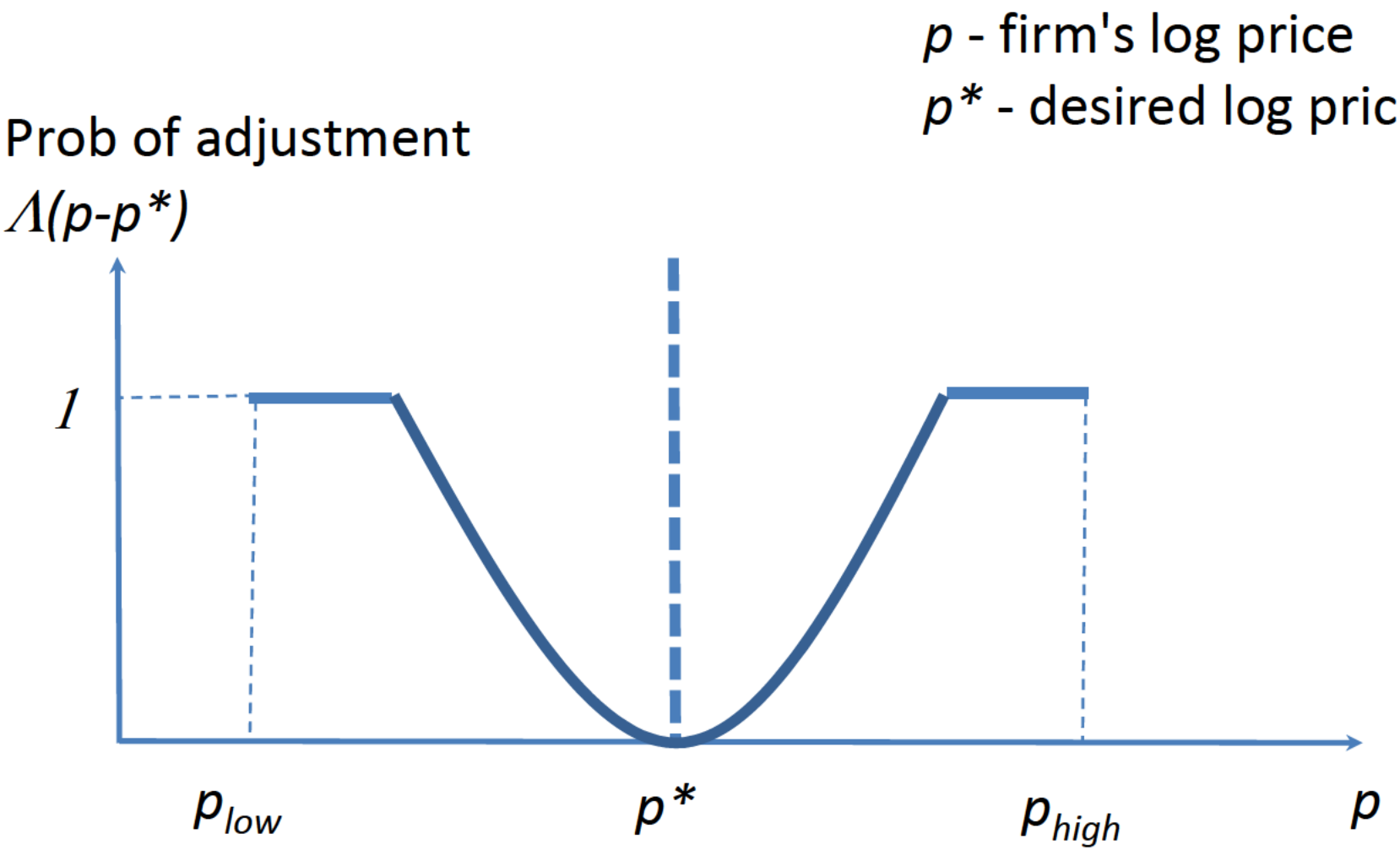

Probability of a price change increases with $|p-p^*|$

State-dependent adj-nt (Golosov-Lucas'07)

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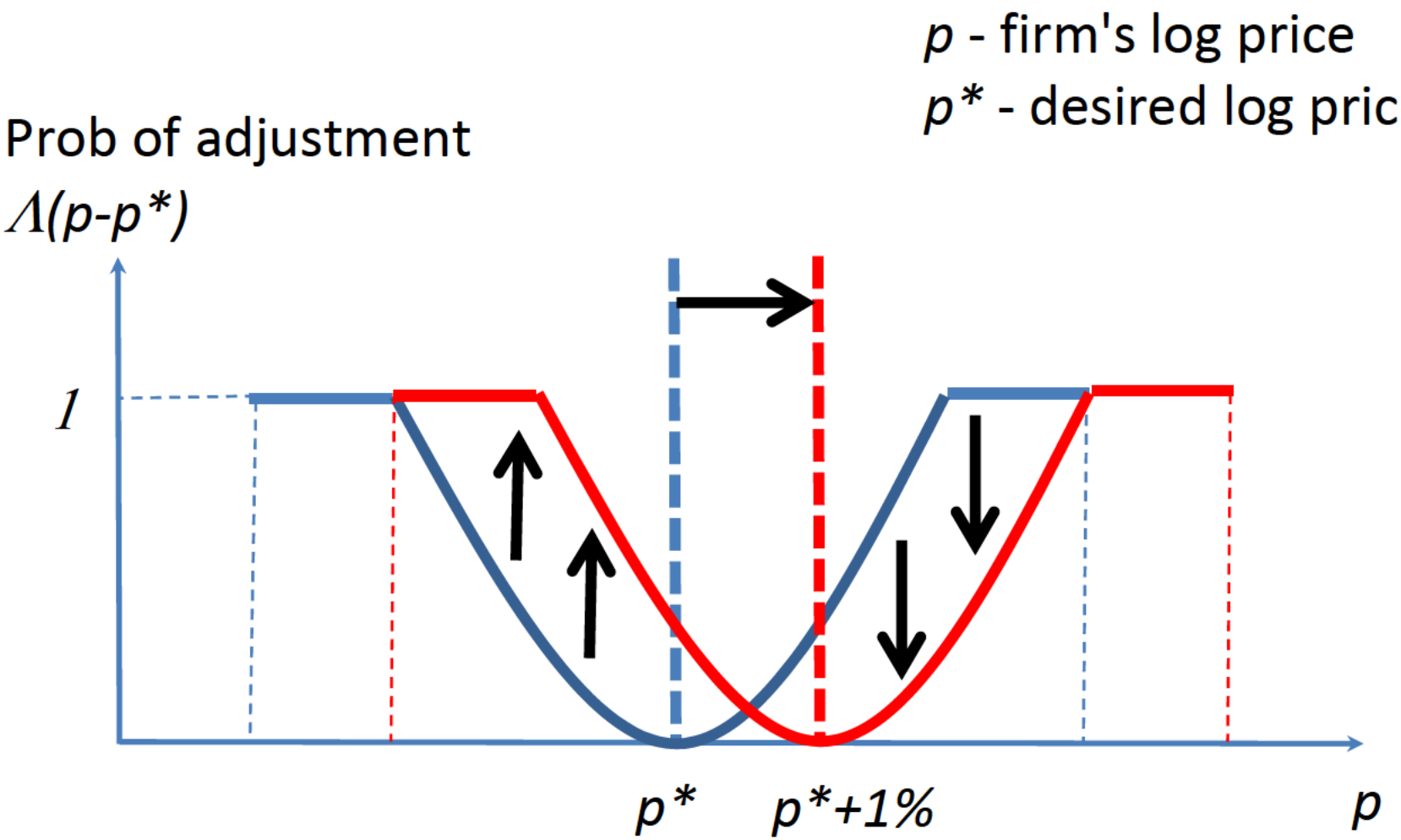

Conditional on aggregate nominal shock,
probability higher for low prices, and lower for high prices

Questions

- Is there evidence on price selection in the data?
- How important is price selection for inflation sensitivity?
- What are the implications for sticky price models?

Existing work

1. Indirect inference from sticky price models

   Caplin and Spulber (1987), Danziger (1999), Caballero and Engel (2007), Golosov and Lucas (2007), Gertler and Leahy (2008), Nakamura and Steinsson (2010), Costain and Nakov (2011 a,b), Midrigan (2011), Karadi and Reiff (2012), Head et al. (2012), Carvalho and Schwartzman (2015), Alvarez and Lippi (2014), Alvarez, Le Bihan, Lippi (2016)

2. Empirical studies of micro price response to p^*

   Kryvtsov and Klenow (2008), Nakamra and Steinsson (2008), Eichenbaum, Jaimovich, Rebelo (2011), Gagnon, Lopez-Salido, and Vincent (2012), Carlsson (2016)

3. Decomposition of inflation response to shocks

   Caballero and Engel (2007), Costain and Nakov (2011 b), Bils, Klenow, Malin (2012)

Existing work

1. Indirect inference from sticky price models

   Wide range of the estimated degree of price selection

2. Empirical studies of micro price response to p^*

   Hard to measure p^*, $\Lambda(p-p^*)$ and their response to agg shocks

3. Decomposition of inflation response to shocks

   Require model for p^*, $\Lambda(p-p^*)$ and their response to agg shocks

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No agreement on the importance of price selection

This paper

- Model-free way to measure price selection
  - Decompose inflation into components, and identify price selection
  - Can be consistently applied to micro data and simulated data

- Measure contribution of price selection to inflation in micro data for the UK, US and Canada
  1. Strong price selection across goods and services., accounting for around 39% (UK), 26% (US), 17% (Canada) of its variance
  2. Price selection increases with price stickiness and inflation volatility
  3. Price selection weakens with aggregation of the data (but less so if price discounts are included)

- Multi-sector menu-cost models broadly consistent with facts
  - One-sector Calvo is fine approximation of agg regular-price inflation

Price micro data

Statistic	U.K.	Canada	U.S.
Source	U.K. Office for National Statistics	Statistics Canada	Symphony IRI Inc.
Consumption coverage	Non-shelter goods and services	Non-shelter goods and services	Grocery products
Sample	1996:02 - 2015:09	1998:02 - 2009:12	2001:01 - 2011:12
# of months	236	143	132
# of obs/month	102,801	58,670	274,369
# of categories	1152	705	31
Fraction of sales	5.6	9.0	9.0
Fraction of subs	4.6	3.5	N/A
Inflation	0.121	0.171	0.282
Freq p-changes	0.124	0.217	0.213
Mean p-duration	5.65	6.85	3.47
Std p-duration	5.33	6.21	3.95
Abs size p-changes	12.16	8.14	8.32

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Inflation decomposition using micro price data

$$\pi_{jt} \equiv \frac{\sum_i (p_{ij,t} - p_{ij,t-1})}{N_j}$$

$p_{ij,t}$ log price of product i in category-stratum j in month t

Inflation decomposition using micro price data

$$\pi_{jt} \equiv \frac{\sum_i \left(p_{ij,t} - p_{ij,t-1}\right)}{N_j}$$

$$= \underbrace{\frac{\sum_i I_{ij,t}}{N_j}}_{Fr_{jt}} \cdot \left[\underbrace{\frac{\sum_i I_{ij,t}\left(p_{ij,t} - P_{j,t-1}\right)}{\sum_i I_{ij,t}}}_{P_{jt}^{res}} - \underbrace{\frac{\sum_i I_{ij,t}\left(p_{ij,t-1} - P_{j,t-1}\right)}{\sum_i I_{ij,t}}}_{P_{jt}^{pre}} \right]$$

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$I_{ij,t}$ p-change indicator: $=1$ if $p_{ij,t} - p_{ij,t-1} \neq 0$, and $=0$ otherwise

Fr_{jt-1} fraction of price changes in category-stratum j in month t

Inflation decomposition using micro price data

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DP_{jt} avg size of price changes in month t, $DP_{jt} = P_{jt}^{res} - P_{jt}^{pre}$

P_{jt}^{res} avg ending level of price changes

P_{jt}^{pre} avg starting level of price changes

P_{jt-1} category-stratum j mean log price level in month t

Inflation decomposition using micro price data

- Aggregate over strata using consumption expenditure weights
- Two levels of aggregation
  - Category time series

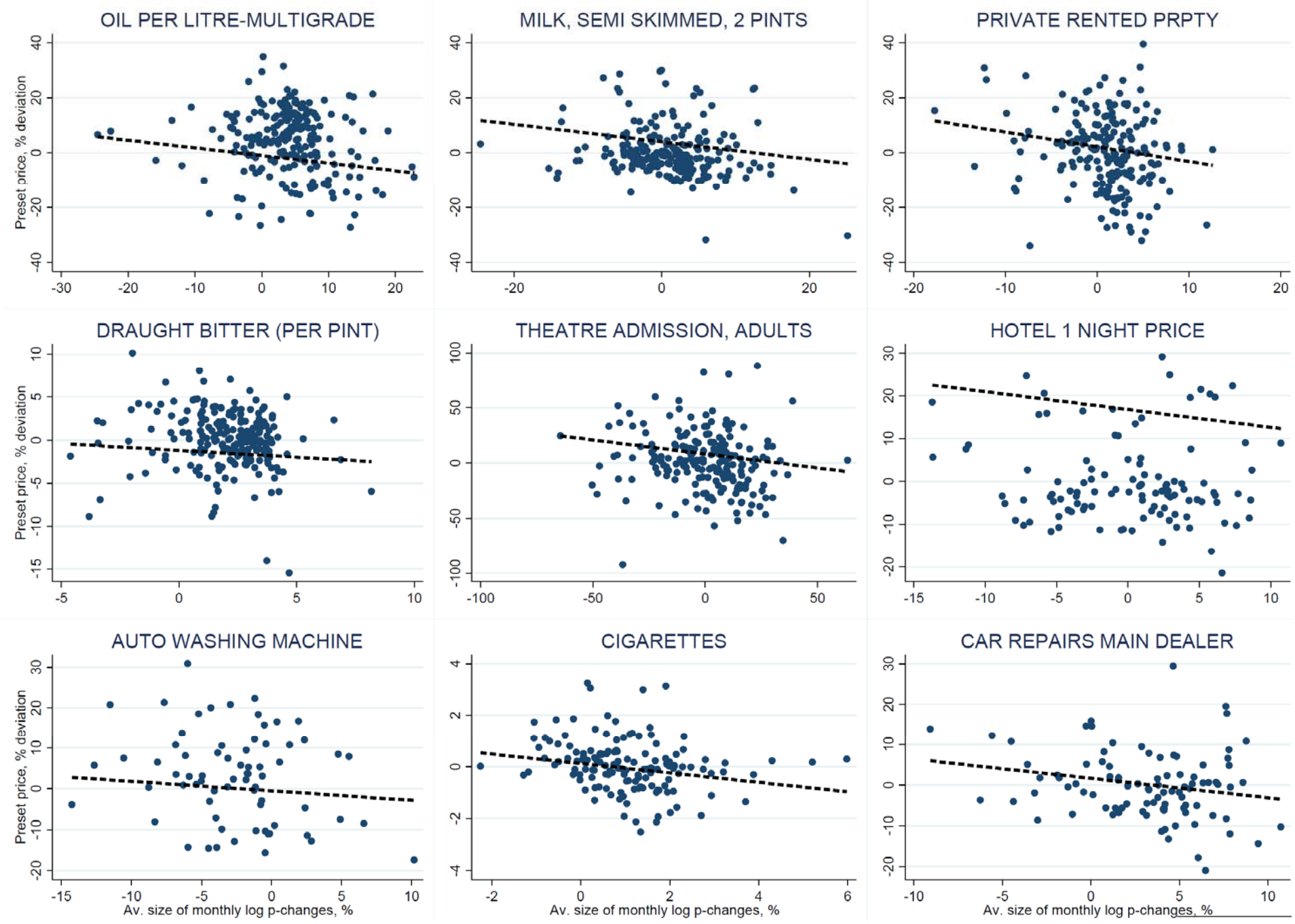
$$\pi_{ct} \equiv Fr_{ct} \cdot \underbrace{[P_{ct}^{res} - P_{ct}^{pre}]}_{DP_{ct}}$$

  - Aggregate time series

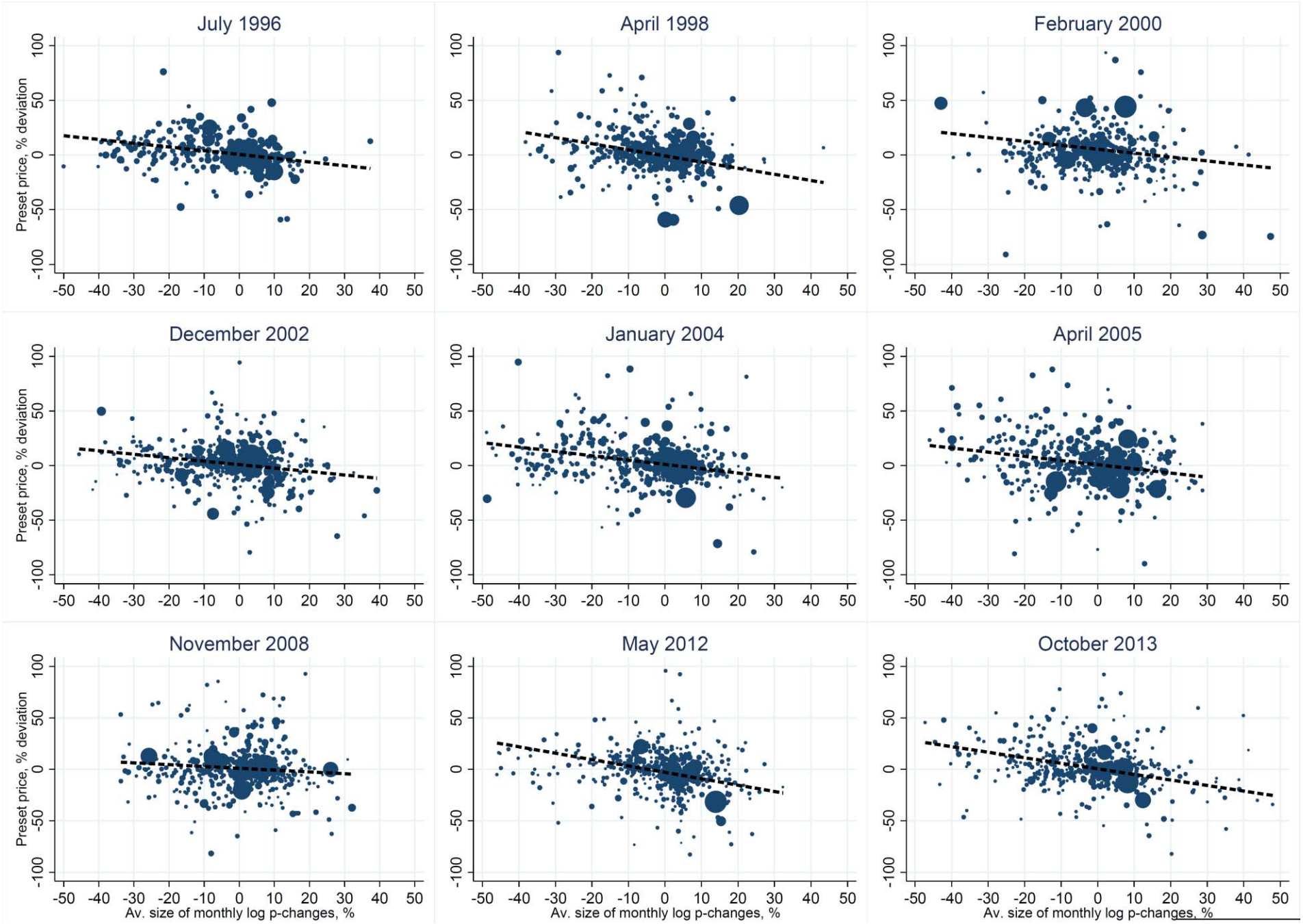
$$\pi_{t} \equiv Fr_{t} \cdot \underbrace{[P_{t}^{res} - P_{t}^{pre}]}_{DP_{t}}$$

- **How much P_t^{pre} contributes to fluctuations in DP_t?**

P_{ct}^{pre} and DP_{ct} for selected goods in the U.K.



P_{ct}^{pre} and DP_{ct} for selected months in the U.K.



Price selection, category time series

- Estimate weighted panel regression
  - δ_c – category fixed effects, δ_{cal} – calendar-month fixed effects

$$P_{ct}^{pre} = \beta DP_{ct} + \delta_{cal} + \delta_c + error$$

- Estimated β is the measure of price selection
  - $|\beta|$ is the fraction of DP_{ct} variance accounted for by $P^{pre}{}_{ct}$
- Benchmark: exclude price discounts and product substitutions

Price selection, category time series

Sample	U.K.	Canada	U.S.
Regular prices	**-0.385*** **	**-0.172*** **	**-0.259*** **
Number of obs	115,776	49,545	390,620
R^2	0.108	0.158	0.278
All posted prices	**-0.359*** **	**-0.255*** **	**-0.217*** **
Number of obs	116,312	54,129	410,387
R^2	0.176	0.253	0.362

- Significant price selection
  - Robust across datasets, treatments of sales, subs, seasonal effects, category-level linear and business-cycle (Baxter-King) trends

Price selection and price adjustment

- Modify the weighted panel regression

$$P_{ct}^{pre} = \beta_1 DP_{ct} + \beta_2 DP_{ct} \times \Gamma_{ct} + \delta_t + error$$

  - Study how price selection varies with price adjustment moments

$$\beta = \beta_1 + \beta_2 \Gamma_{ct}$$

  - Price adjustment moments, Γ_{ct}:
    - Frequency and average size of price changes
    - Absolute size of individual price changes
    - Kurtosis of non-zero price changes
    - Standard deviation of price spell durations
  - Focus on cross-section: δ_t – time fixed effects

Price selection and price adjustment, U.K.

Independent variables	(A)	(B)	(C)	(D)	(E)	(F)	(G)
DP	-0.317***	-0.355***	-0.335***	-0.225***	-0.292***	-0.339***	-0.257***
	(0.006)	(0.007)	(0.016)	(0.016)	(0.012)	(0.006)	(0.039)
Interaction terms							
DP x Fr		0.405***					0.386***
		(0.044)					(0.048)
DP x ADP			0.001				-0.002**
			(0.001)				(0.001)
DP x Kurt p-changes				-0.020***			-0.019***
				(0.003)			(0.004)
DP x Std p-spells					-0.006**		0.004
					(0.002)		(0.003)
DP x DP						-0.005***	-0.005***
						(0.000)	(0.000)
Number of obs	115,776	115,776	115,776	115,776	115,772	115,776	115,772
R^2	0.034	0.035	0.034	0.034	0.034	0.040	0.041

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- Selection increases with price stickiness and inflation volatility

Different level of aggregation, UK food products

Level of aggregation	Number of cross-section categories	Regular prices	All prices
Category and stratum	7079	-0.359***	-0.364***
		(0.002)	(0.002)
Category	**298**	**-0.269*** **	**-0.290*** **
		(0.007)	**(0.005)**
Basic class	13	-0.156***	-0.186***
		(0.018)	(0.013)

- Price selection weakens with aggregation of the data

Price selection, aggregate time series

- Estimate time series OLS regression
  - δ_{cal} – calendar-month fixed effects

$$P_t^{pre} = \beta DP_t + \delta_{cal} + error$$

Price selection, aggregate time series

Sample	U.K.	Canada	U.S.
Regular prices	**-0.198*** **	**-0.011**	**0.060***
Number of obs	235	133	131
R^2	0.110	0.285	0.132
All posted prices	**-0.394*** **	**-0.041**	**-0.140*** **
Number of obs	235	133	131
R^2	0.327	0.330	0.325

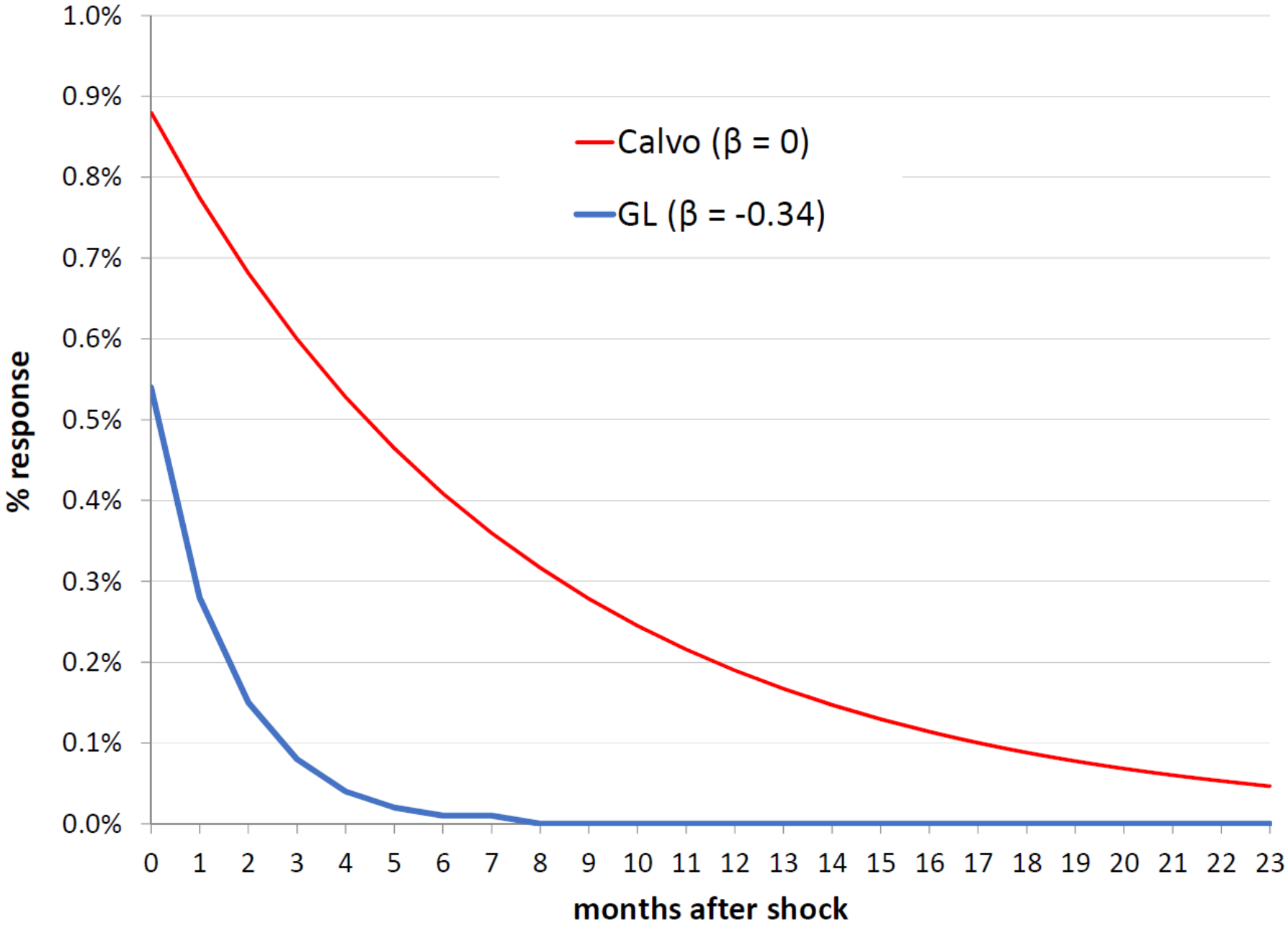
- Weak to none regular price selection for aggregate data
- Sales strengthen aggregate price selection
  - Consistent with cyclical sales behaviour (Kryvtsov and Vincent, 2017)

Price selection in standard sticky-price models

- **One-sector:** Calvo (1982), Taylor (1980), Golosov-Lucas (2007)
  - Monopolistically competitive firms are constrained in adjusting prices
  - Firms-specific cost shocks
  - Nominal demand (monetary) shock – the only aggregate shock
  - Calibrated to match same set of moments for monthly price changes

- **Multiple-sector:** Taylor, Golosov-Lucas
  - 67 consumption sectors
  - Firms follow Taylor or menu cost pricing (add fraction of Calvo firms)
  - Calibrate to match for each class in UK data: freq of p-changes, selection

Output responses to +1% money growth impulse



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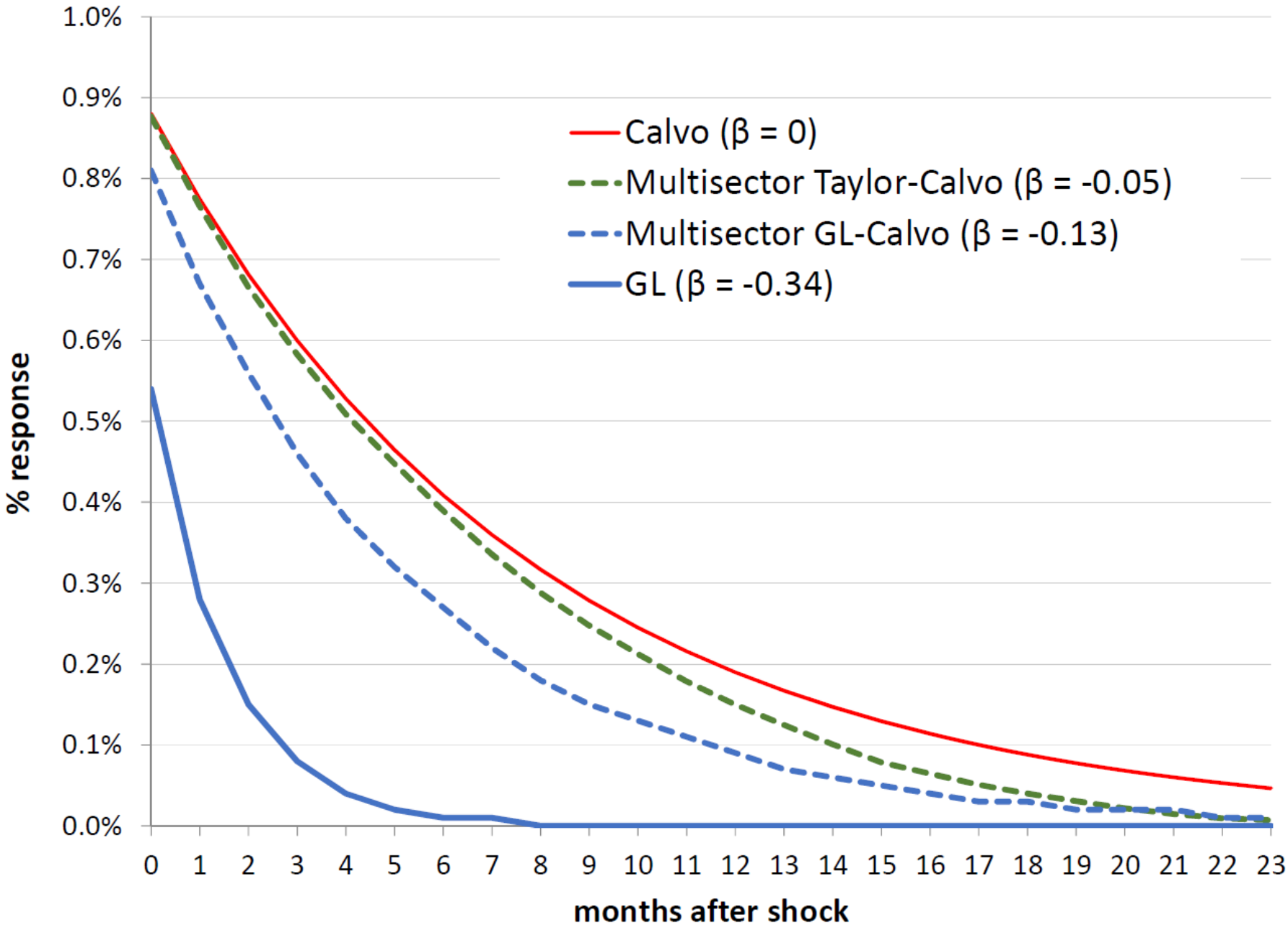

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  - Can be consistently applied to micro data and simulated data

- Measure contribution of price selection to inflation in micro data for the UK, US and Canada
  1. Strong price selection across goods and services., accounting for around 39% (UK), 26% (US), 17% (Canada) of its variance
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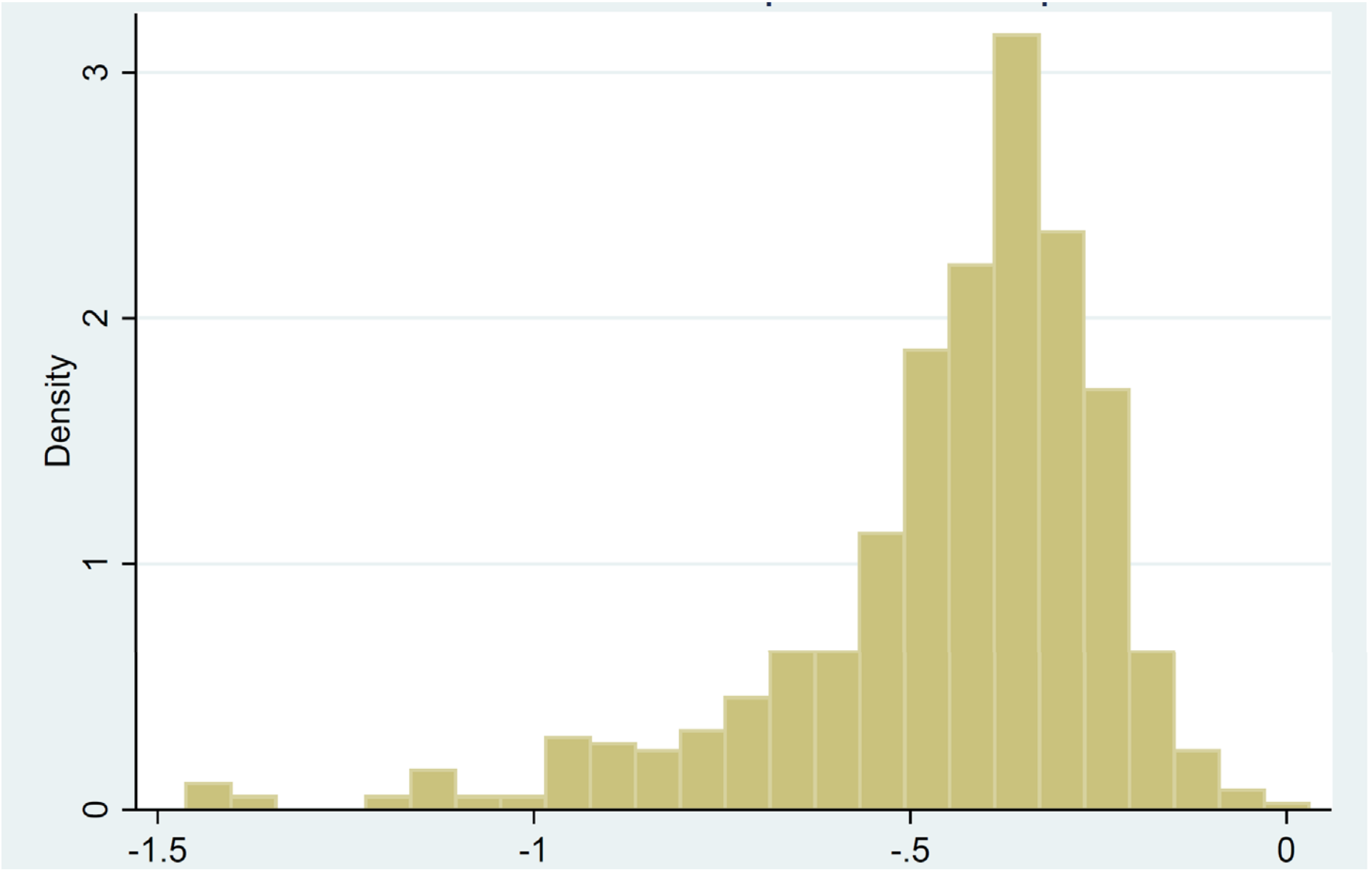
  - One-sector Calvo is fine approximation of agg regular-price inflation

Alternative standard errors, U.K. data

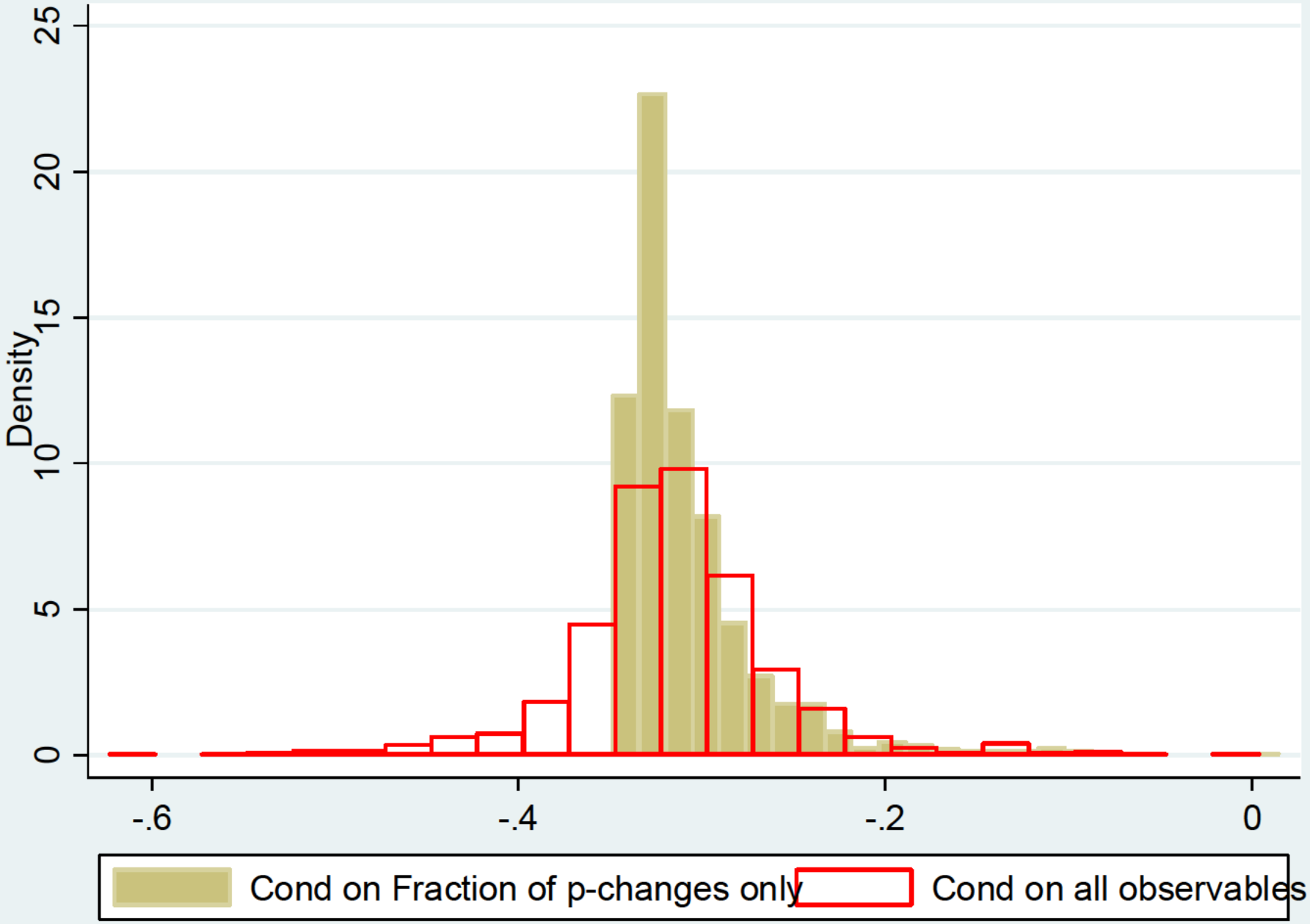
Coefficient	Point estimate	Standard errors			
		Pooled WLS	Driscoll-Kraay	Cluster by category	Cluster by month
	(1)	(2)	(3)	(4)	(5)
Price selection	-0.386	0.006***	0.028***	0.025***	0.026***

Price selection across product categories, U.K.



- Categories with $\beta \neq 0$: Mean = -0.444, Median -0.527

Fitted price selection across UK categories



IRFs in sticky price models and real rigidities