Price Selection

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

Inflation and micro price adjustments

- Challenge: reconciling price behavior at micro and macro levels
  - Macro: inflation is stable, persistent, little sensitive to shocks
  - Micro: product-level prices change frequently, volatile, transient
- Need large "contract multiplier"
  - Real rigidities and/or information
  - Micro price changes do not fully adjust to nominal shocks
- This paper: price selection
  - *which* prices adjust/do not adjust to shocks?

Price selection

- Prices that change are not representative of population
  - Theory: price selection makes inflation more sensitive to shocks
    - ★ Caplin-Spulber (1987), Danziger (1999), Golosov-Lucas (2007)
    - ★ E.g., increases in inflation can be amplified because adjusting prices tend to originate from below-average levels
  - Heuristic example

Price selection in Golosov-Lucas (2007)

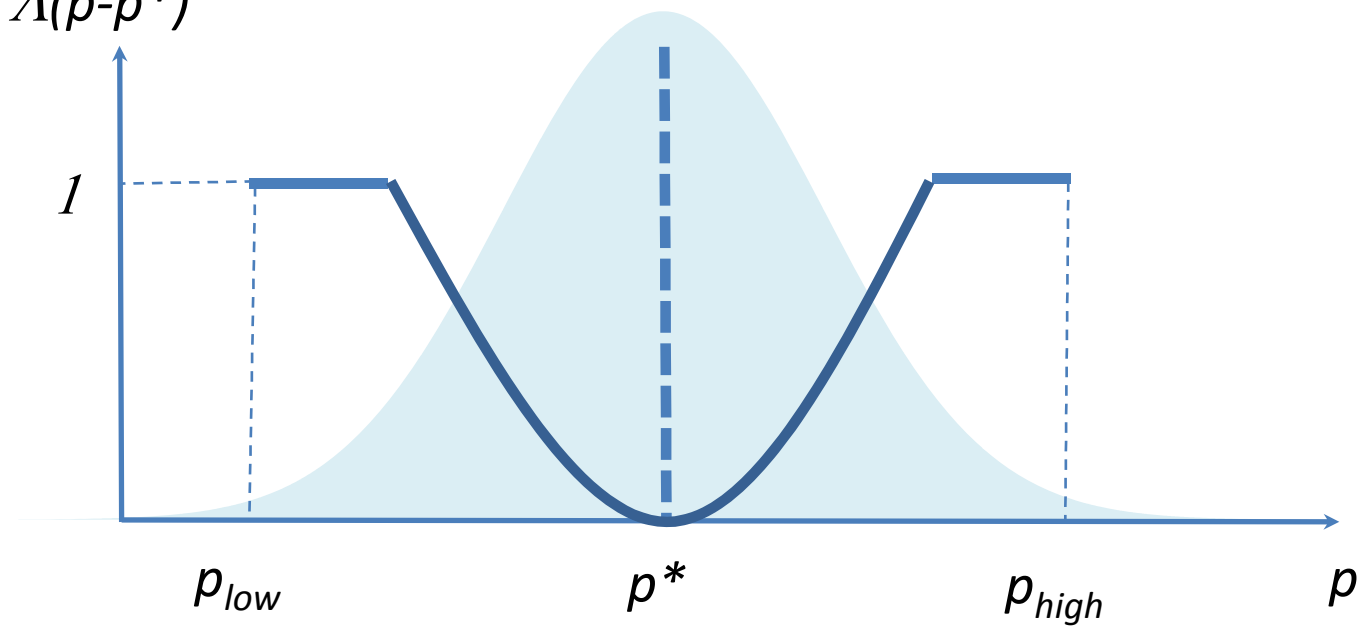
p - firm's log price

p^* - desired log price

price distribution

Prob of adjustment

$\Lambda(p-p^*)$



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

Price selection in Golosov-Lucas (2007)

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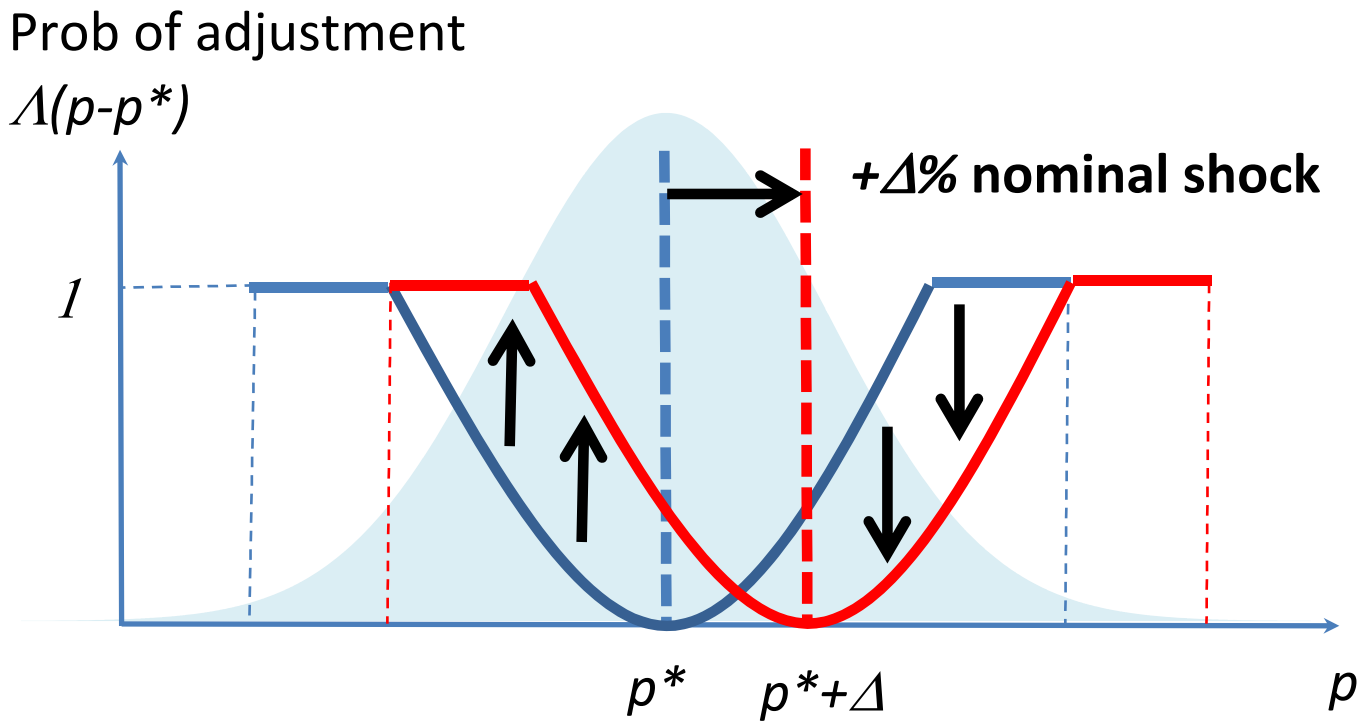
price distribution



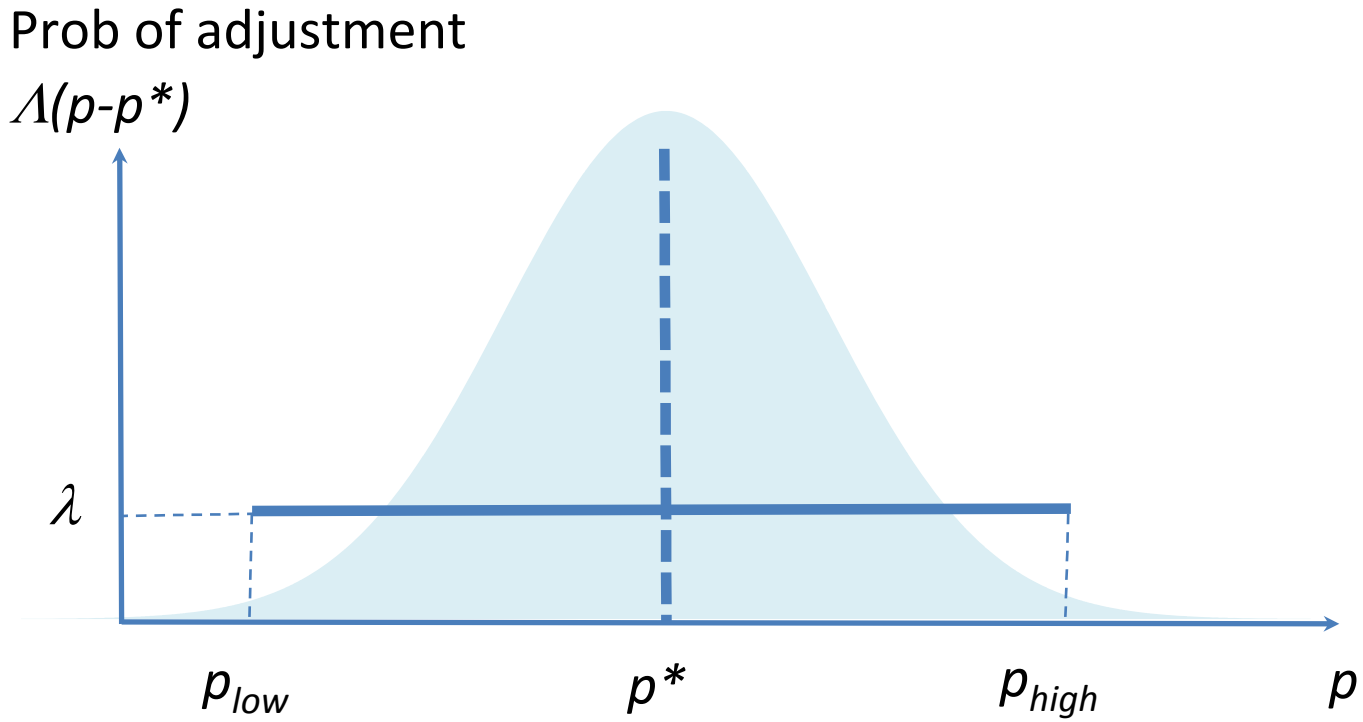
Conditional on common nominal shock,
probability higher for low prices, and lower for high prices

Zero price selection in Calvo (1983)

p - firm's log price

p^* - desired log price

price distribution



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

Zero price selection in Calvo (1983)

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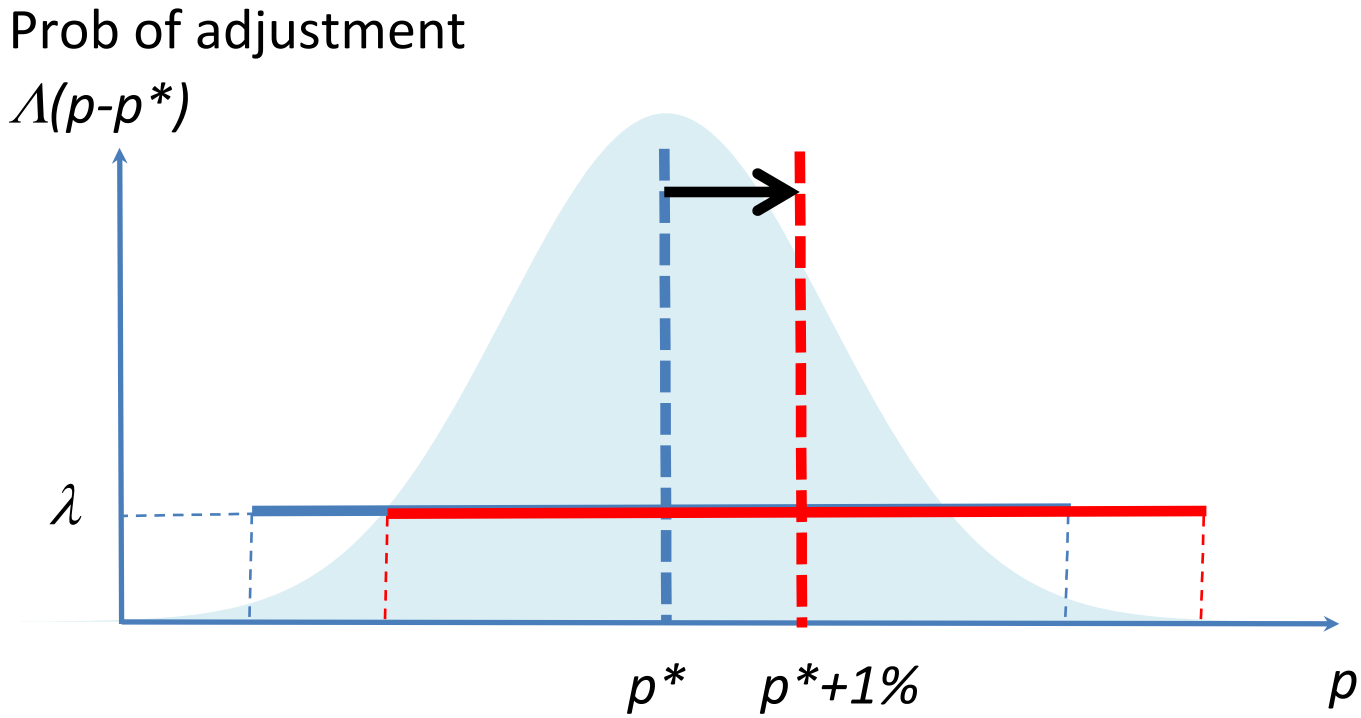
price distribution



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

This paper

- Study if up (down) movements in inflation in t tend to be associated with price changes that come from below (above) average in $t-1$
  - Model-free way to measure price selection (inflation decomposition)
  - Apply to micro data for the U.K., U.S. and Canada:
    - ★ @Product: 28–36% of inflation variance over time
    - ★ Price selection stronger with price durations and avg size of p-changes
    - ★ @Aggregate: weaker than product price selection (except if price discounts are included)
  - Multi-sector models with selection qualitatively consistent with facts
    - ★ Fit well sector-level selection, generate weaker aggregation selection
    - ★ Predict tight relationship bw price selection and monetary non-neutrality

Existing work

1. **Models:** wide range of "estimates"

   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), Bhattarai and Schoenle (2014), Gauthier and Le Bihan (2017)

2. **Empirical studies of p^*-shocks:** hard to measure p^*

   Eichenbaum, Jaimovich, Rebelo (2011), Gagnon, Lopez-Salido, and Vincent (2012), Bils, Klenow, Malin (2012), Carlsson (2016)

3. **Theoretical decompositions:** assumptions on p^*

   Caballero and Engel (2007), Alvarez and Lippi (2014), Alvarez, Le Bihan, Lippi (2016), Alvarez, Lippi, Passadore (2016), Carvalho and Schwartzman (2015)

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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
# of strata/category	22	13	50
Fraction of sales	5.6	9.0	9.0
Fraction of subs	4.6	3.5	N/A
Inflation	0.121	0.182	0.291
Freq of p-changes	0.127	0.217	0.223
Mean of p-spells	5.62	6.94	3.56
Std of p-spells	5.33	6.28	4.11
Abs. size of p-changes	12.22	8.25	8.43

Inflation decomposition using micro price data

$$\pi_{st} \equiv \frac{\sum_i (p_{is,t} - p_{is,t-1})}{N_{st}}$$

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

Inflation decomposition using micro price data

$$\pi_{st} \equiv \frac{\sum_i (p_{is,t} - p_{is,t-1})}{N_{st}}$$

$$\equiv \underbrace{\frac{\sum_i I_{is,t}}{N_{st}}}_{Fr_{st}} \times$$

$I_{is,t}$ p-change indicator: $I_{ist} = 1$ if $p_{is,t} - p_{is,t-1} \neq 0$, and 0 otherwise
Fr_{st} fraction of price changes in category-stratum s in month t

Inflation decomposition using micro price data

$$\pi_{st} \equiv \frac{\sum_i (p_{is,t} - p_{is,t-1})}{N_{st}}$$

$$\equiv \underbrace{\frac{\sum_i I_{is,t}}{N_{st}}}_{Fr_{st}} \times \left[\underbrace{\frac{\sum_i I_{is,t} (p_{is,t} - P_{st-1})}{\sum_i I_{is,t}}}_{P_{st}^{res}} - \underbrace{\frac{\sum_i I_{is,t} (p_{is,t-1} - P_{st-1})}{\sum_i I_{is,t}}}_{P_{st}^{pre}} \right]$$

DP_{st} avg size of price changes in month t, $DP_{st} \equiv P_{st}^{res} - P_{st}^{pre}$

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

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

P_{st-1} category-stratum s mean log price level in month t

How much P_{st}^{pre} contributes to DP_{st} fluctuations?

- Price selection, category-stratum time series

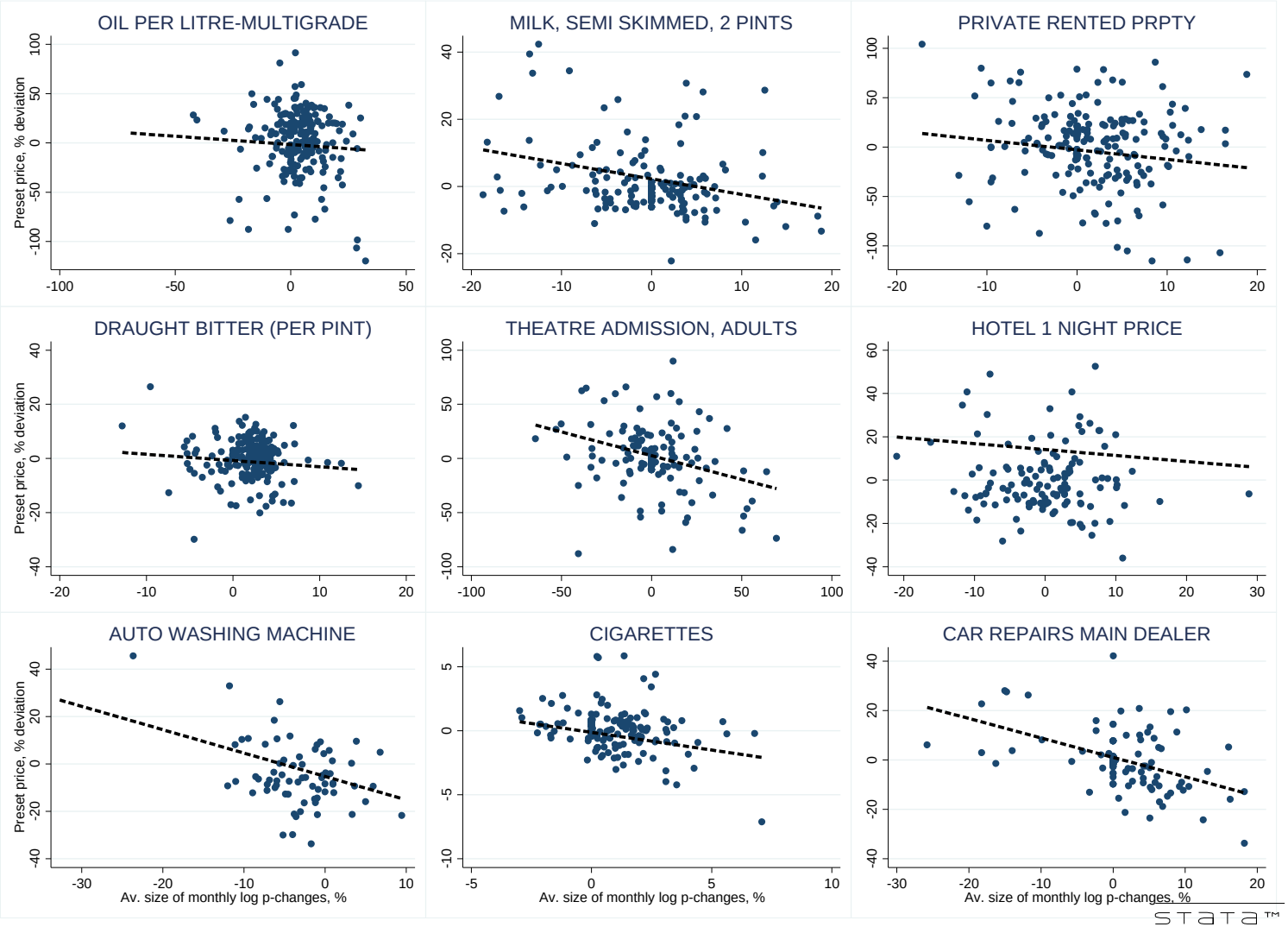
$$\pi_{st} \equiv Fr_{st} \cdot \underbrace{\left[P_{st}^{res} - P_{st}^{pre}\right]}_{DP_{st}}$$

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

$$P_{st}^{pre} = \beta DP_{st} + \delta_{cal} + \delta_s + error$$

  - Estimated β is the measure of price selection
    - ★ $|\beta|$ is the fraction of DP_{st} variance accounted for by P_{st}^{pre}

P_{st}^{pre} and DP_{st} for selected categories in the U.K.



Price selection, category-stratum time series

United Kingdom

	Regular prices, excluding subs			Unweighted	All prices	Incl. subs
	(1)	(2)	(3)	(4)	(5)	(6)
A. U.K.						
Price selection	**-0.371***** (0.002)	**-0.371***** (0.002)	**-0.369***** (0.002)	**-0.357***** (0.002)	**-0.333***** (0.002)	**-0.415***** (0.002)
Calendar-month effects	Y	N	Y	Y	Y	Y
Stratum linear trend	N	N	Y	N	N	N
Number of observations	1,073,089	1,073,089	1,073,089	1,073,089	1,075,108	1,077,371
R^2	0.032	0.032	0.032	0.046	0.039	0.055

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

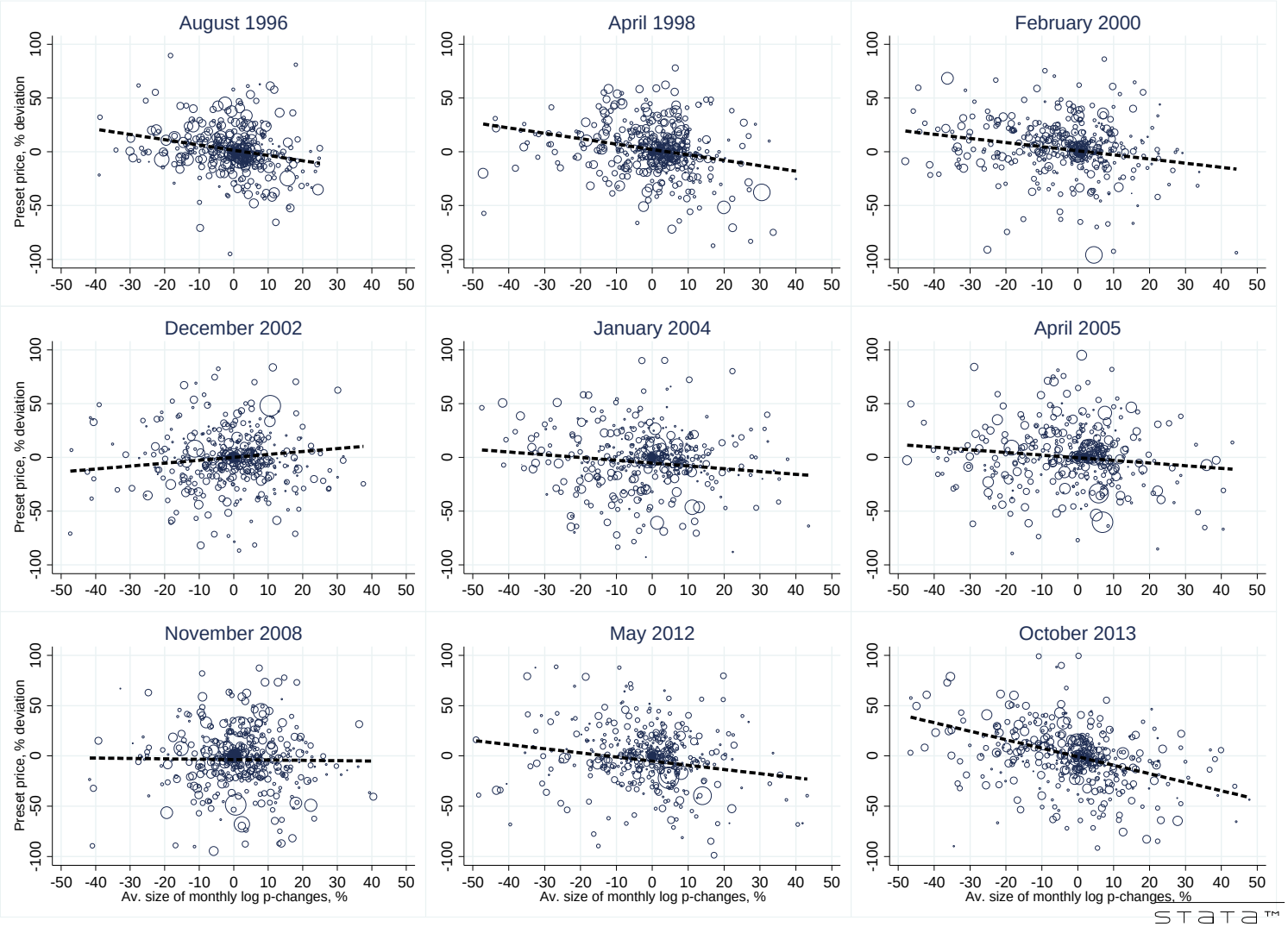
Price selection, category-stratum time series

Regular prices, excluding subs

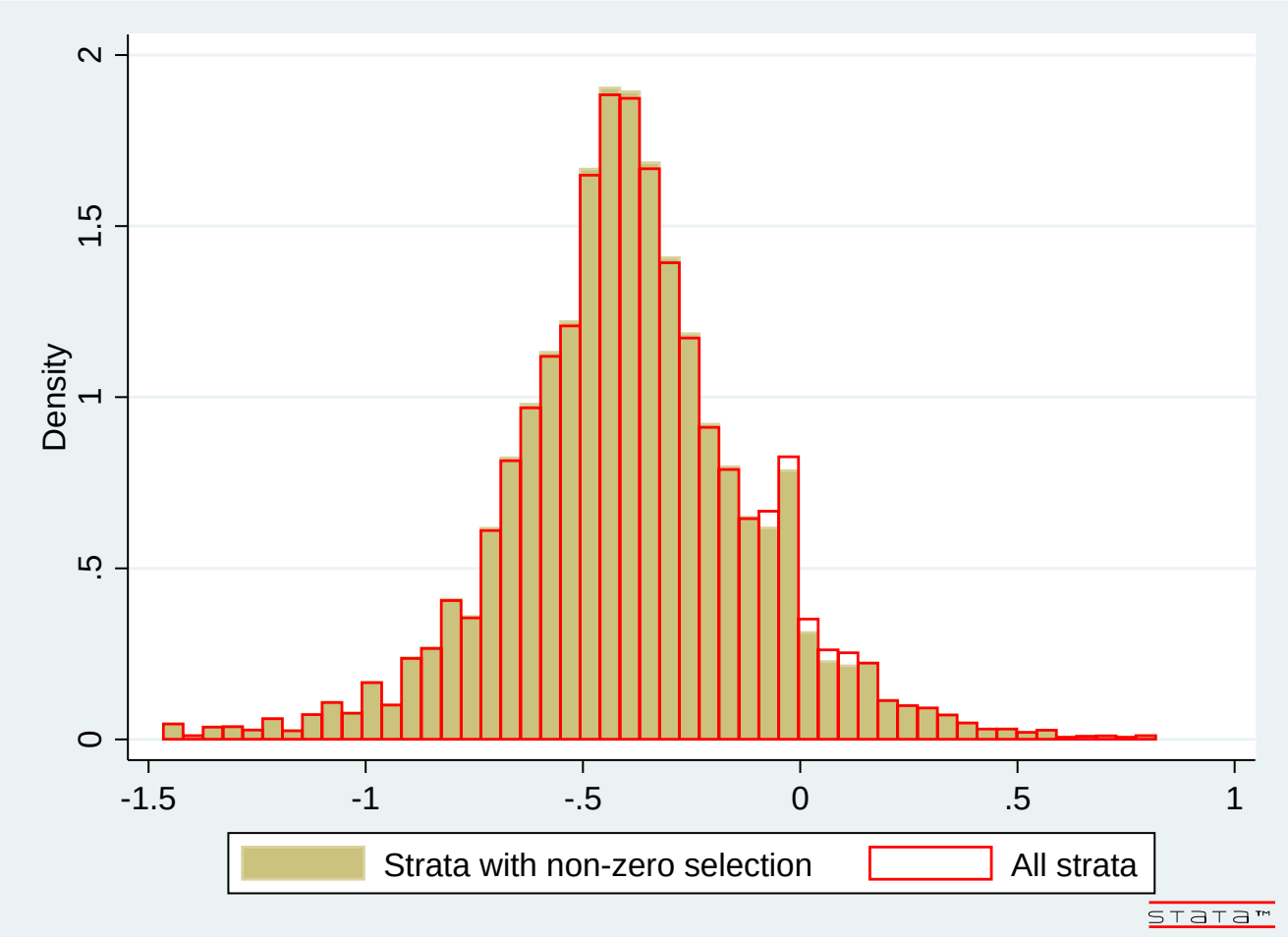
	U.K.	Canada	U.S.
Price selection	**-0.371***** (0.002)	**-0.285***** (0.003)	**-0.360***** (0.000)
Calendar-month effects	Y	Y	Y
Stratum linear trend	N	N	N
Number of observations	1,073,089	568,264	18,402,238
R^2	0.032	0.022	0.198

- Results consistent across country datasets
  - Weaker selection in Canada (coarser strata)

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



Price selection across product categories, U.K.



- Mean = –0.392 (all), –0.396 (non-zero); 91% weight bw 0 and –1

Price selection and price adjustment

- Modify the weighted panel regression

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

  - Study how price selection varies with price adjustment moments

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

  - Price adjustment moments, Γ_{st}:
    - ★ 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	U.K.				Canada	U.S.
	Baseline	Baseline	All prices	Incl. subs	Baseline	Baseline
		With interaction terms			With interaction terms	
DP_{st}	-0.367***	-0.370***	-0.368***	-0.437***	-0.560***	-0.546***
	(0.002)	(0.010)	(0.009)	(0.008)	(0.013)	(0.000)
Interaction terms						
DP_{st} x Fr_{st}		0.220***	0.193***	0.396***	0.566***	0.668***
		(0.012)	(0.010)	(0.011)	(0.011)	(0.001)
DP_{st} x DP_{st}		-0.003***	-0.003***	-0.001***	-0.005***	-0.003***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DP_{st} x ADP_{st}		0.001**	0.001***	-0.001***	0.003***	-0.001***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DP_{st} x Kurt p-$chgs_s$		-0.006***	-0.005***	-0.004***	0.004**	0.001***
		(0.001)	(0.001)	(0.000)	(0.002)	(0.000)
DP_{st} x Std p-$spells_s$		-0.005***	-0.012***	-0.001	0.005***	0.003***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Number of obs	1,073,089	1,072,899	1,075,029	1,077,315	567,573	18,393,701
R^2	0.033	0.036	0.049	0.059	0.033	0.224

- Selection increases with price stickiness and size of price changes

Price selection and price adjustment, U.K.

Independent variables	U.K.				Canada	U.S.
	Baseline	Baseline	All prices	Incl. subs	Baseline	Baseline
		With interaction terms			With interaction terms	
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		(0.012)	(0.010)	(0.011)	(0.011)	(0.001)
DP_{st} x DP_{st}		-0.003***	-0.003***	-0.001***	-0.005***	-0.003***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DP_{st} x ADP_{st}		0.001**	0.001***	-0.001***	0.003***	-0.001***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
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		(0.001)	(0.001)	(0.000)	(0.002)	(0.000)
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- Selection increases with price stickiness and size of price changes

Aggregate price selection

- Aggregate time series:
  - $Fr_t = \sum_s \omega_s Fr_{st}$
    - ★ $P_t^{res} = \sum_s \omega_s \frac{Fr_{st}}{Fr_t} P_{st}^{res}, \quad P_t^{pre} = \sum_s \omega_s \frac{Fr_{st}}{Fr_t} P_{st}^{pre}$
      (frequency-weighted to account for heterogeneity across strata)
  - Obtain same decomposition as before:

$$\pi_t \equiv Fr_t \cdot \underbrace{[P_t^{res} - P_t^{pre}]}_{DP_t}$$

  - Estimate time series OLS regression

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

Price selection, aggregate time series

Level of aggregation	Number of groups	Regular prices, excluding subs		Incl. subs
A. U.K.				
Stratum	8941	-0.371***		-0.415***
Aggregate	**1**	**-0.197*** (0.072)**		**-0.188*** (0.069)**
B. Canada				
Stratum	9165	-0.285***		-0.268***
Aggregate	**1**	**-0.003 (0.021)**		**0.013 (0.020)**
C. U.S.				
Stratum	1550	-0.360***		N/A
Aggregate	**1**	**0.061* (0.035)**		

- Price selection weakens with aggregation of the data

Price selection, aggregate time series

Level of aggregation	Number of groups	Regular prices, excluding subs	All prices	Incl. subs
A. U.K.				
Stratum	8941	-0.371***	-0.333***	-0.415***
Aggregate	**1**	**-0.197*** (0.072)**	**-0.394*** (0.065)**	**-0.188*** (0.069)**
B. Canada				
Stratum	9165	-0.285***	-0.327***	-0.268***
Aggregate	**1**	**-0.003 (0.021)**	**-0.039 (0.028)**	**0.013 (0.020)**
C. U.S.				
Stratum	1550	-0.360***	-0.303***	N/A
Aggregate	**1**	**0.061* (0.035)**	**-0.140*** (0.021)**	

- Price selection weakens with aggregation of the data
  - Sales tend to strengthen aggregate price selection (consistent with cyclical sales behavior - Kryvtsov and Vincent, 2017)

Aggregate price selection, U.K.

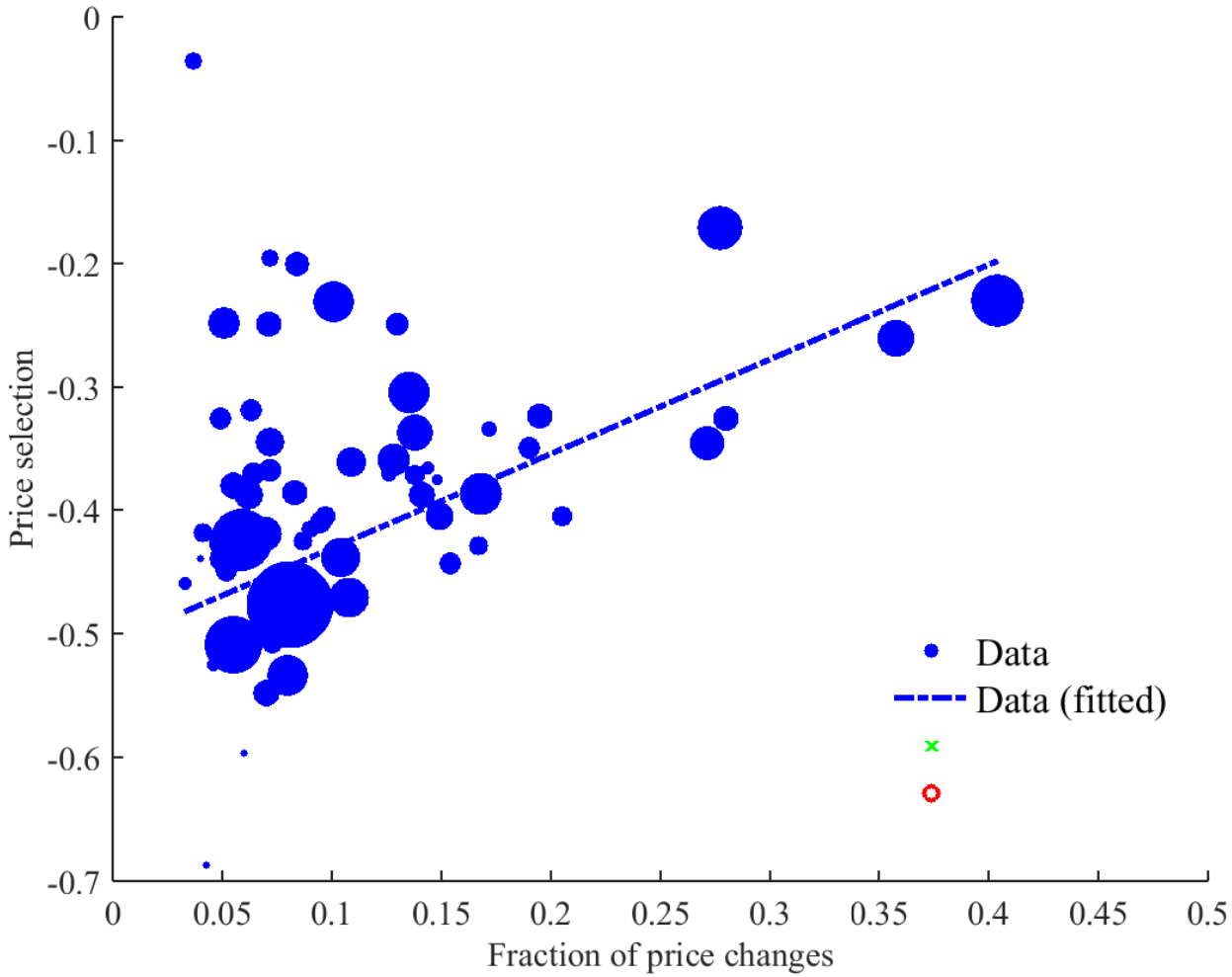
Level of aggregation	Number of groups	Regular prices, excluding subs	All prices	Incl. subs
A. U.K.				
Stratum	8941	-0.371***	-0.333***	-0.415***
		(0.002)	(0.002)	(0.002)
Category	1037	-0.385***	-0.359***	-0.404***
		(0.006)	(0.005)	(0.005)
Basic class	66	-0.361***	-0.357***	-0.330***
		(0.016)	(0.013)	(0.014)
Aggregate	**1**	**-0.197*** **	**-0.394*** **	**-0.188*** **
		(0.072)	**(0.065)**	**(0.069)**

- Aggregation across broad consumption sectors contributes the most

Price selection in multi-sector sticky-price models

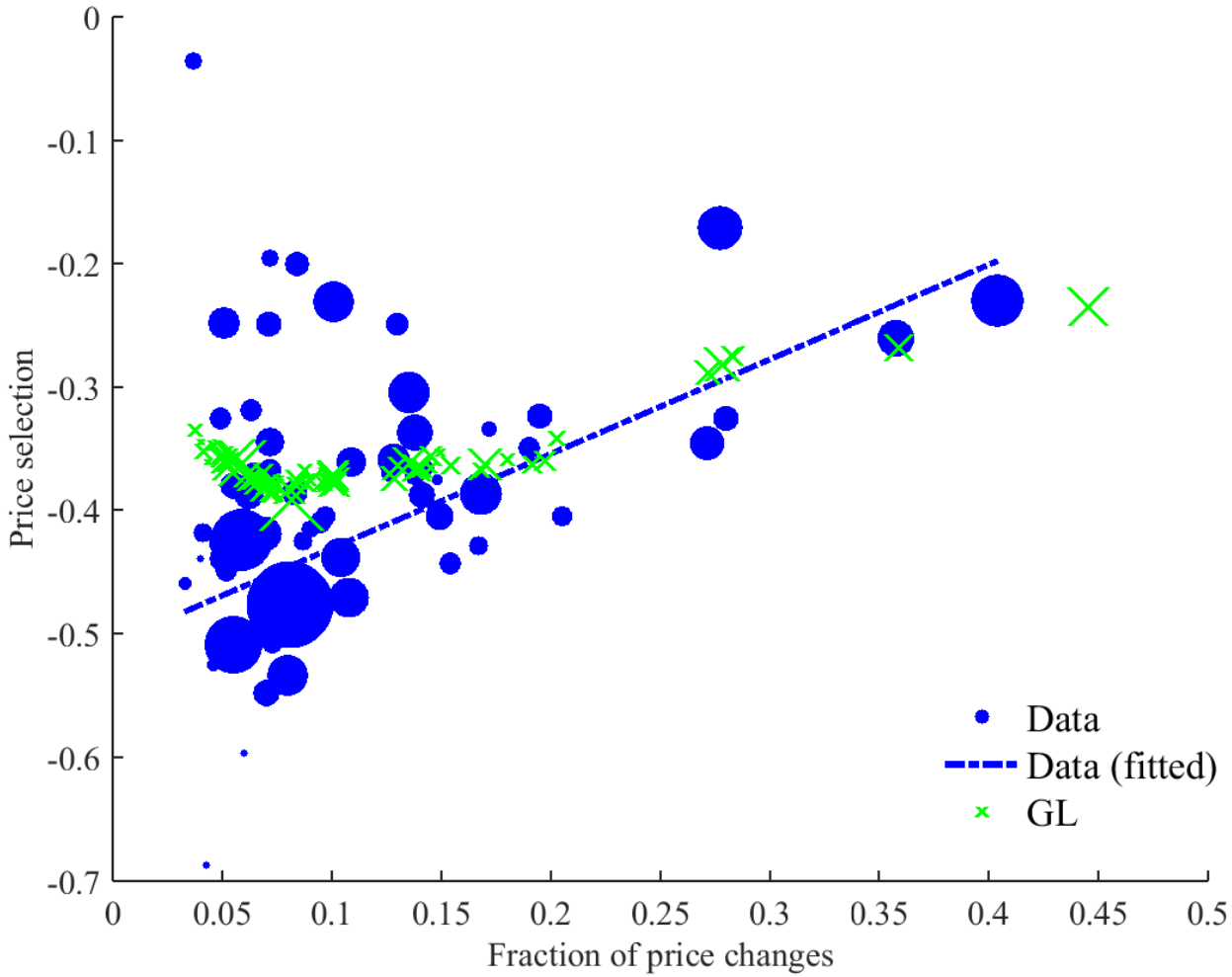
- Multi-sector Golosov-Lucas (2007) model
  - Monopolistically competitive firms pay menu cost to adjust prices
    - ⋆ Firms-specific AR(1) cost shocks, i.i.d. money growth shock
  - N consumption sectors differ by frequency of p-changes
    - ⋆ U.K. data for 66 consumption sectors
    - ⋆ Pick menu cost for each sector to match freq of p-changes in the data
    - ⋆ Parameters for AR(1) shocks common across sectors
    - ⋆ Strategic neutrality for p-changes across firms

Model results: sector-level price selection



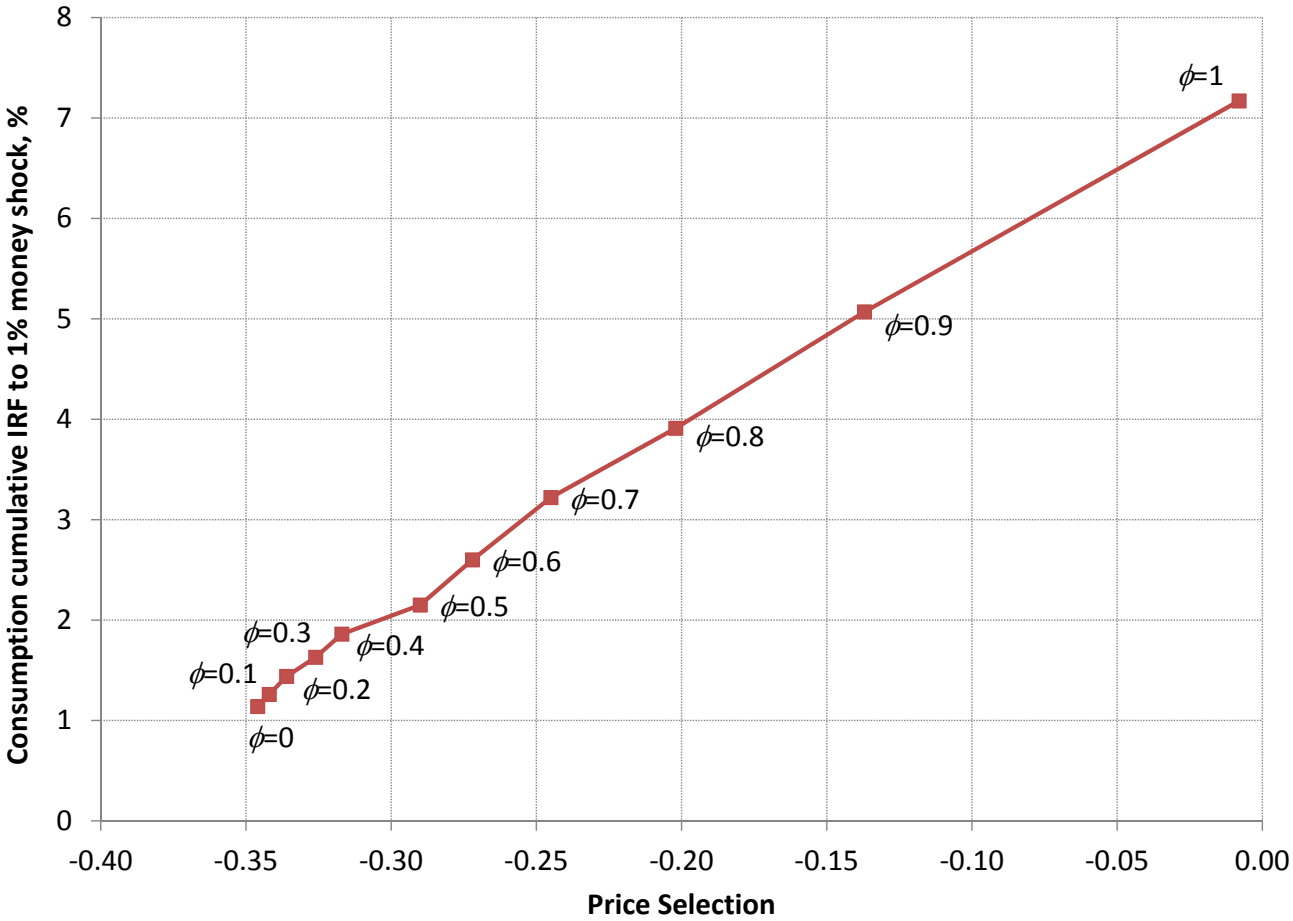
- Freq of p-changes accounts for around 20% of selection across sectors

Model results: sector-level price selection



- GL model fits fairly well sector-level selection

Monetary non-neutrality in nested Calvo-GL model



- Nested GL and Calvo model: weight ϕ on Calvo price adjustment
  - Tight relationship between price selection and monetary non-neutrality

Conditional selection: two aggregate shocks

- Selection: Unconditional in the data x conditional in the model
- Calvo-GL model with monetary and productivity shocks

Table 5. *Calibration strategy: GL-Calvo 2shocks model*

Calibration targets	DATA	**No Correlation**	**Correlation**
Fraction of pch (%)	0.13	0.14	0.13
Abs size of pch (%)	12.22	12.23	12.22
Ser. corr of reset prices	-0.03	-0.02	0.01
Inflation stdev (%)	0.002	0.003	0.002
Consumption ser. corr	0.85	0.83	0.83
Inflation mean (%)	0.12	0.12	0.12
Consumption stdev (%)	0.89	0.88	0.92
Price Selection	-0.20	-0.23	-0.22

Table 6. *Price Selection*

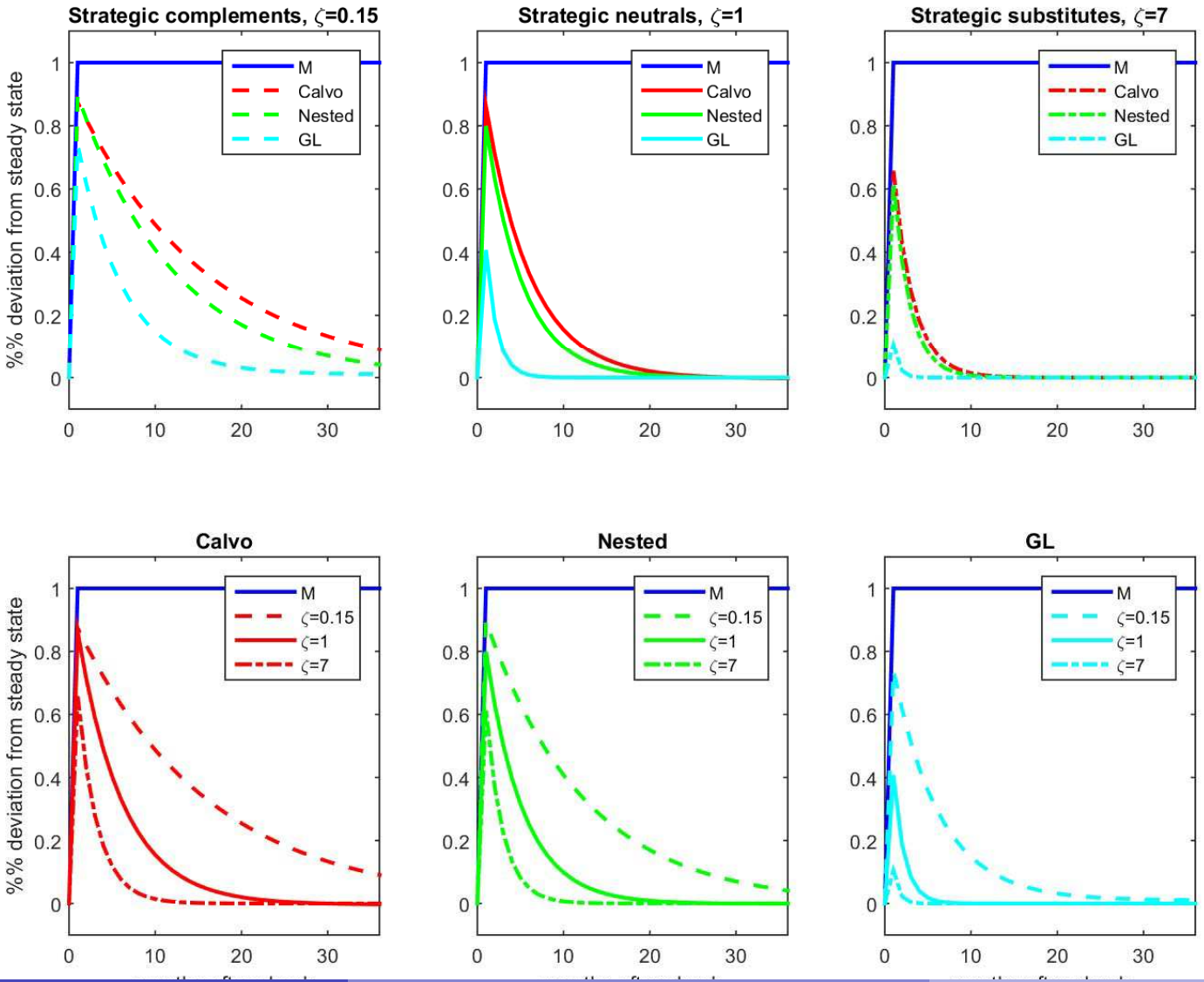
	All shocks	*Monetary Shocks Only*	*Productivity Shocks Only*
No Correlation	-0.23	-0.29	-0.29
Correlation	-0.22	-0.27	-0.28

- Why not estimate conditional selection in the data?

Conclusions

- Multi-sector models with selection qualitatively consistent with facts
  - Generate sector-level selection, weaker aggregate selection
    - ⋆ Still need: broader range of selection, weaker agg selection (e.g., information frictions, other features)
  - Measuring price selection allows more accurately identify determinants of monetary non-neutrality
    - ⋆ "Model-free" measure, straightforward to apply to models/data
    - ⋆ Models: tight relationship between price selection and non-neutrality
    - ⋆ Can assess importance "real rigidities", sufficient statistics, etc.

Price selection and real rigiditites



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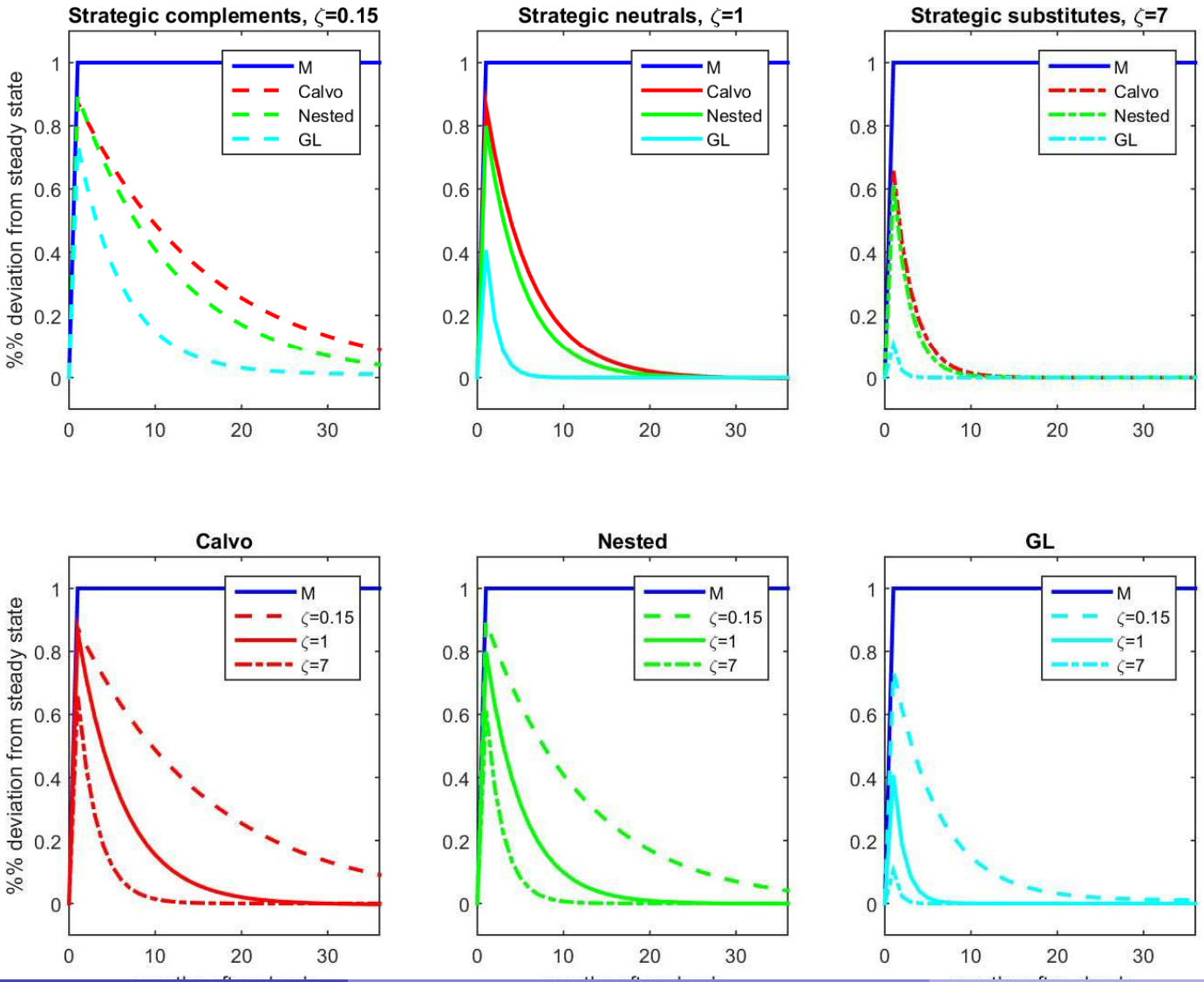

Price selection and size of aggregate shocks