Markups and Inflation in Oligopolistic Markets: Evidence from Wholesale Price Data

Patrick Alexander
Bank of Canada

Lu Han
Bank of Canada

Oleksiy Kryvtsov
Bank of Canada

Ben Tomlin
Bank of Canada

AEA Session on "Variable Markups and Misallocation"
January 4, 2025

Does market power influence inflation dynamics and transmission of MP?

Markets are concentrated; rising market power over time (De Loecker, Eeckhout, & Unger 20)

Recent theory: important interactions between firms' market power and nominal rigidity

- Stronger non-neutrality due to pricing complementarity (Mongey 21; Wang & Werning 22)

Does market power influence inflation dynamics and transmission of MP?

Markets are concentrated; rising market power over time (De Loecker, Eeckhout, & Unger 20)

Recent theory: important interactions between firms' market power and nominal rigidity

- Stronger non-neutrality due to pricing complementarity (Mongey 21; Wang & Werning 22)

Lack of direct empirical evidence

- Existing studies focus on flexible price (Auer & Schoenle 16; Amiti, Itskhoki, Konings 19)

This paper: studies how market power interacts with nominal rigidity using micro data

This paper

Model with oligopolistic competition, Calvo sticky prices and heterogeneous firms

- derive closed-form solution for firm-level price adjustments to cost shocks
- differential reset price pass-through of 'common' (industry) vs idiosyncratic cost changes

This paper

Model with oligopolistic competition, Calvo sticky prices and heterogeneous firms

- derive closed-form solution for firm-level price adjustments to cost shocks
- differential reset price pass-through of 'common' (industry) vs idiosyncratic cost changes

Estimate pass-throughs using confidential micro data from Canadian wholesale firms:

- accurate proxy of the marginal cost changes $\Rightarrow$ decompose into 'common' vs idio components
- pass-through estimates in line with model predictions

This paper

Model with oligopolistic competition, Calvo sticky prices and heterogeneous firms

- derive closed-form solution for firm-level price adjustments to cost shocks
- differential reset price pass-through of 'common' (industry) vs idiosyncratic cost changes

Estimate pass-throughs using confidential micro data from Canadian wholesale firms:

- accurate proxy of the marginal cost changes $\Rightarrow$ decompose into 'common' vs idio components
- pass-through estimates in line with model predictions

Micro to macro: empirical estimates of market power imply

- one-sector model: $1/3$ decline in slope of New Keynesian Phillips Curve (NKPC)
- multi-sector model: $2/3$ decline in slope of NKPC

Roadmap

- Model and closed form
- Empirical results
- Micro to macro: aggregate price and output dynamics

Multi-sector model with oligopolistic competition and sticky prices

- Oligopolistically-competitive distributors
- Distributors buy goods from monopolistically-competitive producers
- Distributor's cost: common and idiosyncratic components
- Sector heterogeneity in market power and price stickiness

Multi-sector model with oligopolistic competition and sticky prices

- Oligopolistically-competitive distributors
- Distributors buy goods from monopolistically-competitive producers
- Distributor's cost: common and idiosyncratic components
- Sector heterogeneity in market power and price stickiness
- Timing of distributor's price and cost changes is *synchronized* data
  - standard feature of distributors (Eichenbaum, Jaimovich & Rebelo 11; Goldberg & Hellerstein 13)

Multi-sector model with oligopolistic competition and sticky prices

- Oligopolistically-competitive distributors
- Distributors buy goods from monopolistically-competitive producers
- Distributor's cost: common and idiosyncratic components
- Sector heterogeneity in market power and price stickiness
- Timing of distributor's price and cost changes is *synchronized* data

Additional (standard) assumptions to get closed form solution:

- Log consumption utility and linear labour: $U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\ln C_t + L_t \right)$
- Cobb-Douglas aggregation across sectors: $C_t = \Pi_j C_{jt}^{\alpha_j}$
- Cash-in-advance constraint: $M_t = W_t = P_t C_t$
- Small shocks (first order approximation remains accurate)

Key proposition

The distributor's optimal reset price, up to a first-order approximation, is:

$$\widehat{P}_{ijt,t} = \frac{1}{1+\varphi_{ij}} \times \underbrace{\left(\widehat{Q}_{ijt} - \widehat{Q}_{jt}\right)}_{\text{Idiosyncratic change}} + \left[\frac{1}{1+\varphi_{ij}} + \frac{\varphi_{ij}}{1+\varphi_{ij}} \left(\frac{1-\Lambda(\vec{\varphi}_j, \lambda_j)}{1-\beta\lambda_j\Lambda(\vec{\varphi}_j, \lambda_j)}\right)\right] \times \underbrace{\widehat{Q}_{jt}}_{\text{Common change}}$$

- $\widehat{Q}_{ijt}$ – firm's cost shock; $\widehat{Q}_{jt} \equiv \sum_i s_{ij} \widehat{Q}_{ijt}$
- s_{ij} – firm's market share
- λ_j – share of firms that do not adjust prices
- $\varphi_{ij} \equiv (\theta-1)s_{ij}/(1-s_{ij})$ – strategic complementarity due to market power
- $\Lambda(\vec{\varphi}_j, \lambda_j)$ is 'sticky price multiplier' that governs dynamics of sectoral prices

Key proposition

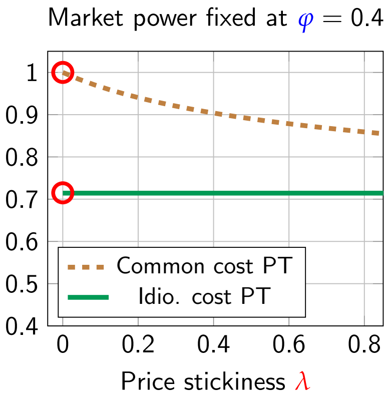
The distributor's optimal reset price, up to a first-order approximation, is:

$$\widehat{P}_{ijt,t} = \frac{1}{1+\varphi_{ij}} \times \underbrace{\left(\widehat{Q}_{ijt} - \widehat{Q}_{jt}\right)}_{\text{Idiosyncratic change}} + \left[\frac{1}{1+\varphi_{ij}} + \frac{\varphi_{ij}}{1+\varphi_{ij}}\left(\frac{1-\Lambda(\vec{\varphi}_j, \lambda_j)}{1-\beta\lambda_j\Lambda(\vec{\varphi}_j, \lambda_j)}\right)\right] \times \underbrace{\widehat{Q}_{jt}}_{\text{Common change}}$$

- $\widehat{Q}_{ijt}$ – firm's cost shock; $\widehat{Q}_{jt} \equiv \sum_i s_{ij} \widehat{Q}_{ijt}$
- s_{ij} – firm's market share
- λ_j – share of firms that do not adjust prices
- $\varphi_{ij} = (\theta - 1)\left(\frac{\theta-1}{\theta}\mu_{ij} - 1\right)$ – strategic complementarity due to market power
- $\Lambda(\vec{\varphi}_j, \lambda_j)$ is 'sticky price multiplier' that governs dynamics of sectoral prices

Differential pass-through by market power and price stickiness

$$\widehat{P}_{ijt,t} = \frac{1}{1+\varphi_{ij}} \times \left(\widehat{Q}_{ijt} - \widehat{Q}_{jt}\right) + \left[\frac{1}{1+\varphi_{ij}} + \frac{\varphi_{ij}}{1+\varphi_{ij}} \left(\frac{1-\Lambda(\vec{\varphi}_j, \lambda_j)}{1-\beta\lambda\Lambda(\vec{\varphi}_j, \lambda_j)}\right)\right] \times \widehat{Q}_{jt}$$

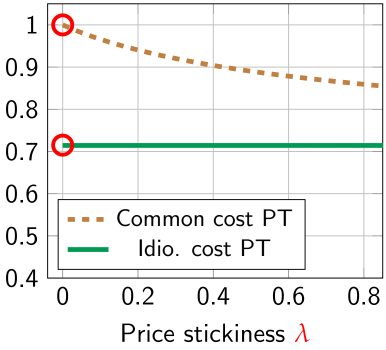


- Flexible price case: complete pass through to common cost change (Amiti, Itskhoki, Konings 19)

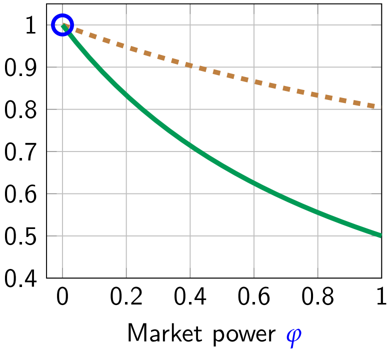
Differential pass-through by market power and price stickiness

$$\widehat{P}_{ijt,t} = \frac{1}{1+\varphi_{ij}} \times \left(\widehat{Q}_{ijt} - \widehat{Q}_{jt}\right) + \left[\frac{1}{1+\varphi_{ij}} + \frac{\varphi_{ij}}{1+\varphi_{ij}} \left(\frac{1-\Lambda(\vec{\varphi}_j, \lambda_j)}{1-\beta\lambda\Lambda(\vec{\varphi}_j, \lambda_j)}\right)\right] \times \widehat{Q}_{jt}$$

Market power fixed at $\varphi = 0.4$



Price stickiness fixed at $\lambda = 0.4$



- No market power: complete PT to both shocks as in standard NK models

Roadmap

- Model and closed form
- Empirical results
- Micro to macro: aggregate price and output dynamics

Canadian Wholesale Services Price Index microdata

- Monthly data from Jan 2013 to Dec 2019
- Firm-product level info on price and cost ($\approx$ 280k obs after cleaning)
  - selling price, purchase price (reliable measure of marginal cost)
  - markup = (selling price)/(purchase price)
- A large sample of firms ($\approx$ 1,800 obs after cleaning)
  - can identify common (industry-wide) vs. idiosyncratic cost changes
- Observe the sector (4-digit NAICS and 7-digit NAPCS codes) of the firm-product
  - exploit sector-level variation in price stickiness and market power (average markup)

▸ markup by sector

Empirical specification: Step 1

Decompose cost changes into two components using a fixed effect approach:

(*à la* Di Giovanni, Levchenko & Mejean 14)

$$\Delta \ln(Q_{ijt}) = \underbrace{\epsilon_{jt}}_{\text{Common cost change}} + \underbrace{\epsilon_{ijt}}_{\text{Idiosyncratic cost change}}$$

- i, j, t denotes firm-product, sector, month, respectively

Empirical specification: Step 2

Estimate selling price adjustments to these two cost changes:

$$\Delta \log(P_{ijt}) = \underbrace{(\Psi + \Psi^{ps}\lambda_j + \Psi^{mp}D_j)}_{\text{common cost PT}} \cdot \widehat{\epsilon}_{jt} + \underbrace{(\psi + \psi^{ps}\lambda_j + \psi^{mp}D_j)}_{\text{idiosyncratic cost PT}} \cdot \widehat{\epsilon}_{ijt} + FE_{ij} + \nu_{ijt}$$

- Estimate conditional on price adjustment: when $\Delta \log(P_{ijt}) \neq 0$
- Weighted by market share of firm-product s_{ij}
- λ_j: sectoral price stickiness
- D_j: dummy for high markup (market power) sectors

Reset price pass-through estimates (NAICS4 industries)

	Data	Model prediction
Common cost		≈ 1
Common cost $\times$ Sector stickiness		< 0
Common cost $\times$ High-markup sector		< 0
Idio. cost		< 1
Idio. cost $\times$ Sector stickiness		≈ 0
Idio. cost $\times$ High-markup sector		< 0
Observations	136,085	
Firm-product fixed effects	✓	
R^2	0.5	

† means not statistically different from 1; ‡ means statistically different from 1; $**$ means statistically different from 0.

By industry estimates · Firm Heter. · NAPCS7 Estimates

Reset price pass-through estimates (NAICS4 industries)

	Data	Model prediction
Common cost	1.08† (0.11)	≈ 1
Common cost $\times$ Sector stickiness	-0.96** (0.34)	< 0
Common cost $\times$ High-markup sector	-0.29** (0.11)	< 0
Idio. cost		< 1
Idio. cost $\times$ Sector stickiness		≈ 0
Idio. cost $\times$ High-markup sector		< 0
Observations	136,085	
Firm-product fixed effects	✓	
R^2	0.5	

$\dagger$ means not statistically different from 1; $\ddagger$ means statistically different from 1; $**$ means statistically different from 0.

By industry estimates | Firm Heter. | NAPCS7 Estimates

Reset price pass-through estimates (NAICS4 industries)

	Data	Model prediction
Common cost	1.08†	≈ 1
	(0.11)	
Common cost × Sector stickiness	-0.96**	< 0
	(0.34)	
Common cost × High-markup sector	-0.29**	< 0
	(0.11)	
Idio. cost	0.75‡	< 1
	(0.06)	
Idio. cost × Sector stickiness	0.03	≈ 0
	(0.13)	
Idio. cost × High-markup sector	-0.25***	< 0
	(0.05)	
Observations	136,085	
Firm-product fixed effects	✓	
R^2	0.5	

† means not statistically different from 1; ‡ means statistically different from 1; ** means statistically different from 0.

By industry estimates | Firm Heter. | NAPCS7 Estimates

Roadmap

- Model and closed form
- Empirical results
- Micro to macro: aggregate price and output dynamics

Aggregation: homogeneous sectors

When $\varphi_j = \varphi$ and $\lambda_j = \lambda$, the aggregate New Keynesian Phillips curve is given by:

$$\widehat{\pi}_t = \frac{(1-\beta\lambda)(1-\lambda)}{\lambda\,(1+\varphi)}\widehat{mc}_t + \beta\mathbb{E}_t\widehat{\pi}_{t+1}$$

Aggregation: homogeneous sectors

When $\varphi_j = \varphi$ and $\lambda_j = \lambda$, the aggregate New Keynesian Phillips curve is given by:

$$\widehat{\pi}_t = \frac{(1-\beta\lambda)(1-\lambda)}{\lambda\,(1+\varphi)}\widehat{mc}_t + \beta\mathbb{E}_t\widehat{\pi}_{t+1}$$

Relative to standard monopolistic competitive Calvo,

- Slope of NKPC is reduced by a factor of $\frac{1}{1+\varphi} \approx 0.7$
- Cumulative output response to MP shock is amplified by a factor of $\frac{\Lambda(1-\lambda)}{\lambda(1-\Lambda)} \approx 1.28$

$\Rightarrow$ Sizable amplification

Amplification of monetary non-neutrality

Relative to monopolistic competitive Calvo

	(1)
	one-sector OC
Slope of NKPC	0.70
Cum. Output to MP shock	1.28

1. Market power reduces the NKPC by 30%, resulting output amplification of 28%

Amplification of monetary non-neutrality

Relative to monopolistic competitive Calvo

	(1) one-sector OC	(2) multi-sector OC, heter price stick + homo market power
Slope of NKPC	0.70	0.52
Cum. Output to MP shock	1.28	1.57

2. Allowing industry heterogeneity in price stickiness further reduces slope of NKPC by 20%

Amplification of monetary non-neutrality

Relative to monopolistic competitive Calvo

	(1) one-sector OC	(2) multi-sector OC, heter price stick + homo market power	(3) multi-sector OC, heter price stick + heter market power
Slope of NKPC	0.70	0.52	0.36
Cum. Output to MP shock	1.28	1.57	1.96

3. With heterogeneity in market power and price stickiness
   - 64% reduction in slope of NKPC and 100% increase in cumulative output response
   - amplification due to pos corr between nominal price rigidity and str complementarity

▸ NAPCS7 Results

Contributions

How interaction of market power and price stickiness impacts transmission of shocks

- Account for effect of price stickiness on degree of pass-through at monthly frequency
- Incorporate the observed margin as a reliable measure of market power
- Distinguish pass-through of idiosyncratic and common cost shocks
- Exploit variation in price stickiness and market power across and within sectors

Contributions

How interaction of market power and price stickiness impacts transmission of shocks

- Account for effect of price stickiness on degree of pass-through at monthly frequency
- Incorporate the observed margin as a reliable measure of market power
- Distinguish pass-through of idiosyncratic and common cost shocks
- Exploit variation in price stickiness and market power across and within sectors

At the aggregate level, this interaction results in:

- 2/3 decline in slope of New Keynesian Phillips curve
- 100% increase cumulative output response to monetary policy shock

Appendix

Optimal reset price

Distributors' optimal reset price takes the usual Calvo form:

$$P_{ijt,t} = \frac{\mathbb{E}_t \sum_{\tau=0}^{\infty} (\beta\lambda_j)^{\tau} \vartheta_{ijt+\tau,t} C_{ijt+\tau,t}}{\mathbb{E}_t \sum_{\tau=0}^{\infty} (\beta\lambda_j)^{\tau} (\vartheta_{ijt+\tau,t} - 1) C_{ijt+\tau,t} / Q_{ijt+\tau}}$$

- i, j, t denotes firm, industry, time; λ_j is probability of no price adjustment
- $Q_{ijt+\tau}$ is cost of product sold; $C_{ijt+\tau,t}$ is expected demand of $t+\tau$ at t

Expected effective demand elasticity:

$$\mathbb{E}_t \vartheta_{ijt+\tau,t} = \mathbb{E}_t \left[\frac{1}{\theta} (1 - s_{ijt+\tau,t}) + s_{ijt+\tau,t} \right]^{-1}$$

Changes in expected market share depends on expected future sector price $\mathbb{E}_t \widehat{P}_{jt+\tau}$:

$$\mathbb{E}_t \widehat{s}_{ijt+\tau,t} = -(\theta - 1) \left[\widehat{P}_{ijt,t} - \mathbb{E}_t \widehat{P}_{jt+\tau} \right]$$

With small shocks: $\mathbb{E}_t \widehat{P}_{jt+\tau}$ can be solved analytically $\Rightarrow$ closed-form solution

▸ Details

Aggregation: heterogeneous sectors

With heterogeneity in λ_j, aggregate price stickiness is no longer $\lambda \equiv \sum_j \alpha_j \lambda_j$ (Carvalho 06)

Under a permanent monetary policy shock at $t = 0$ (i.e., $\widehat{M}_\tau = 1 \ \forall \tau \geq 0$):

$$\widehat{P}_\tau = (1-\lambda)\widehat{P}_{\tau,\tau} + \lambda \widehat{P}_{\tau-1} - Cov_j\left[\lambda_j, \frac{1-\Lambda_j}{1-\lambda_j}(\Lambda_j)^\tau\right]$$

$$\widehat{C}_\tau = 1 - \widehat{P}_\tau = \Lambda^{\tau+1} \quad + \underbrace{x_\tau \Lambda^{\tau+1}}_{\text{heterogeneity effect } \geq 0}$$

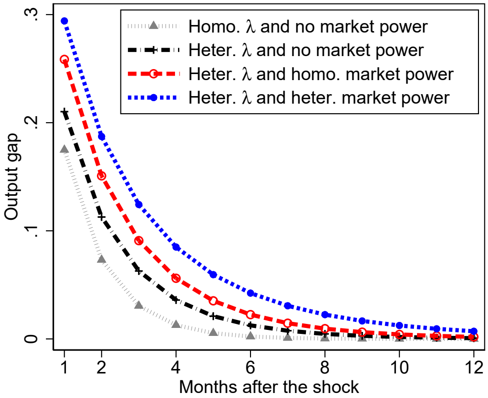
- $\Lambda_j(\lambda_j, \varphi_j) \geq \lambda_j$ is sticky price multiplier with $\Lambda_j \to \lambda_j$ as $\varphi_j \to 0$
- $\Lambda \equiv \sum_j \alpha_j \Lambda_j$ and $x_\tau \equiv \sum_j \alpha_j \Lambda_j^{\tau+1} / \Lambda^{\tau+1} - 1 \geq 0$

Next, calibrate the model to match industrial heterogeneity in λ_j and φ_j

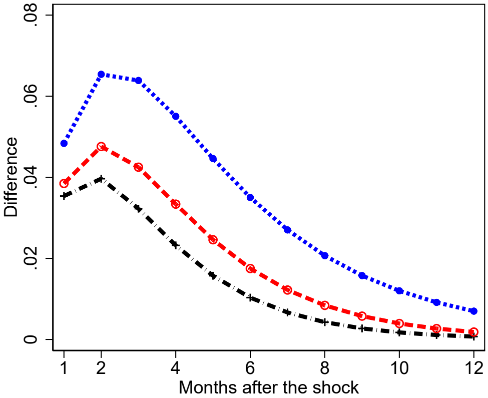
Data

Amplification due to heterogeneity

(a) Output response to MP shock: $\widehat{C}_\tau$



(b) Heterogeneity effect: $x_\tau \Lambda^{\tau+1}$



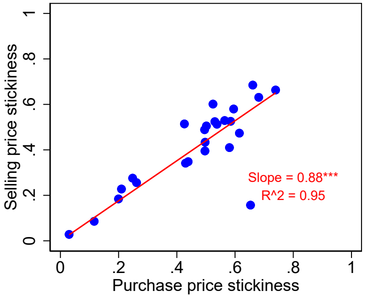
$\Rightarrow$ Much larger effects due to heterogeneity in price stickiness and market power

Synchronization in selling and purchase price adjustments

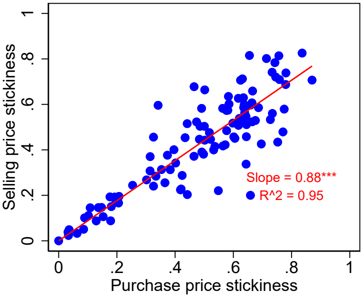
(a) firm-product level

		Selling price change	
		Yes	No
Purchase price change	Yes	**0.86**	0.14
	No	0.25	0.75

(b1) 4-digit NAICS industry level

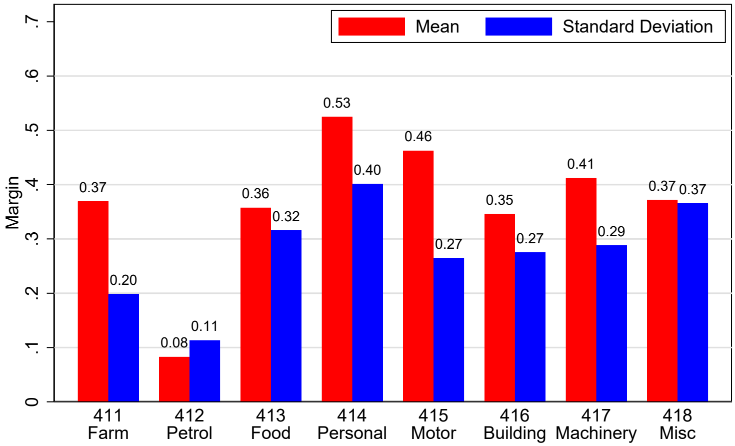


(b2) 7-digit NAPCS product level



Back

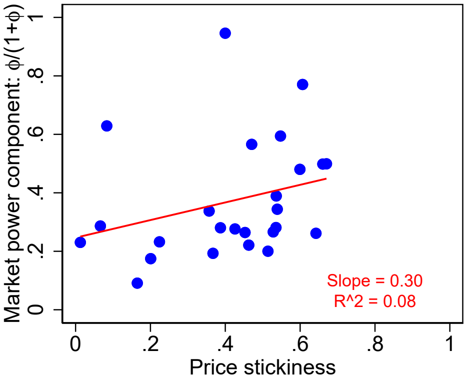
Average markup by 3-digit NAICS wholesale industry



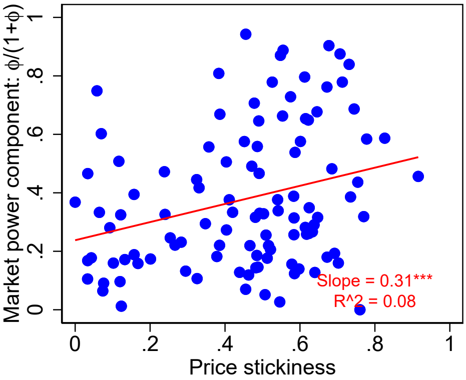
Back

Correlation between market power and stickiness

(a) NAPCS4 Industry Estimates



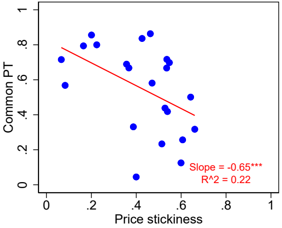
(b) NAPCS7 Product Estimates



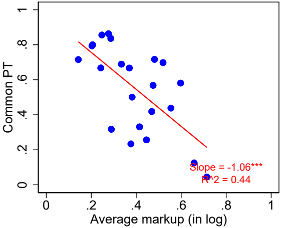
Back

Estimates by 4-digit NAICS wholesale industries

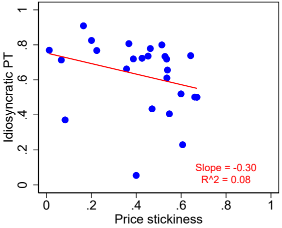
(a) Common PT vs price stick



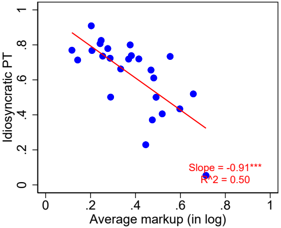
(b) Common PT vs markup



(c) Idio PT vs price stick



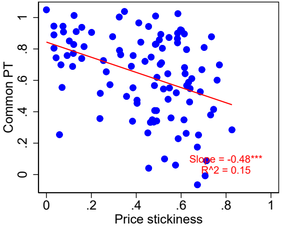
(d) Idio PT vs markup



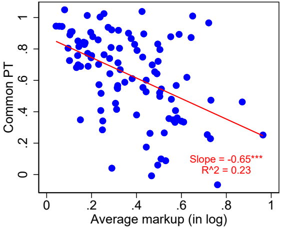
Back

(i) Estimates by NAPCS7 products

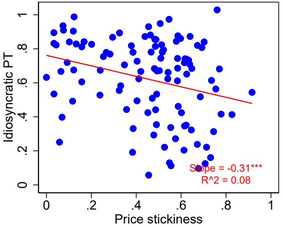
(a) Common PT vs price stick



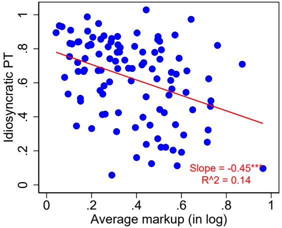
(b) Common PT vs markup



(c) Idio PT vs price stick



(d) Idio PT vs markup



Back

(ii) Pooled pass-through estimates by NAPCS7 product characteristics

	Data	Model prediction
Common cost	0.89	≈ 1
	(0.04)	
Common cost $\times$ Product stickiness	-0.23	< 0
	(0.17)	
Common cost $\times$ High-markup product	-0.22	< 0
	(0.15)	
Idio. cost	$0.75^{\ddagger}$	< 1
	(0.04)	
Idio. cost $\times$ Product stickiness	0.04	≈ 0
	(0.10)	
Idio. cost $\times$ High-markup product	-0.23^{***}	< 0
	(0.09)	
Observations	133,620	
Firm-product fixed effects	✓	
R^2	0.57	

‡ means statistically different from 1; $**$ means statistically different from 0.

Back

(ii) NAICS4 estimates with firm markup interactions

	Data	Model prediction
Common cost	1.05†	≈ 1
	(0.05)	
Common cost $\times$ Industry stickiness	-0.70**	< 0
	(0.25)	
Common cost $\times$ High-markup industry	-0.29**	< 0
	(0.10)	
Common cost $\times$ High-markup firm	**-0.05**	ambiguous
	(0.19)	
Idio. cost	0.88‡	< 1
	(0.04)	
Idio. cost $\times$ Industry stickiness	-0.04	≈ 0
	(0.10)	
Idio. cost $\times$ High-markup industry	-0.24***	< 0
	(0.04)	
Idio. cost $\times$ High-markup firm	**-0.33*****	< 0
	(0.04)	
Observations	136,085	
Firm-product fixed effects	✓	
R^2	0.52	

$\dagger$ means not statistically different from 1; $\ddagger$ means statistically different from 1; $**$ means statistically different from 0.

Back

Amplification of monetary non-neutrality: NAPCS7 product results

Relative to monopolistic competitive Calvo

	(1) one-sector OC	(2) multi-sector OC, heter price stick + homo market power	(3) multi-sector OC, heter price stick + heter market power
Slope of NKPC	0.70	0.40	0.26
Cum. Output from MP shock	1.28	1.84	2.38

Back

Expected sectoral price dynamics

The usual Calvo dynamics hold in **expectations**:

$$\begin{aligned}
\mathbb{E}_t \widehat{P}_{jt+\tau} &= \mathbb{E}_t \sum_i s_{ijt+\tau} \widehat{P}_{ijt+\tau} \\
&= (1-\lambda_j)\mathbb{E}_t \sum_i s_{ijt+\tau} \widehat{P}_{ijt+\tau,t+\tau} + \lambda_j \mathbb{E}_t \sum_i s_{ijt+\tau} \widehat{P}_{ijt+\tau-1} \\
&\approx (1-\lambda_j)\mathbb{E}_t \widehat{P}_{jt+\tau,t+\tau} + \lambda_j \mathbb{E}_t \widehat{P}_{jt+\tau-1}.
\end{aligned}$$

- Works for small shocks: $\sum_i s_{ijt+\tau} \widehat{P}_{ijt+\tau-1} \approx \sum_i s_{ijt+\tau-1} \widehat{P}_{ijt+\tau-1}$

Expected sectoral New Keynesian Phillips Curve can be expressed as:

$$\mathbb{E}_t \widehat{\pi}_{jt} = \sum_i s_{ij} \frac{(1-\beta\lambda_j)(1-\lambda_j)}{\lambda_j (1+\varphi_{ij})} \mathbb{E}_t (\widehat{Q}_{ijt,t} - \widehat{P}_{jt}) + \beta \mathbb{E}_t \widehat{\pi}_{jt+1}$$

- Can be solved analytically and used in firm's problem to get closed-form solution

Back

Comparing theoretical vs simulated responses

(when $\theta = 3$, $\bar{s} = 0.5$ and $\beta = 0.98^{1/12}$)