Market structure and monetary non-neutrality

Simon Mongey

Federal Reserve Bank of Minneapolis

RBA Quantitative Macroeconomics Workshop

December 14, 2017

The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

Introduction

Monetary economics

- How do changes in nominal spending affect output vs. inflation?
- Nominal rigidity + Firms are ‘small’ in their market (competitive)

Introduction

Monetary economics

- How do changes in nominal spending affect output vs. inflation?
- Nominal rigidity + Firms are ‘small’ in their market (competitive)

This paper

- Nominal rigidity + Firms are ‘large’ in their market (strategic)

Introduction

Monetary economics

- How do changes in nominal spending affect output vs. inflation?
- Nominal rigidity + Firms are ‘small’ in their market (competitive)

This paper

- Nominal rigidity + Firms are ‘large’ in their market (strategic)

Motivation

1. Markets dominated by a few large firms ▸ Fig. - Distributions of concentration

   e.g. Mayonnaise, Ohio, 2005:Q1 - Hellman’s 45%, Kraft 33% (IRI data)
2. “Increasing concentration” - Philippon Gutierrez (2017), Autor et al. (2017)

Introduction

Monetary economics

- How do changes in nominal spending affect output vs. inflation?
- Nominal rigidity + Firms are ‘small’ in their market (competitive)

This paper

- Nominal rigidity + Firms are ‘large’ in their market (strategic)

Motivation

1. Markets dominated by a few large firms ▸ Fig. - Distributions of concentration

   e.g. Mayonnaise, Ohio, 2005:Q1 - Hellman’s 45%, Kraft 33% (IRI data)
2. “Increasing concentration” - Philippon Gutierrez (2017), Autor et al. (2017)

Quantitative question

- How does market structure affect transmission of monetary shocks?

Approach

Quantitative model

- Firm heterogeneity - Idiosyncratic productivity shocks (z)
- Exog. changes in nominal spending - Aggregate money shocks (M)
- Nominal rigidity - Menu cost of changing prices (ξ)
- New - Two ‘large’ firms in each sector. Dynamic oligopoly. ▸ Literature

Approach

Quantitative model

- Firm heterogeneity - Idiosyncratic productivity shocks (z)
- Exog. changes in nominal spending - Aggregate money shocks (M)
- Nominal rigidity - Menu cost of changing prices (ξ)
- New - Two 'large' firms in each sector. Dynamic oligopoly. ▸ Literature

How does market structure affect transmission of monetary shocks?

- Compare: Oligopoly vs. Monopolistic competition
- Calibrate to match same data on good-level price dynamics
  - Frequency of adjustment, Size of adjustment, Average markup

Approach

Quantitative model

- Firm heterogeneity - Idiosyncratic productivity shocks (z)
- Exog. changes in nominal spending - Aggregate money shocks (M)
- Nominal rigidity - Menu cost of changing prices (ξ)
- New - Two 'large' firms in each sector. Dynamic oligopoly. ▸ Literature

How does market structure affect transmission of monetary shocks?

- Compare: Oligopoly vs. Monopolistic competition
- Calibrate to match same data on good-level price dynamics
  - Frequency of adjustment, Size of adjustment, Average markup

Main finding

- **2.5 times larger output fluctuations under duopoly**

Today

- Model
- Simulations $\rightarrow$ Mechanism
- Calibration and results
  1. Firm values are hump-shaped in the menu cost $\rightarrow$ "optimal menu cost"
  2. If $\xi = 0$, then markups 10 ppt smaller $\rightarrow$ "output losses due to $\xi > 0$"
  3. At same parameters prices twice as sticky $\rightarrow$ "endogenous stickiness"
  4. The model does not ...
     - Fit into the class studied by Alvarez-Lippi-Behin
     - Run into the same problems as Klenow-Willis, Burstein-Hellwig
- Market concentration and price flexibility in the IRI data

Household

Flow utility

$$U(C,N) = \log C - N$$

$$C = \left[\int_0^1 C_j^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}} \quad , \quad \theta > 1$$

$$C_j = \left[c_{1j}^{\frac{\eta-1}{\eta}} + c_{2j}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \quad , \quad \eta > \theta$$

Total nominal expenditure

$$PC = \int_0^1 \left[p_{1j}c_{1j} + p_{2j}c_{2j}\right] dj \leq M$$

▸ Details - Recursive household problem with dynamic budget constraint → Discount factor

Markups and profits

Markups

$$\underbrace{\mu_{ij} = \frac{p_{ij}}{W / z_{ij}}}_{\text{Firm}} \quad , \quad \underbrace{\mu_j = \frac{P_j}{W}}_{\text{Sector}} \quad , \quad \underbrace{\mu = \frac{P}{W}}_{\text{Aggregate}}$$

Markups and profits

Markups

$$\underbrace{\mu_{ij} = \frac{p_{ij}}{M / z_{ij}}}_{\text{Firm}} \quad , \quad \underbrace{\mu_j = \frac{P_j}{M}}_{\text{Sector}} \quad , \quad \underbrace{\mu = \frac{P}{M} = \frac{1}{C}}_{\text{Aggregate}}$$

Markups and profits

Markups

$$\underbrace{\mu_{ij} = \frac{p_{ij}}{M / z_{ij}}}_{\text{Firm}} \quad , \quad \underbrace{\mu_j = \frac{P_j}{M}}_{\text{Sector}} \quad , \quad \underbrace{\mu = \frac{P}{M} = \frac{1}{C}}_{\text{Aggregate}}$$

Profits

$$\frac{\pi_{ij}}{M} = \underbrace{\left(\frac{\mu_{ij}}{\mu_j}\right)^{-\eta} \left(\frac{\mu_j}{\mu}\right)^{-\theta} \frac{1}{\mu}}_{\text{Demand } q_{ij}} \underbrace{\left(\mu_{ij} - 1\right)}_{\text{Per-unit profit}} - \underbrace{\xi}_{\text{Menu cost}}$$

where

$$\mu_j = \left[{\mu_{1j}}^{1-\eta} + {\mu_{2j}}^{1-\eta} \right]^{\frac{1}{1-\eta}}$$

$$\mu = \left[\int_0^1 {\mu_j}^{1-\theta} dj \right]^{\frac{1}{1-\theta}}$$

▸ Technical details

Markups and profits

Markups

$$\underbrace{\mu_{ij} = \frac{p_{ij}}{M/z_{ij}}}_{\text{Firm}} \quad , \quad \underbrace{\mu_j = \frac{P_j}{M}}_{\text{Sector}} \quad , \quad \underbrace{\mu = \frac{P}{M} = \frac{1}{C}}_{\text{Aggregate}}$$

Profits

$$\frac{\pi_{ij}}{M} = \underbrace{\left(\frac{\mu_{ij}}{\mu_j}\right)^{-\eta}\left(\frac{\mu_j}{\mu}\right)^{-\theta}\frac{1}{\mu}}_{\text{Demand } q_{ij}}\underbrace{\left(\mu_{ij}-1\right)}_{\text{Per-unit profit}} - \underbrace{\xi_{ij}}_{\xi_{ij}\sim U[0,\bar{\xi}]}$$

where

$$\mu_j = \left[\mu_{1j}^{1-\eta} + \mu_{2j}^{1-\eta}\right]^{\frac{1}{1-\eta}}$$

$$\mu = \left[\int_0^1 \mu_j^{1-\theta} dj\right]^{\frac{1}{1-\theta}}$$

▸ Technical details

Markups and profits

Markups

$$\underbrace{\mu_{ij} = \frac{p_{ij}}{M/z_{ij}}}_{\text{Firm}} \quad , \quad \underbrace{\mu_j = \frac{P_j}{M}}_{\text{Sector}} \quad , \quad \underbrace{\mu = \frac{P}{M} = \frac{1}{C}}_{\text{Aggregate}}$$

Profits

$$\frac{\pi_{ij}}{M} = \underbrace{\left(\frac{\mu_{ij}}{\mu_j}\right)^{-\eta}\left(\frac{\mu_j}{\mu}\right)^{-\theta}}_{\text{Demand } q_{ij}} \underbrace{\frac{1}{\mu}\left(\mu_{ij}-1\right)}_{\text{Per-unit profit}} - \underbrace{\xi_{ij}}_{\xi_{ij}\sim U[0,\bar{\xi}]}$$

where

$$\mu_j = \left[\int_0^1 {\mu_{ij}}^{1-\eta} di\right]^{\frac{1}{1-\eta}}$$

$$\mu = \left[\int_0^1 {\mu_j}^{1-\theta} dj\right]^{\frac{1}{1-\theta}}$$

▸ Technical details

Recursive equilibrium

- Symmetric profit, value, markup, and adjustment prob. functions

$$x = (\mu_1, \mu_2)\,,\; X = \{\lambda, g\},\; \left\{\pi(x,X),\; V(x,X),\; \mu^*(x,X),\; \gamma(x,X)\right\}$$

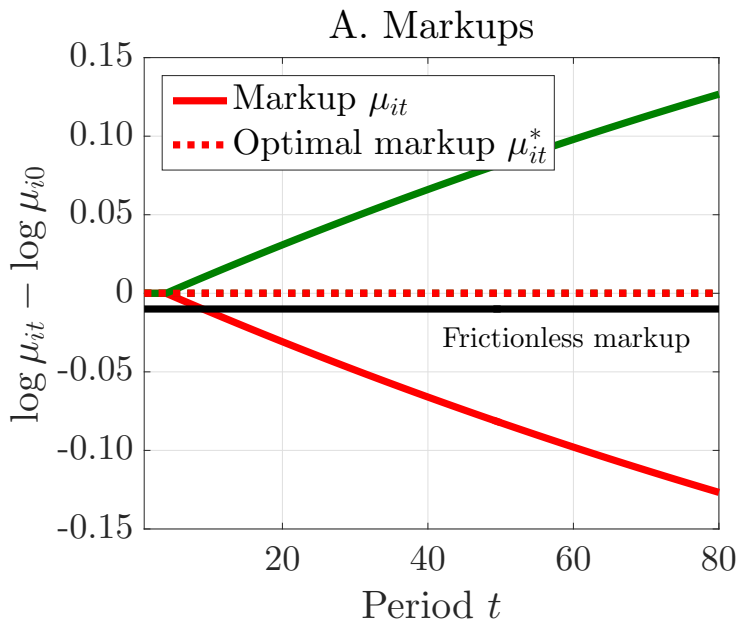
- Transition function for the distribution of sectors $\lambda' = \Gamma_\lambda(X, \lambda)$
- Aggregate markup function $\mu(X)$

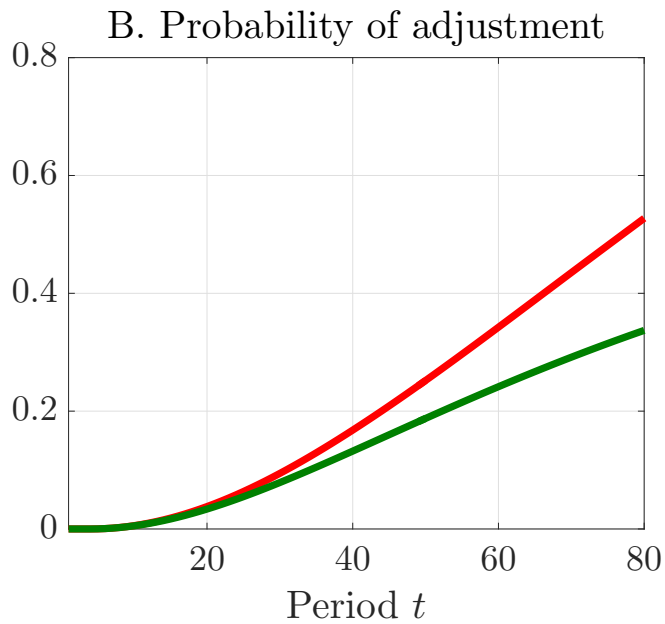
such that

1. Firm policies and values are Markov-Perfect at the sectoral level
2. Labor supply: $W/P = C$, Nominal demand: $PC = M$, Markup: $\mu = P/W$
3. Profit functions are consistent with household optimization (demand functions)
4. Transition function for λ is consistent with policies and processes
5. Aggregate mark-up is consistent with (i) mark-up policies, (ii) λ

▸ Details - States, Information, Forecasting ▸ Details - Computation ▸ Bellman equations

Monopolistic competition





Intensive margin

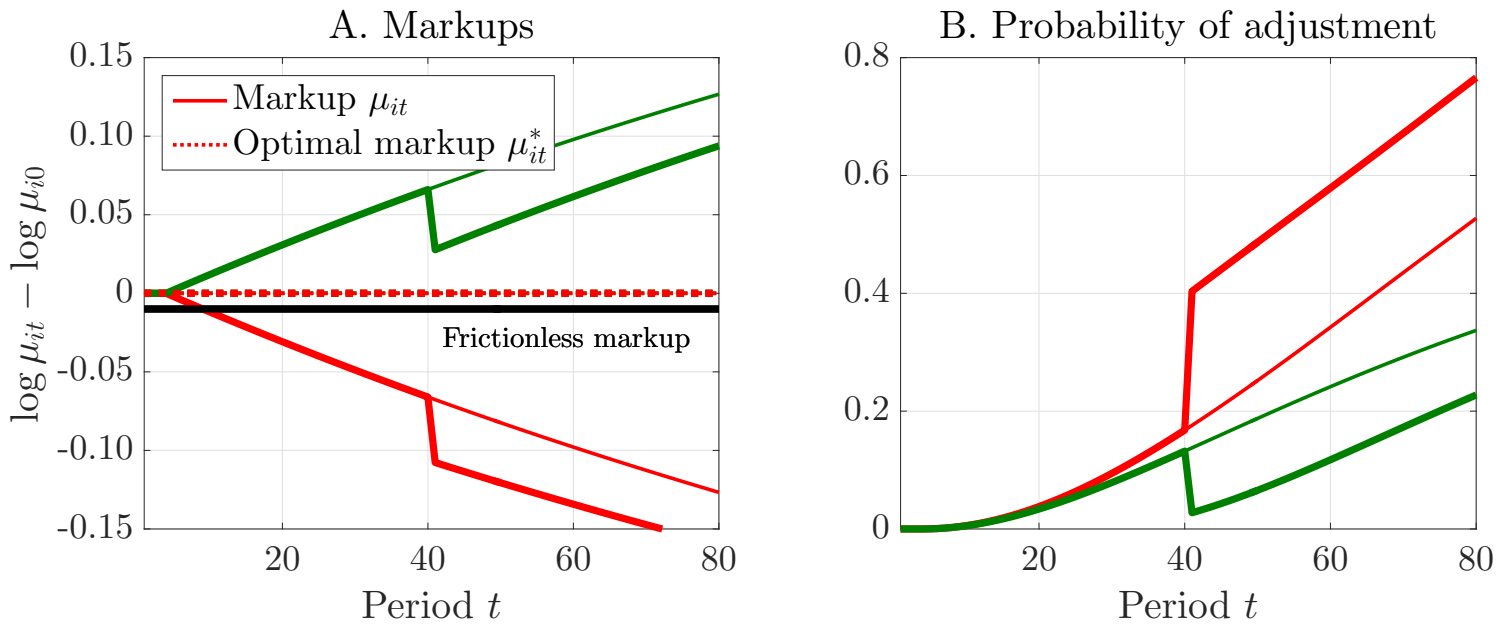
- Same optimal markup $\mu^*_L = \mu^*_H$

Extensive margin

- Precautionary motive $\gamma_L > \gamma_H$

▸ Profit functions

Monopolistic competition - ↑ M



Intensive margin

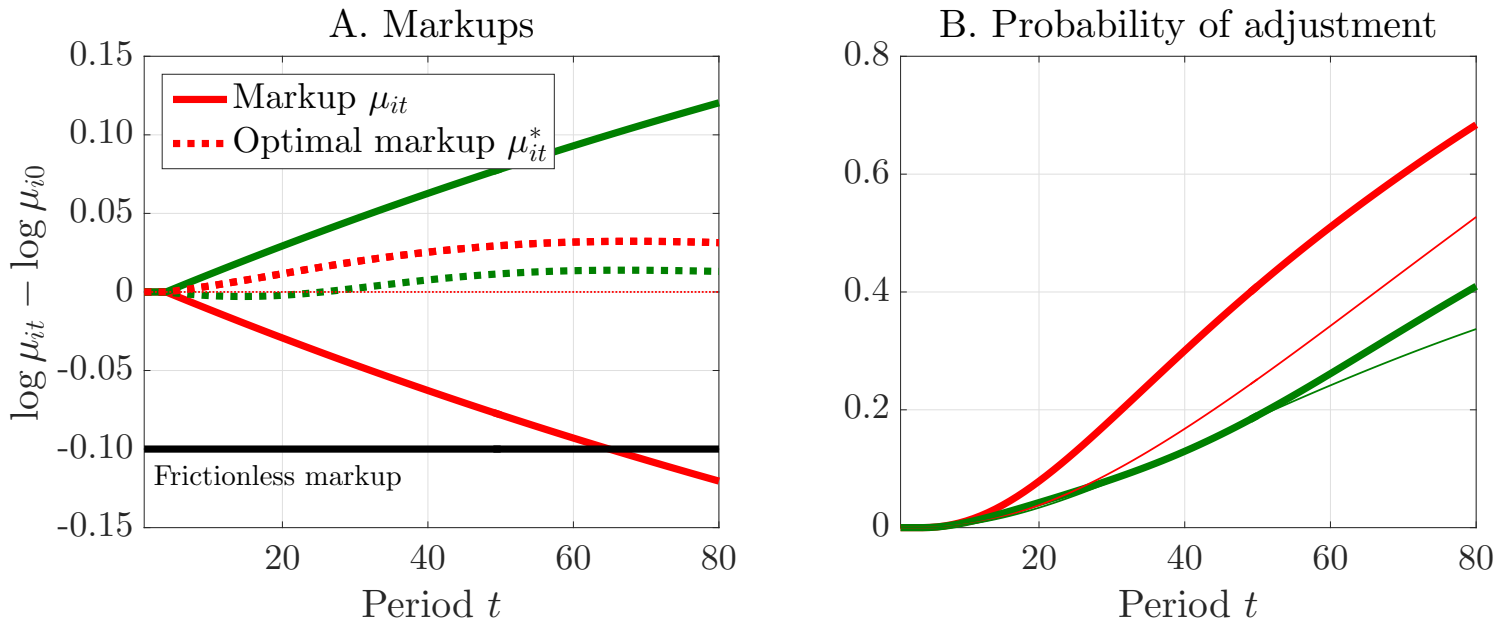
- Optimal price adjustment increases by ΔM

Extensive margin

- Jump in γ_L shifts distribution of price changes to price increases

▸ Profit functions

Duopoly



Intensive margin

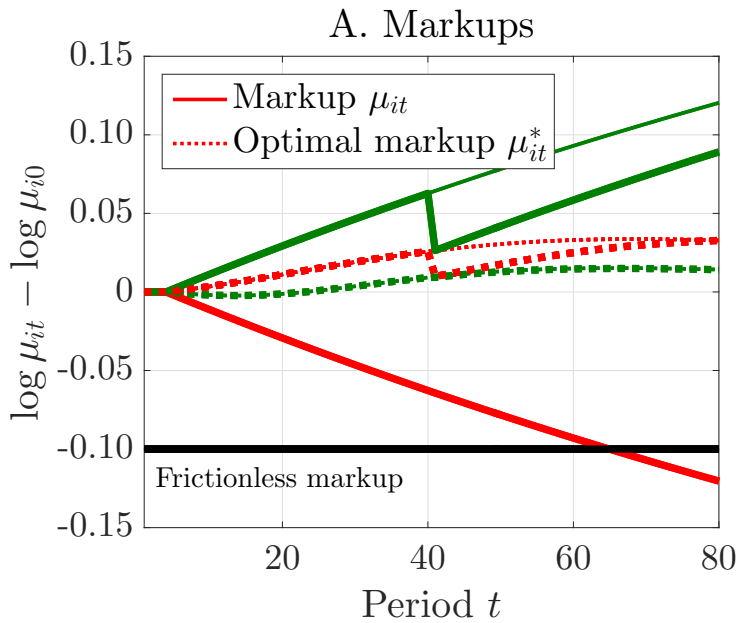
- Policies support a high sectoral markup
- Dynamic complementarity

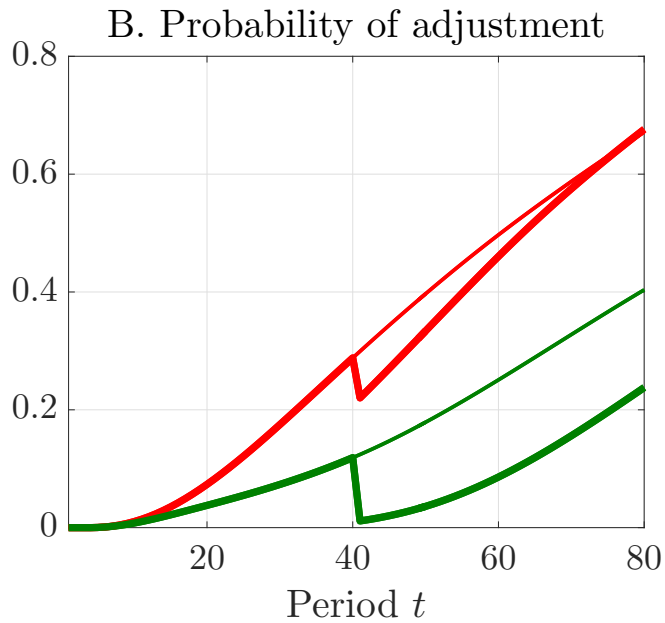
Extensive margin

- High γ_L of price increase incentivizes low γ_H of price decrease

▸ Profit functions

Duopoly - ↑ M





Intensive margin

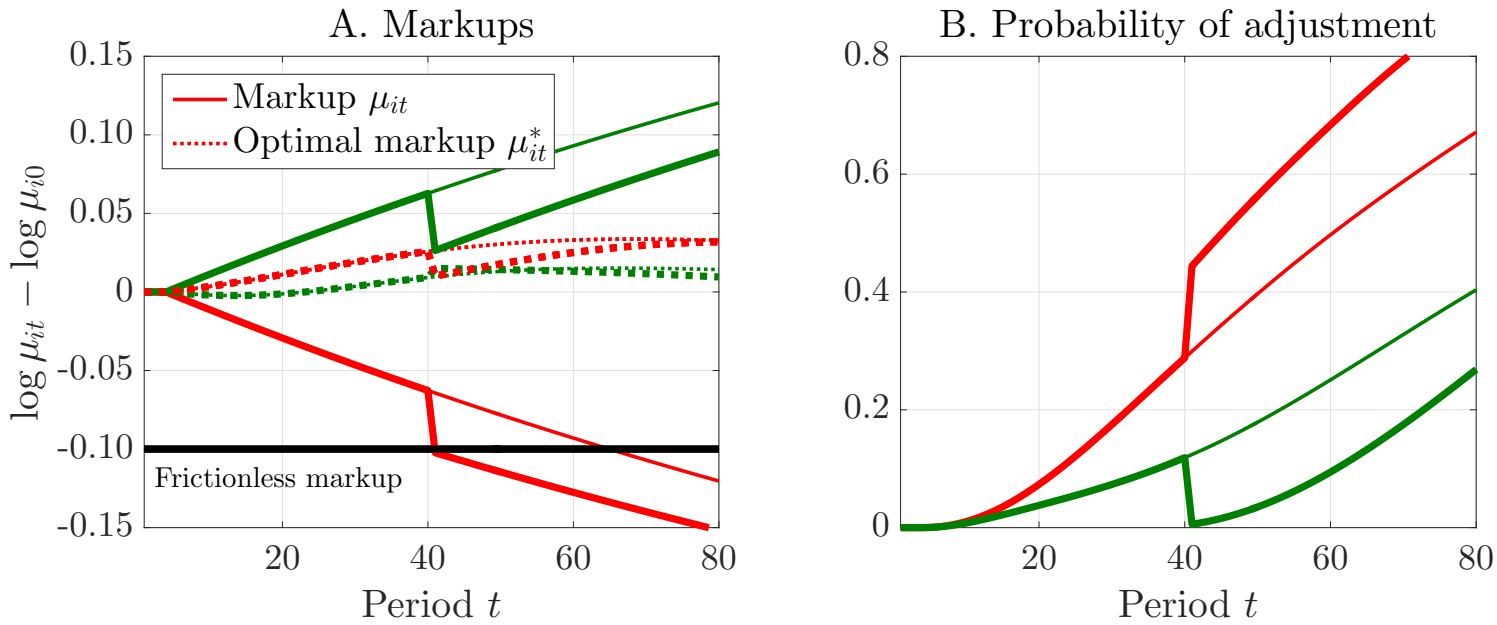
- Lower μ_H reduces μ^*_L

Extensive margin

- Smaller residual demand reduces γ_L

▸ Profit functions

Duopoly - ↑ M



Intensive margin

- Optimal adjustment $\Delta p_L = \mu^*_L / \mu_L$ increases by less than ΔM

Extensive margin

- Dampened increase in γ_L

▸ Profit functions ▸ Two low prices

Calibration - What contributes to larger output effects?

Static complementarity

- More substitutable within sectors η, less across sectors θ

Dynamic complementarity

- *Under what conditions can firms better track each other in MPE?*
- Menu costs are large $\uparrow \bar{\xi}$
- Idiosyncratic shocks are small $\downarrow \sigma_z$
- Price adjustments are chosen, not random (ie Calvo)
- Lower trend money growth $\bar{g}$?
- Lower volatility of money growth σ_g?

Calibration - Parameters and results

		Duopoly	MC
A. Parameter			
Cross-sector demand elasticity	θ	1.5	1.5
Within-sector demand elasticity	η	10.5	4.5
Size of menu cost	$\bar{\xi}$	0.17	0.21
Size of idiosyncratic shocks (%)	σ_z	3.80	4.00
B. Moments matched			
Average markup	$\mathbb{E}\left[\mu_{it}\right]$	1.30	1.30
Frequency of price change		0.13	0.13
Ave. absolute size of price change		0.10	0.10
C. Results			
Std. deviation consumption	$std\left[\log C_t\right] \times 100$	0.31	0.13
Average minus Frictionless markup	$\mathbb{E}\left[\mu_{it}\right] - \mu_f$	0.10	0.02

Calibration - Parameters and results

		Duopoly	MC
A. Parameter			
Cross-sector demand elasticity	θ	1.5	1.5
Within-sector demand elasticity	η	10.5	4.5
Size of menu cost	$\bar{\xi}$	0.17	0.21
Size of idiosyncratic shocks (%)	σ_z	3.80	4.00
B. Moments matched			
Average markup	$\mathbb{E}[\mu_{it}]$	1.30	1.30
Frequency of price change		0.13	0.13
Ave. absolute size of price change		0.10	0.10
C. Results			
Std. deviation consumption	$std[\log C_t] \times 100$	0.31	0.13
Average minus Frictionless markup	$\mathbb{E}[\mu_{it}] - \mu_f$	0.10	0.02

1. 2.5 times larger output fluctuations (Data: US 1969-2016, $std[c_t] \times 100 = 1.01$)

Calibration - Parameters and results

		Duopoly	MC
A. Parameter			
Cross-sector demand elasticity	θ	1.5	1.5
Within-sector demand elasticity	η	10.5	4.5
Size of menu cost	$\bar{\xi}$	0.17	0.21
Size of idiosyncratic shocks (%)	σ_z	3.80	4.00
B. Moments matched			
Average markup	$\mathbb{E}[\mu_{it}]$	1.30	1.30
Frequency of price change		0.13	0.13
Ave. absolute size of price change		0.10	0.10
C. Results			
Std. deviation consumption	$std[\log C_t] \times 100$	0.31	0.13
Average minus Frictionless markup	$\mathbb{E}[\mu_{it}] - \mu_f$	0.10	0.02

1. 2.5 times larger output fluctuations (Data: US 1969-2016, $std[c_t] \times 100 = 1.01$)
2. 10 ppt larger markups than frictionless economy $\rightarrow$ Lower output

Calibration - Parameters and results

		Duopoly	MC
A. Parameter			
Cross-sector demand elasticity	θ	1.5	1.5
Within-sector demand elasticity	η	10.5	4.5
Size of menu cost	$\bar{\xi}$	0.17	0.21
Size of idiosyncratic shocks (%)	σ_z	3.80	4.00
B. Moments matched			
Average markup	$\mathbb{E}[\mu_{it}]$	1.30	1.30
Frequency of price change		0.13	0.13
Ave. absolute size of price change		0.10	0.10
C. Results			
Std. deviation consumption	$std[\log C_t] \times 100$	0.31	0.13
Average minus Frictionless markup	$\mathbb{E}[\mu_{it}] - \mu_f$	0.10	0.02

1. 2.5 times larger output fluctuations (Data: US 1969-2016, $std[c_t] \times 100 = 1.01$)
2. 10 ppt larger markups than frictionless economy $\rightarrow$ Lower output
3. Smaller shocks deliver observed size of price change

Calibration - Parameters and results

		Duopoly	MC
A. Parameter			
Cross-sector demand elasticity	θ	1.5	1.5
Within-sector demand elasticity	η	10.5	4.5
Size of menu cost	$\bar{\xi}$	0.17	0.21
Size of idiosyncratic shocks (%)	σ_z	3.80	4.00
B. Moments matched			
Average markup	$\mathbb{E}[\mu_{it}]$	1.30	1.30
Frequency of price change		0.13	0.13
Ave. absolute size of price change		0.10	0.10
C. Results			
Std. deviation consumption	$std[\log C_t] \times 100$	0.31	0.13
Average minus Frictionless markup	$\mathbb{E}[\mu_{it}] - \mu_f$	0.10	0.02

1. 2.5 times larger output fluctuations (Data: US 1969-2016, $std[c_t] \times 100 = 1.01$)
2. 10 ppt larger markups than frictionless economy $\rightarrow$ Lower output
3. Smaller shocks deliver observed size of price change
4. 25 percent smaller menu costs deliver same frequency of price change

▸ Figure - (i) ξ comp. stats., (ii) IRF of C_t ▸ Table - Alternative calibrations ▸ Figure - Comp. stats η

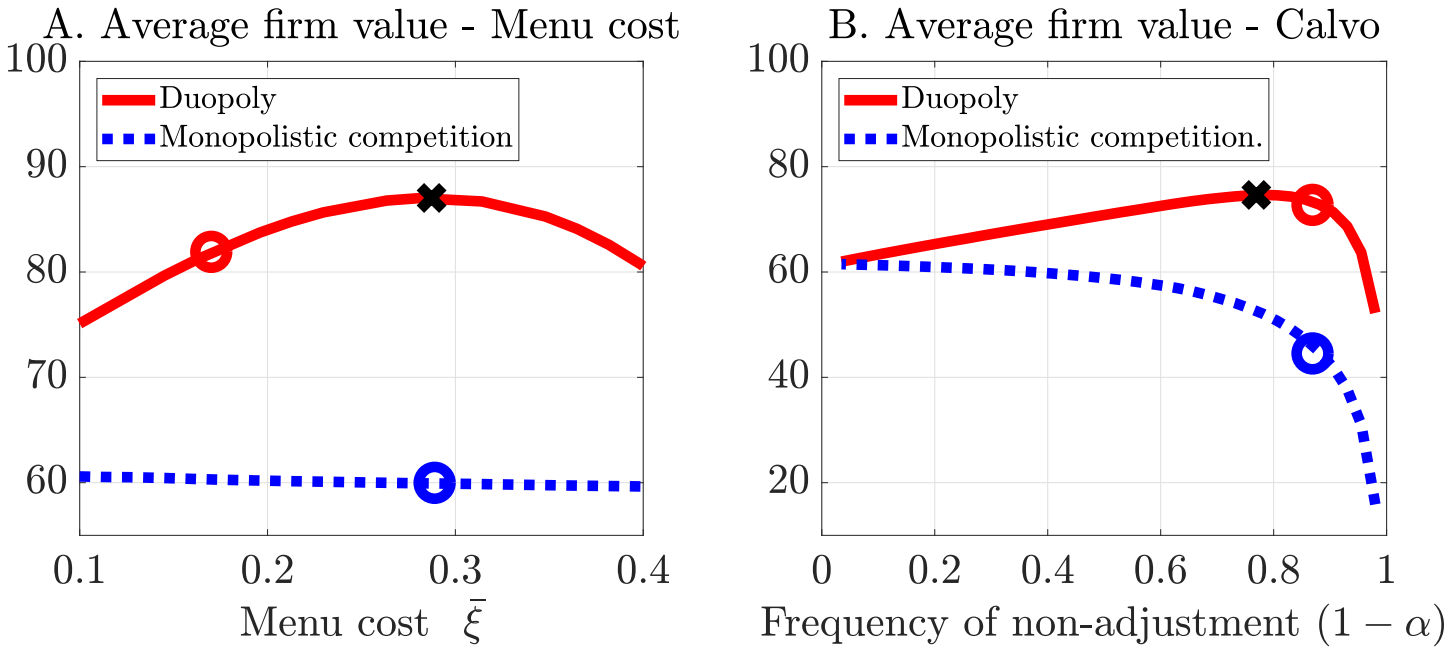
Calibration - Parameters and results

		Duopoly	MC	MC′
A. Parameter				
Cross-sector demand elasticity	θ	1.5	1.5	1.5
Within-sector demand elasticity	η	**10.5**	4.5	↑ **10.5**
Size of menu cost	$\bar{\xi}$	**0.17**	0.21	↓ **0.17**
Size of idiosyncratic shocks (%)	σ_z	**3.80**	4.00	↓ **3.80**
B. Moments matched				
Average markup	$\mathbb{E}[\mu_{it}]$	1.30	1.30	↓ 1.12
Frequency of price change		0.13	0.13	↑ 0.19
Ave. absolute size of price change		0.10	0.10	↓ 0.05
C. Results				
Std. deviation consumption	$std[\log C_t] \times 100$	0.31	0.13	⇓ 0.06
Average minus Frictionless markup	$\mathbb{E}[\mu_{it}] - \mu_f$	0.10	0.02	↓ 0.01

1. 2.5 times larger output fluctuations (Data: US 1969-2016, $std[c_t] \times 100 = 1.01$)
2. 10 ppt larger markups than frictionless economy $\rightarrow$ Lower output
3. Smaller shocks deliver observed size of price change
4. 25 percent smaller menu costs deliver same frequency of price change

▸ Figure - (i) ξ comp. stats., (ii) IRF of C_t ▸ Table - Alternative calibrations ▸ Figure - Comp. stats η

Pricing frictions and firm value



✓ More frictions $\rightarrow$ Higher markups

✗ More frictions $\rightarrow$ Markups further away from μ_{it}^*

- Rationalizes why firms may want to create pricing frictions
  - Sep 24: Apple announces price of $999 for new iPhone on sale Nov 3
  - Annual IKEA catalogue

Market concentration and price flexibility in IRI data

1. Oligopoly

- Prices change less when firms behave strategically
- Lower menu cost in duopoly model
- Here 1 firm = Non-strategic, 2 firms = Strategic, ∞ firms = Non-strategic

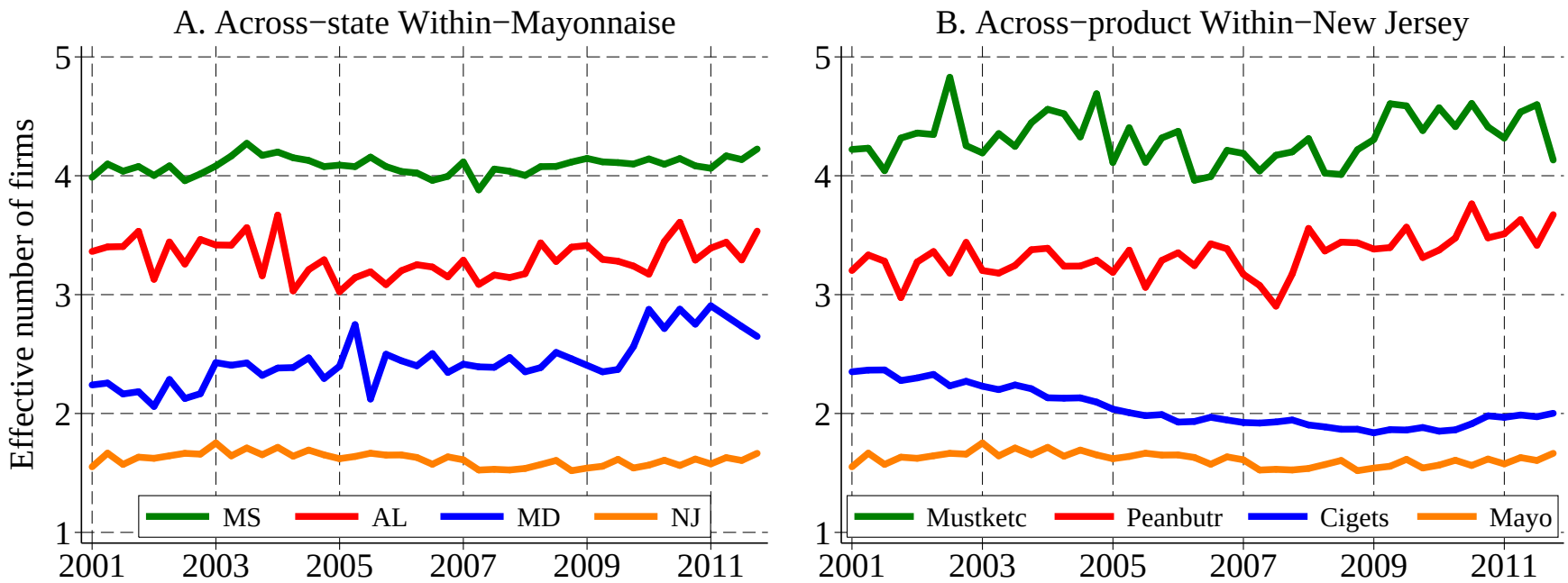
2. Elasticity

- More firms $\rightarrow$ More elastic demand $\rightarrow$ More price changes

Examine correlation structure of IRI data

- U-shaped r'ship between freq of price change and concentration
- Hump-shaped r'ship between size of price change and concentration

Market concentration and price flexibility in IRI data



- Effective number of firms = Inverse Herfindahl Index

✓ Variation across states, within product categories

✓ Variation across product categories, within states

See: Bronnenburg Dhar Dubé (JPE '09), Bronnenburg Dubé Gentzkow (AER '12)

▸ Robust - Revenue share of top firm

▸ Fig. Cross/within region variation in (i) frequency, (ii) size of price changes

Market concentration and price flexibility in IRI data

	Across-state w/in product		Across-product w/in state	
	Size (%)	Frequency	Size (%)	Frequency
Eff. number of firms	0.244***	-0.912***	0.201***	-0.900***
	(0.037)	(0.161)	(0.043)	(0.181)
Eff. number of firms^2	**-0.048*** **	**0.171*** **	**-0.038*** **	**0.228*** **
	(0.010)	(0.043)	(0.012)	(0.072)
Observations	32,016	32,016	32,016	32,016
R-squared	0.100	0.106	0.036	0.031
Rev_{pst} control	✓	✓	✓	✓

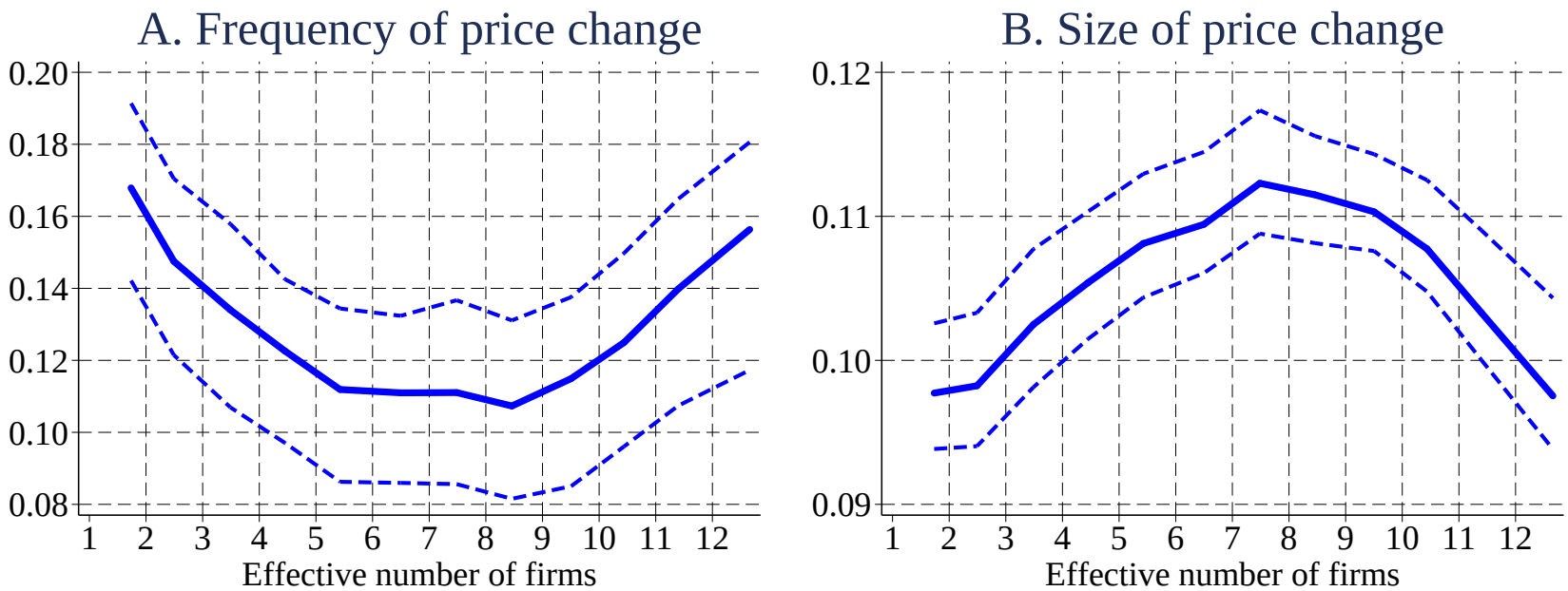
- Standard errors clustered at State $\times$ Product level

Result

- Hump-shaped profiles of price flexibility by market concentration
- Robust to either specification

▸ Estimating equations ▸ Unweighted ▸ Number of goods weighted ▸ No rev. control ▸ Revenue share

Market concentration and price flexibility in IRI data



Note Solid lines plot the revenue weighted mean of predicted (A.) frequency (B) size of price change from across-state within-product regression. Means are computed within *Effective number of firms* bins of width one. Dashed lines give 25^{th} / 75^{th} percentiles.

Conclusion

Market structure quantitatively important for understanding

1. Aggregate price flexibility following nominal spending shocks
2. Firm level price flexibility following idiosyncratic shocks
3. Empirical cross-sectional heterogeneity in price flexibility

Market structure important for macroeconomics

- Increasing concentration and falling labor share

  Autor, Dorn, Katz, Patterson, Van Reenen (2016)

- Increasing concentration and weakening Tobin's Q $\leftrightarrow$ Investment

  Philippon Gutierrez (2016)

Need macroeconomic models that can speak to these changes!

THANK YOU!

Household - Solution

Preferences - $\downarrow z_{ij}, \uparrow Cost, \uparrow Demand$

$$C = \left[\int_0^1 C_j^{\frac{1-\theta}{\theta}} dj\right]^{\frac{\theta}{1-\theta}} \quad , \quad C_j = \left[\left(\frac{c_{1j}}{z_{1j}}\right)^{\frac{1-\eta}{\eta}} + \left(\frac{c_{2j}}{z_{2j}}\right)^{\frac{1-\eta}{\eta}}\right]^{\frac{\eta}{1-\eta}}$$

Demand

$$d_{ij} = z_{ij}^{1-\eta}\left(\frac{p_{ij}}{P_j}\right)^{-\eta}\left(\frac{P_j}{P}\right)^{-\theta} C$$

where

$$P_j = \left[\left(z_{1j}\,p_{1j}\right)^{1-\eta} + \left(z_{2j}\,p_{2j}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}$$

$$P = \left[\int_0^1 {P_j}^{1-\theta} dj\right]^{\frac{1}{1-\theta}}$$

▸ Back - Household solution

1. Output loss due to nominal rigidity

$$Y = \frac{1}{\mu} \quad , \quad \mu = \left[\int_0^1 {\mu_j}^{1-\theta} dj \right]^{\frac{1}{1-\theta}} \quad , \quad \mu_j = \left[{\mu_{1j}}^{1-\eta} + {\mu_{2j}}^{1-\eta} \right]^{\frac{1}{1-\eta}}$$

			Mon. Comp.	Duopoly
(1)	Output		0.76	0.75
(2)	... under no dispersion	$\mu_{ij} = \mathbb{E}[\mu_{ij}]$	0.77	0.77
(3)	... with no menu costs	$\mu_{ij} = \mu_f$	0.78	0.83
(3)-(1)	Output loss due to nominal rigidity		2.4%	9.7%

Result

- Nearly 10% output losses due to nominal rigidity in oligopoly
- 1st order - 75% accounted for by higher markups
- 2nd order - 25% accounted for by price dispersion

▸ Back - Additional results

2. Strategic complementarities in MC models

Strategic complementarities

"Substantial nominal rigidity can arise from a combination of strategic complementarities and nominal frictions" - Ball Romer (1990)

Klenow Willis (2016), Burstein Hellwig (2007)

"Recent work has cast doubt on SC as a source of amplification in menu cost models, by showing that introducing SC's can make it difficult match size, freq. for plausible values of $\bar{\xi}$ *and* σ_z*...this challenge is a serious one"* - Nakamura Steinsson (2010)

This paper

- Smaller $\bar{\xi}$ and σ_z under duopoly
- And $\uparrow std[c_t]$ through strategic complementarity
- How? Complementarity is between μ_{1jt} and μ_{2jt}, not μ_{it} and μ_t

▸ Back - Additional results

Extension - Endogenous entry

Resolve two issues

- Data Many small firms with high turnover
- Theory Threat of entry may affect pricing: $\uparrow M$, $\uparrow \pi$
  - Kokovin Parenti Thisee Zhelobodko (2015)

Extension - Endogenous entry

Resolve two issues

- Data Many small firms with high turnover
- Theory Threat of entry may affect pricing: $\uparrow M, \uparrow \pi$
  - Kokovin Parenti Thisee Zhelobodko (2015)

1. Preferences

$$C = \left[\gamma^{\frac{1}{\eta}} \left[(z_1 c_1)^{\frac{\eta-1}{\eta}} + (z_2 c_2)^{\frac{\eta-1}{\eta}} \right] + (1-\gamma)^{\frac{1}{\eta}} C_f^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

Extension - Endogenous entry

Resolve two issues

- Data Many small firms with high turnover
- Theory Threat of entry may affect pricing: $\uparrow M, \uparrow \pi$
  - Kokovin Parenti Thisee Zhelobodko (2015)

1. Preferences

$$C = \left[\gamma^{\frac{1}{\eta}} \left[(z_1 c_1)^{\frac{\eta-1}{\eta}} + (z_2 c_2)^{\frac{\eta-1}{\eta}} \right] + (1-\gamma)^{\frac{1}{\eta}} C_f^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

2. Endogenous measure δ of atomistic, one-period firms $k \in [0, \delta]$

$$C_f = \left[\int_0^{\delta} c_{fk}^{\frac{\rho-1}{\rho}} dk \right]^{\frac{\rho}{\rho-1}}, \quad p_{fk}^* = \frac{\rho}{\rho-1} M, \quad P_f = \delta^{-\frac{1}{\rho-1}} \frac{\rho}{\rho-1} M$$

Extension - Endogenous entry

Resolve two issues

- Data Many small firms with high turnover
- Theory Threat of entry may affect pricing: $\uparrow M, \uparrow \pi$
  - Kokovin Parenti Thisee Zhelobodko (2015)

1. Preferences

$$C = \left[\gamma^{\frac{1}{\eta}} \left[(z_1 c_1)^{\frac{\eta-1}{\eta}} + (z_2 c_2)^{\frac{\eta-1}{\eta}} \right] + (1-\gamma)^{\frac{1}{\eta}} C_f^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

2. Endogenous measure δ of atomistic, one-period firms $k \in [0, \delta]$

$$C_f = \left[\int_0^{\delta} c_{fk}^{\frac{\rho-1}{\rho}} dk \right]^{\frac{\rho}{\rho-1}}, \quad p_{fk}^* = \frac{\rho}{\rho-1} M, \quad P_f = \delta^{-\frac{1}{\rho-1}} \frac{\rho}{\rho-1} M$$

3. Free-entry determines size of fringe $\pi^f \left(p_1, p_2, z_1, z_2, M, \delta \right) - \phi = 0$

Extension - Exchange-rate pass-through

Question in trade literature

- Question — Euro devalues $10c$, BMW reduces US prices by $2.5c$?
- Answer — BMW competes with Ford, Ford unaffected by shock

Extension - Exchange-rate pass-through

Question in trade literature

- Question Euro devalues $10c$, BMW reduces US prices by $2.5c$?
- Answer BMW competes with Ford, Ford unaffected by shock
- Literature 1 Static oligopoly + Flexible prices + CES
  - Atkeson-Burstein, Pennings

Extension - Exchange-rate pass-through

Question in trade literature

- Question Euro devalues $10c$, BMW reduces US prices by $2.5c$?
- Answer BMW competes with Ford, Ford unaffected by shock
- Literature 1 Static oligopoly + Flexible prices + CES
  - Atkeson-Burstein, Pennings
- Literature 2 Dynamic mono. comp. + Nominal rigidities + Kimball
  - Itskhoki-Gopinath, Itskhoki-Mukhin, Berger-Vavra

Extension - Exchange-rate pass-through

Question in trade literature

- Question Euro devalues $10c$, BMW reduces US prices by $2.5c$?
- Answer BMW competes with Ford, Ford unaffected by shock
- Literature 1 Static oligopoly + Flexible prices + CES
  - Atkeson-Burstein, Pennings
- Literature 2 Dynamic mono. comp. + Nominal rigidities + Kimball
  - Itskhoki-Gopinath, Itskhoki-Mukhin, Berger-Vavra

1. Preferences

$$C = \left[\omega_h^{\frac{1}{\sigma}} \left(z_h c_h \right)^{\frac{\sigma-1}{\sigma}} + \left(1 - \omega_h \right)^{\frac{1}{\sigma}} \left(z_f c_f \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

Extension - Exchange-rate pass-through

Question in trade literature

- Question Euro devalues $10c$, BMW reduces US prices by $2.5c$?
- Answer BMW competes with Ford, Ford unaffected by shock
- Literature 1 Static oligopoly + Flexible prices + CES
  - Atkeson-Burstein, Pennings
- Literature 2 Dynamic mono. comp. + Nominal rigidities + Kimball
  - Itskhoki-Gopinath, Itskhoki-Mukhin, Berger-Vavra

1. Preferences

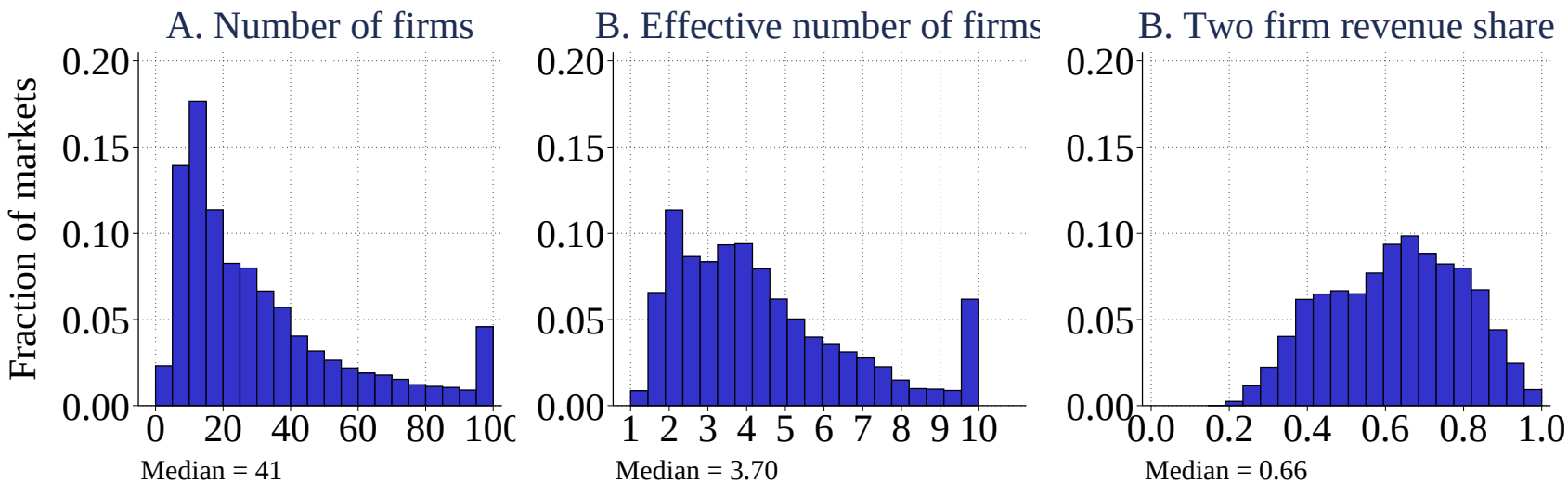
$$C = \left[\omega_h^{\frac{1}{\sigma}} \left(z_h c_h \right)^{\frac{\sigma-1}{\sigma}} + \left(1 - \omega_h \right)^{\frac{1}{\sigma}} \left(z_f c_f \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

2. Marginal cost

$$mc_i = \frac{W^{1-\alpha_i} \left(W^* \right)^{\alpha_i}}{z} \quad + \quad E = \log \left(\frac{W}{W^*} \right) \quad \rightarrow \quad mc_i = \frac{W}{\exp \left(\alpha_i E \right)}$$

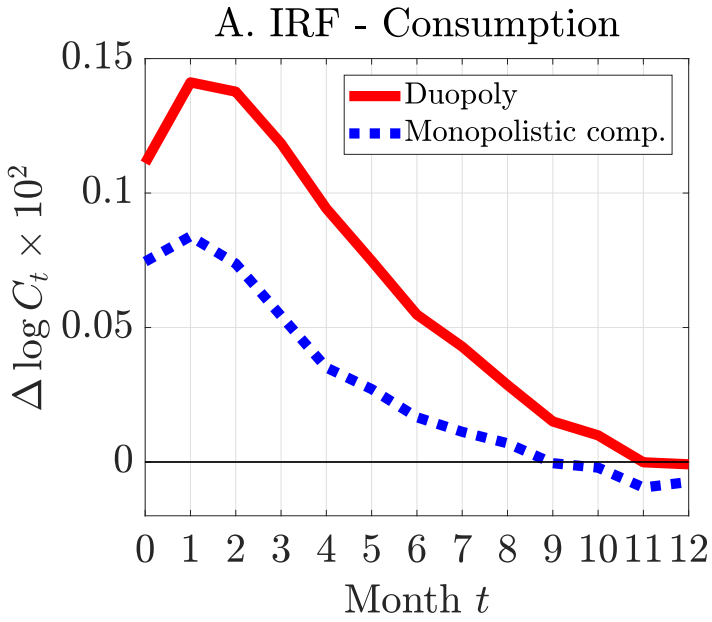
Data - Markets are highly concentrated

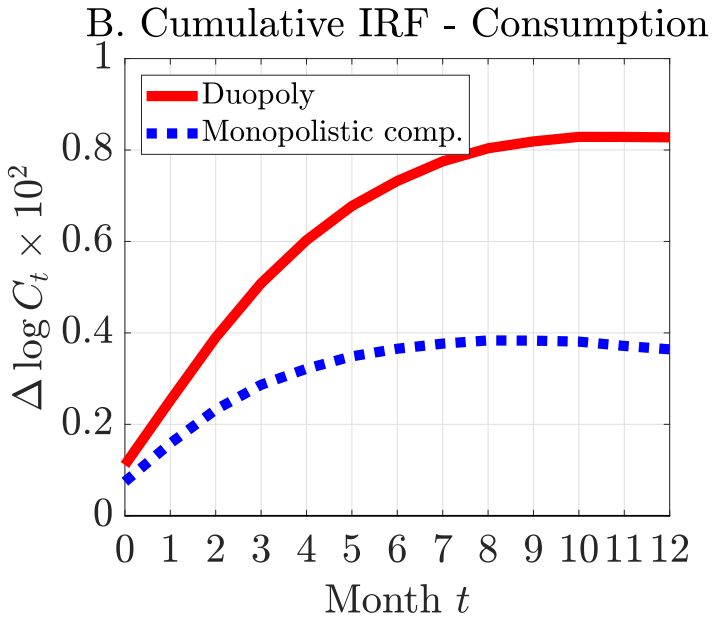
- Market 31 IRI product cat. (p) $\times$ 46 states (s) $\times$ 40 quarters (t)
- Firm First 6 digits of barcode (within a product category)
- Example In the market for Mayonnaise in Ohio, 2005:Q1, of 14 firms, Hellmann's had a 45% revenue share
- Example Herfindahl index of 0.43, Inverse herfindahl index of 2.3



▸ Back - Introduction ▸ Comparison to 6 digit NAICS

Market structure and monetary non-neutrality





Results

- Consumption fluctuations are 2.5 times as large
- Cumulative response of output is 2.4 times as large

Back - Calibration

Literature

1. **Monopolistic competition, menu-costs**

   Monetary Golosov Lucas (2007), Nakamura Steinsson (2010), Midrigan (2011), Vavra (2014)
   Alvarez et al. (2016 $\times 5$), Klenow Willis (2016), Burstein Hellwig (2007)

   Inter'l Itskhoki Gopinath (2010), Itskhoki Mukhin (2016), Berger Vavra (2016)

   New - Dynamic oligopoly

2. **Oligopoly, flexible prices**

   Trade Atkeson Burstein (2008), Edmond Midrigan Xu (2015), Pennings (2015)

   IO Hottman Redding Weinstein (2016)

   New - Nominal rigidity

3. **Dynamic oligopoly, nominal rigidity**

   Maskin-Tirole '88, Jun Vives '04, Einav Somaini '13, Nakamura Zerom '10, Neiman '11

   New - Equilibrium macroeconomic model

Back - Approach

Household

$$\mathbf{W}(S,B) = \max_{\{c_{ij}\},N,\{B(S')\}} \log C - N + \beta \mathbb{E}\left[\mathbf{W}\left(S', B(S')\right)\right]$$

where

$$C = \left[\int_0^1 C_j^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}} \quad , \quad \theta > 1$$

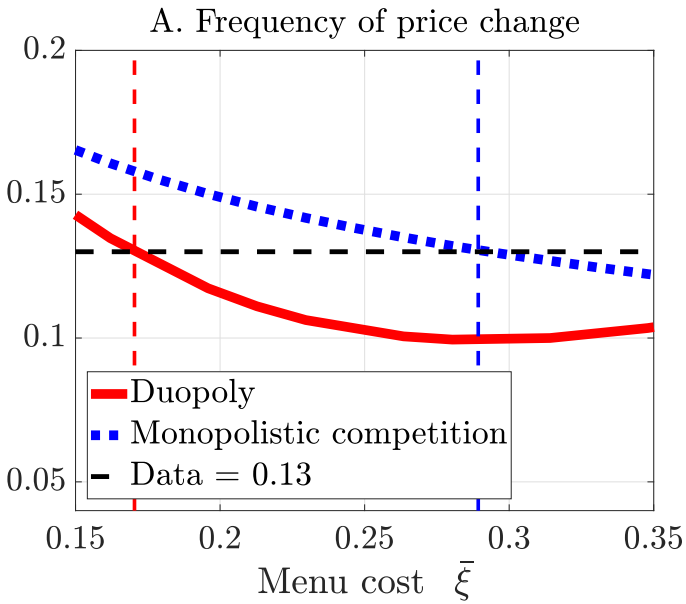
$$C_j = \left[c_{1j}^{\frac{\eta-1}{\eta}} + c_{2j}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \quad , \quad \eta > \theta$$

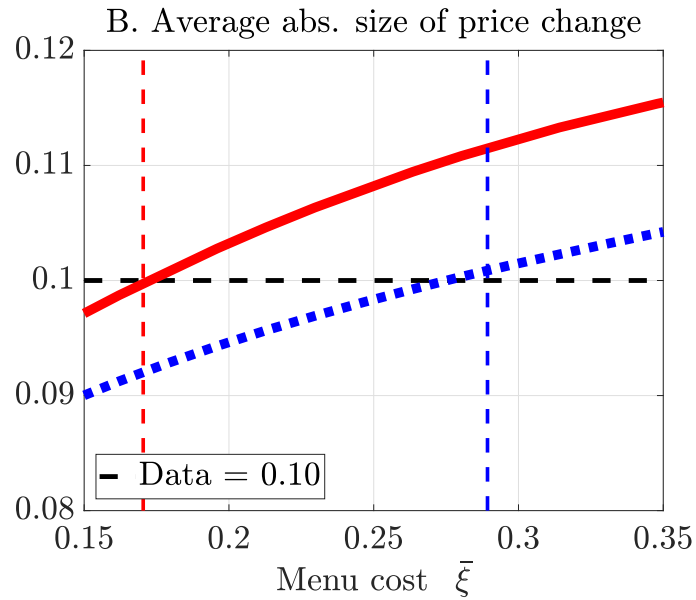
subject to a nominal budget constraint

$$\underbrace{\int_0^1 \left[p_{1j}c_{1j} + p_{2j}c_{2j}\right] dj}_{=M(S)} + \sum_{S'} Q(S,S')B(S') \leq B(S) + W(S)N + \Pi(S)$$

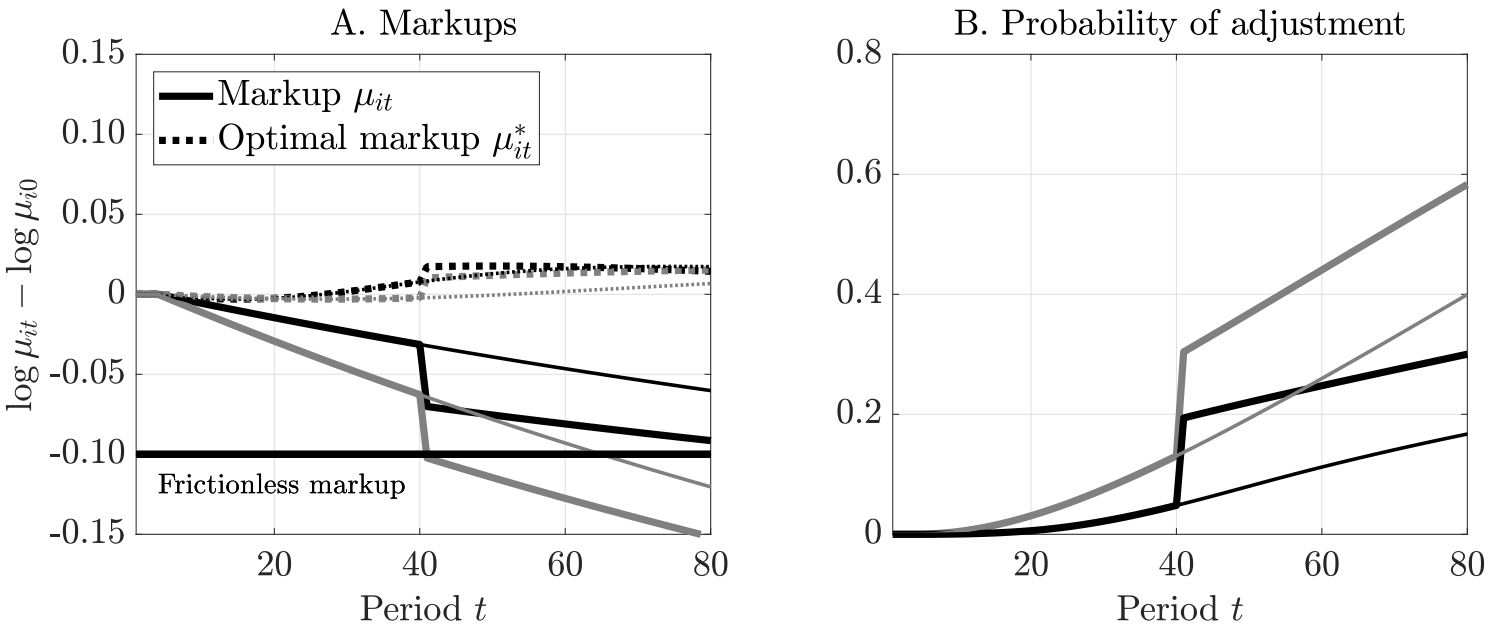
Back - Household preferences

Menu cost comparative statics





Duopoly - ↑ M



Intensive margin

- Optimal adjustment $\Delta p_L = \mu^*_L / \mu_L$ increases by **more** than ΔM

Extensive margin

- Larger increase in γ_H relative to similar MC firm

▸ Back - Duopoly simulation

Calibration - Identification

Increasing ξ

- Costly to adjust. Adjust less often. Widen bounds.
- $\uparrow$ Size, $\downarrow$ Frequency

Increasing σ_z

(i) Given bounds. Hit bounds more often. $\uparrow$ Frequency

(ii) Hit bounds more often $\rightarrow$ Widen bounds $\uparrow$ Size

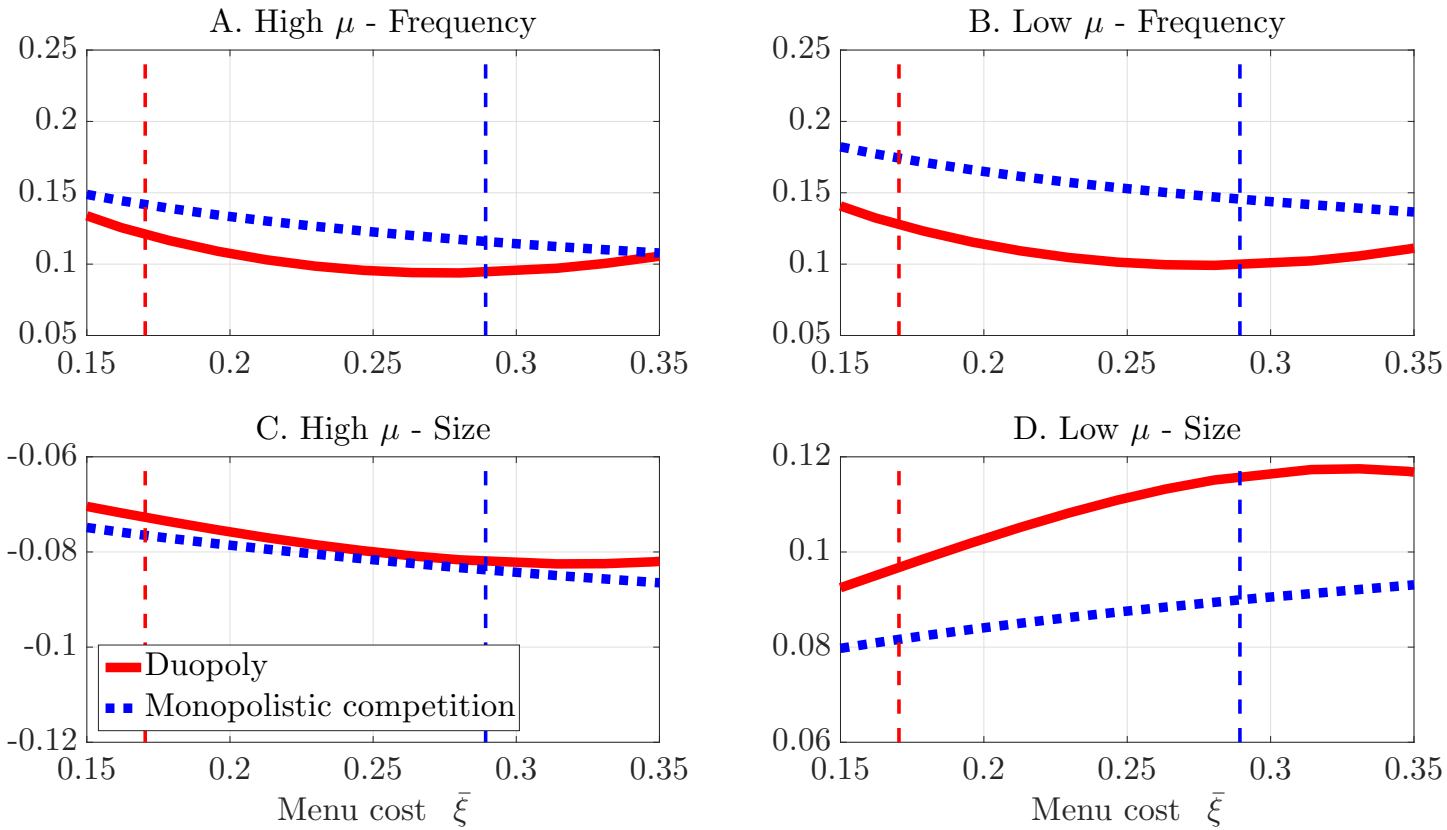
- But... Wider bounds $\rightarrow \downarrow$ Frequency
- Turns out, direct effect dominates

Increasing η

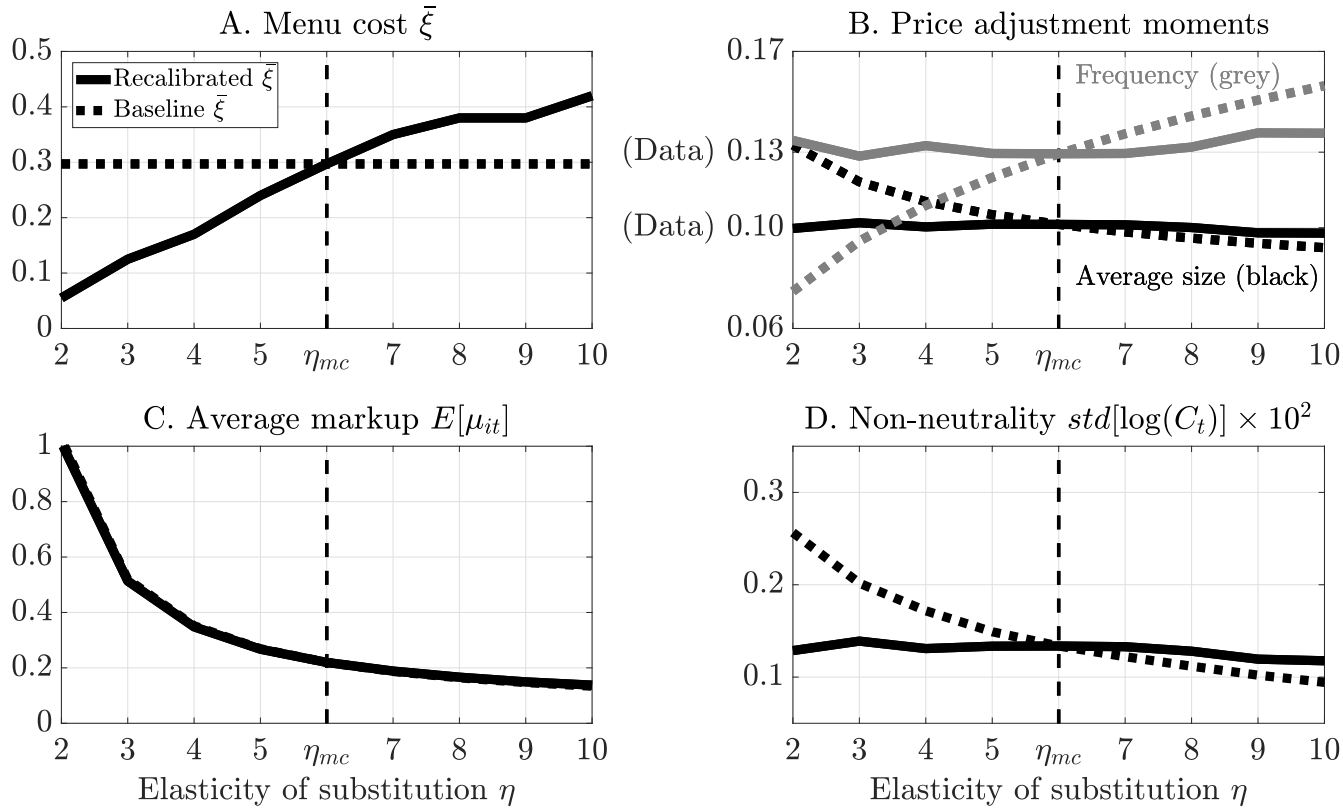
- Increase average markup

Back - Calibration strategy

Menu cost comparative statics



Benchmarking models - Robustness



(A) For each η, choose $\bar{\xi}$ and σ_z to match the data.

(B) Lower $\downarrow \eta \rightarrow$ Profits less sensitive to prices $\rightarrow$ Require lower $\downarrow \bar{\xi}$

(C) Can match $\mathbb{E}[\mu_{it}] = 1.30$ from duopoly model with $\eta^* = 4.5$

(D) **Result** When $\bar{\xi}$ and σ_z are recalibrated $\sigma(C_t)$ is unaffected

▸ Back - Calibration strategy

Recursive equilibrium - Computation

Krussel-Smith

- Conjecture price function for $\mu(S)$

$$\log \mu(S) - \log \bar{\mu} = \alpha_g \left(\log g(S) - \log \bar{g}\right) + \alpha_\mu \left(\log \mu(S_{-1}) - \log \bar{\mu}\right)$$

- Reduces aggregate state to $S = (\mu_{-1}, g)$

MPE policy functions

- Approximate expected value function $V^e(\mu_1, \mu_2, \mu, g)$

$$V^e(\mu_1, \mu_2, \mu, g) = \int V\left(\frac{\mu_1}{e^{\varepsilon_1' + g'(g,\varepsilon_g')}}, \frac{\mu_2}{e^{\varepsilon_2' + g'(g,\varepsilon_g')}}, \mu, g'(g, \varepsilon_g')\right) dF(\varepsilon_1', \varepsilon_2', \varepsilon_g')$$

- Cubic splines in μ_1, μ_2. Linear splines in μ, g
- Guess initial pricing policies $\mu_{-i}^{(0)\prime}(\mu_i, \mu_{-i}, S)$ and $\gamma_{-i}^{(0)\prime}(\mu_i, \mu_{-i}, S)$
- Given competitor policies, use collocation algorithm to solve for value functions
- Determines new $\mu_{-i}^{(1)\prime}(\mu_i, \mu_{-i})$ and $\gamma_{-i}^{(1)\prime}(\mu_i, \mu_{-i})$
- Continue, until $\mu_{-i}^{(k+1)\prime} = \mu_{-i}^{(k)\prime}$ and $\gamma_{-i}^{(k+1)\prime} = \gamma_{-i}^{(k)\prime}$

▸ Back - Recursive equilibrium

Firm problem

Markov states

- Sector Markups $\bar{\mu}_i$, $\bar{\mu}_{-i}$ $x = (\bar{\mu}_i, \bar{\mu}_{-i})$
- Aggregate Distribution $\lambda(x)$, money growth g $X = (\lambda, g)$

Equilibrium functions

- Aggregate markup $\mu(X)$

Timing and Information (Doraszelski Satterthwaite, 2007)

$\underbrace{(x, X) \text{ determined}}_{\text{Public}} \rightarrow \underbrace{\text{Draw menu cost } \xi_i \sim U\left[0, \bar{\xi}\right]}_{\textit{iid} + \text{Private}} \rightarrow \underbrace{\text{Pricing decisions}}_{\text{Simultaneous}}$

Competitor's policies

- Markup adjustment $\mathbf{1}_{-i}^{adj}(x, X, \xi_{-i}) \in \{0, 1\}$
- Markup conditional on adjustment $\mu_{-i}^{*}(x, X) \in \mathbb{R}_+$

▸ Back - Recursive equilibrium

Firm problem

Value

$$V_i(x, X, \xi_i) = \max_{\mathbf{1}_i^{adj} \in \{0,1\}} \mathbf{1}_i^{adj} \left[V_i^{adj}(x, X) - \xi_i \right] + \left(1 - \mathbf{1}_i^{adj}\right) V_i^{stay}(x, X)$$

Value of adjusting price

$$V_i^{adj}(x, X) = \max_{\mu_i^* \in \mathbb{R}_+} \int_0^{\bar{\xi}} \left[\pi\left(\mu_i^*, \mu_{-i}(x, X, \xi_{-i}), \mu(X)\right) + \beta \mathbb{E}\left[V_i\left(x', X', \xi_i'\right) \right] \right] dF(\xi_{-i})$$

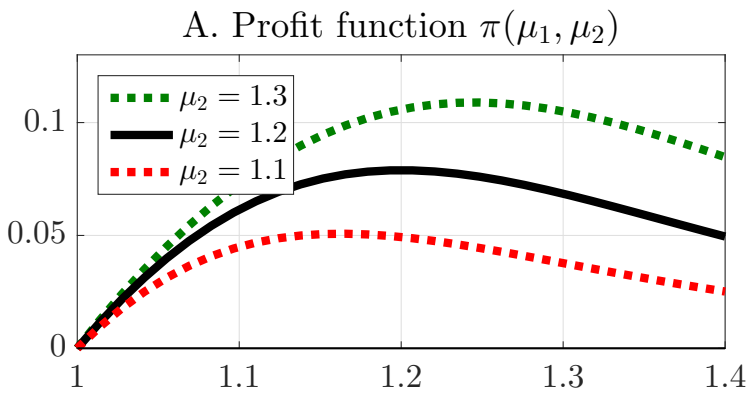
$$\mu_{-i}(x, X, \xi_{-i}) = \underbrace{\mathbf{1}_{-i}^{adj}(x, X, \xi_{-i}) \mu_{-i}^*(x, X)}_{\text{Competitor adjusts}} + \underbrace{\left(1 - \mathbf{1}_{-i}^{adj}(x, X, \xi_{-i})\right) \bar{\mu}_{-i}}_{\text{Competitor stays}}$$

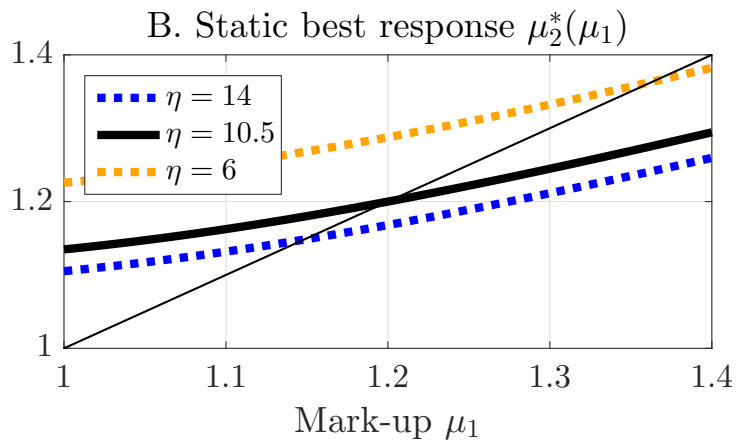
Solution

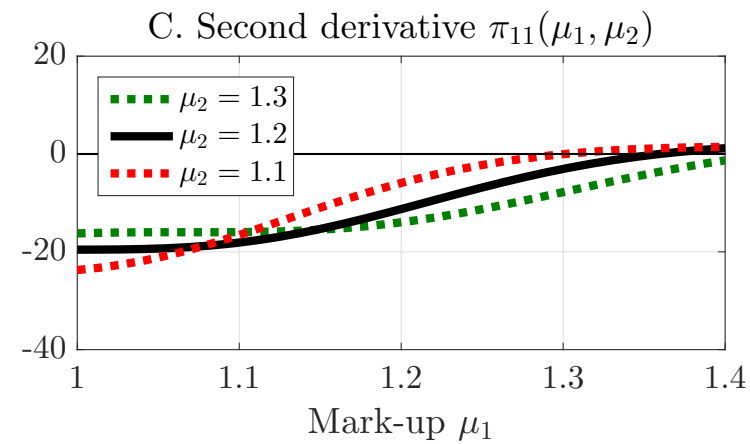
- Probability of price adjustment $\gamma_i(x, X) = \int_0^{\bar{\xi}} \mathbf{1}_i^{adj}(x, X, \xi_i) dF(\xi_i)$
- Markup conditional on adjustment $\mu_i^*(x, X)$

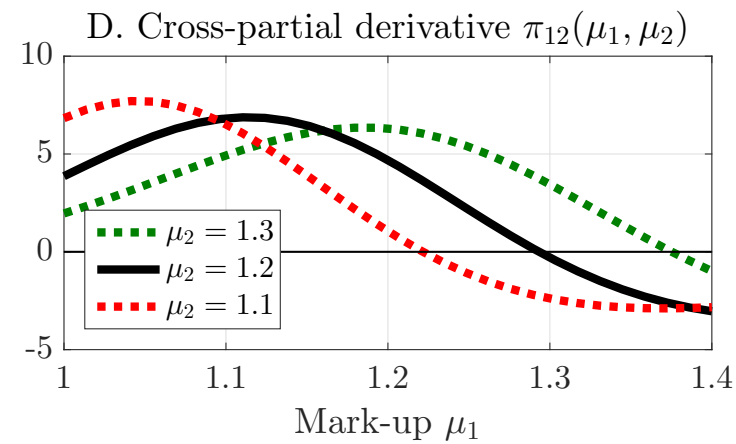
▸ Back - Recursive equilibrium

Profit function properties









- Panel B - Best response slope between 0 and 1
- More elastic demand $\uparrow \eta \rightarrow$ (i) $\downarrow \mu^*$, (ii) $\uparrow$ *slope*

▸ Back - Strategic complementarities

Calibration and results

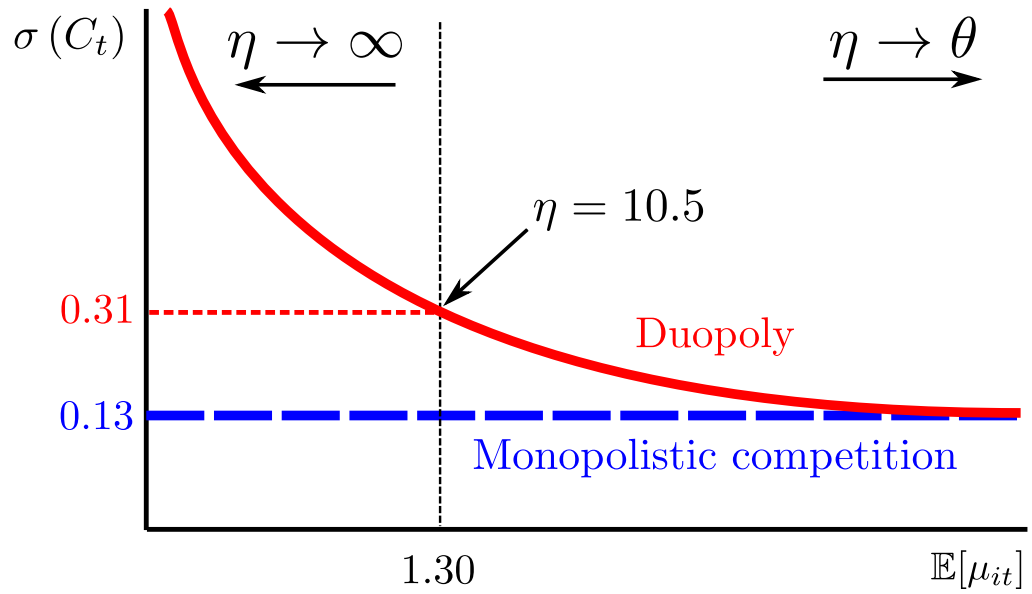
		Duopoly	Mon
			Base
A. Parameter			
Within-sector elasticity of demand	η	10.5	4.5
Upper bound of menu cost distribution	$\xi \sim U[0, \bar{\xi}]$	0.17	0.21
Size of shocks (percent)	σ_z	3.8	4.0
B. Moments			
Markup	$\mathbb{E}[\mu_{it}]$	1.30	1.30
Frequency of price change	$\mathbb{E}[\mathbf{1}\{p_{it} \neq p_{it-1}\}]$	0.13	0.13
Log absolute price change, cond. on price change	$\mathbb{E}[\lvert \log(p_{it}/p_{it-1}) \rvert]$	0.10	0.10
C. Results			
Std. deviation consumption (percent)	$\sigma(\log C_t)$	0.31	0.13
Average markup minus frictionless markup	$\mathbb{E}[\mu_{it}] - \mu^*$	0.10	0.02

I Parameters same as estimated duopoly model

II Same $\eta_m = \eta_d$ re-calibrated $\bar{\xi}_m$, $\sigma_{z,m}$

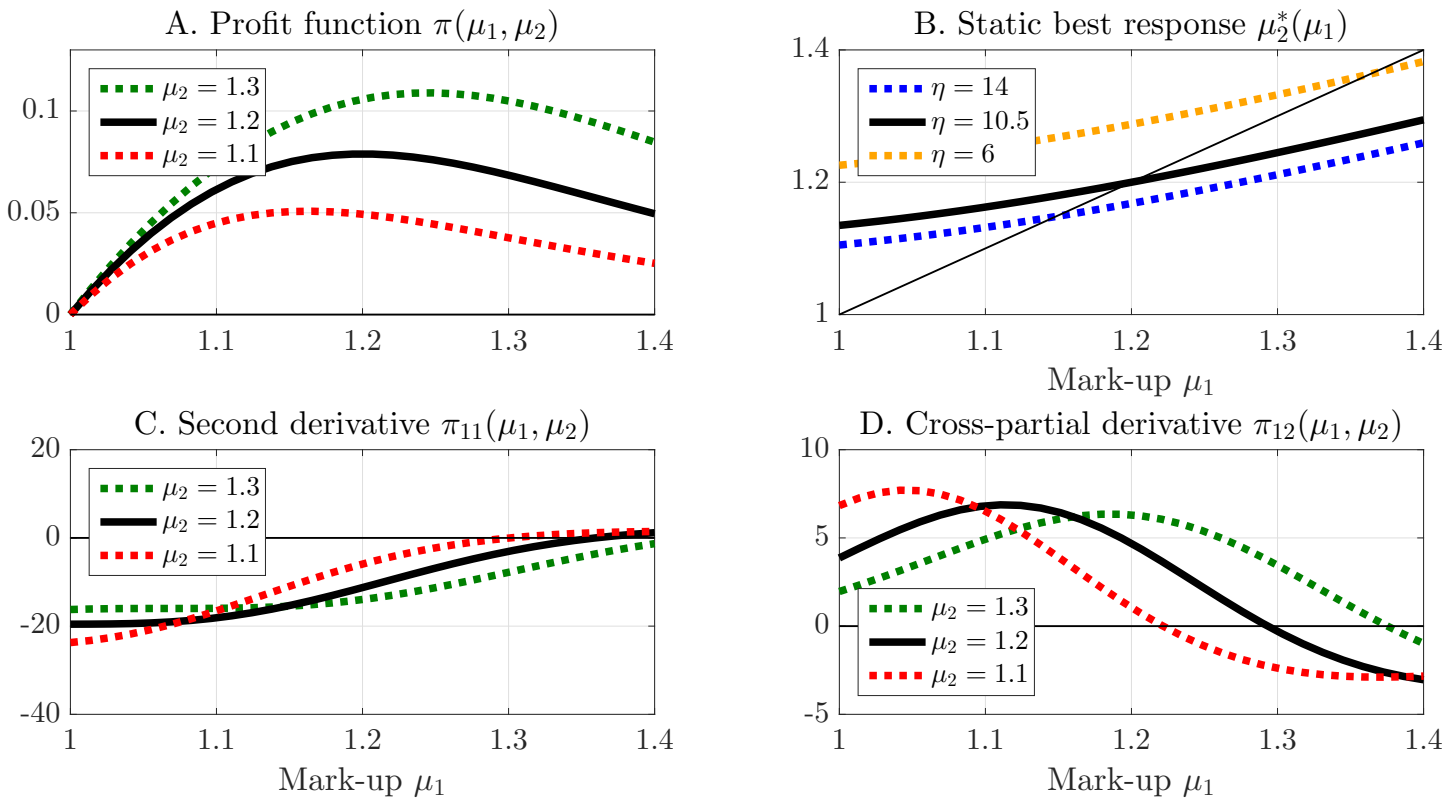
III Both models have flexible price markup of 1.20

Robustness to target $\mathbb{E}\left[\mu_{it}\right]$



Back - Calibration

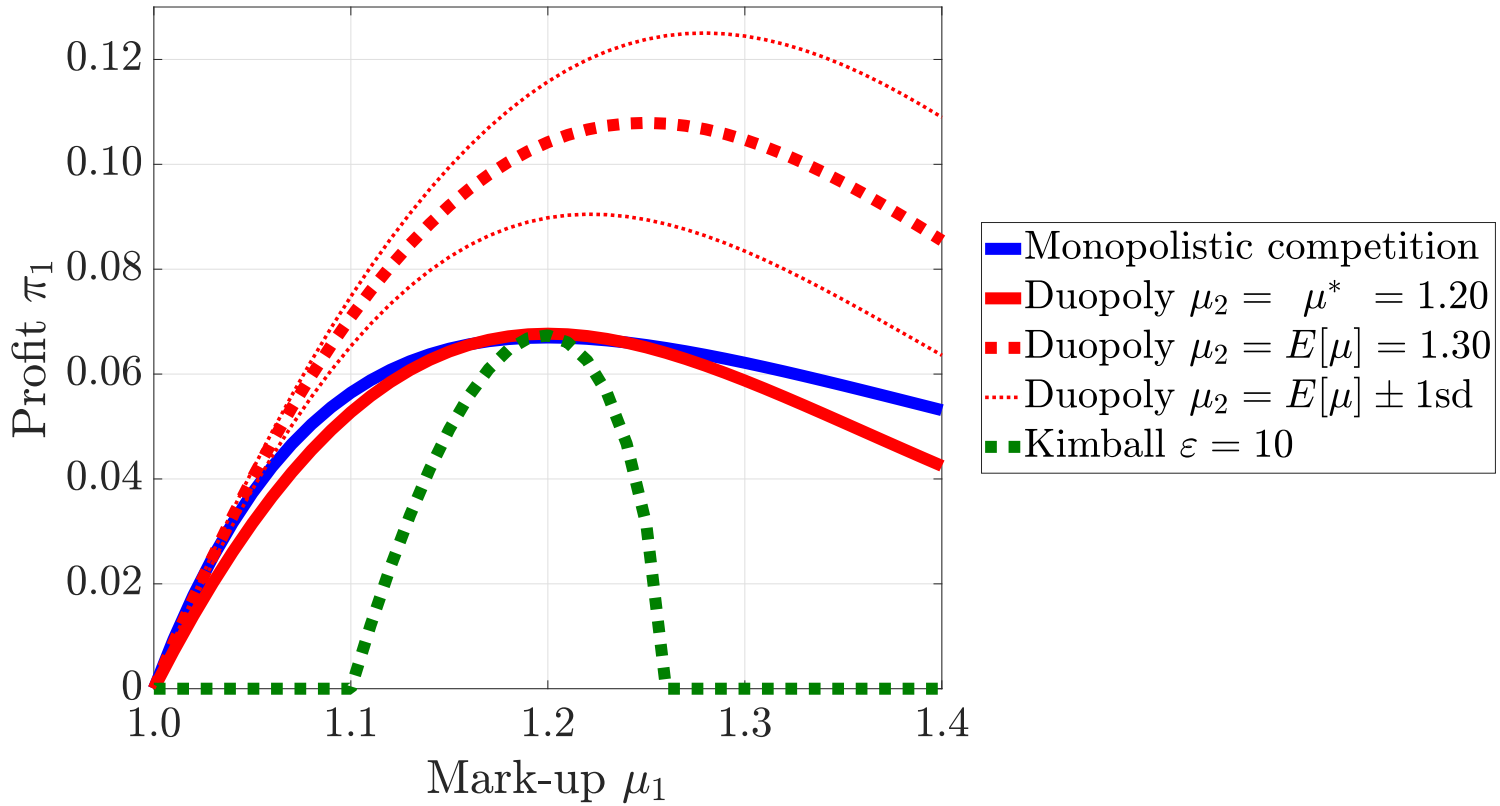
Profit function properties



- Strategic complementarity driven by $\pi_{12} > 0$
- Weird property of CES demand functions - Panel D
- As markups increase, π_{12} falls, then becomes negative

Back - Markups ad Values

Relation to Kimball-style strategic complementarity



- Duopoly demand function super-elasticity $\varepsilon \in [0.3, 0.7]$
- Literature Klenow Willis - $\varepsilon = 10$, Gopinath Itskhoki - $\varepsilon = 4$

▸ Back - Additional results ▸ Back - Example μ policies

Empirical - Data details

- IRI data
  - An observation is at the UPC $\times$ Category $\times$ Store level
  - Stores: 2,000, Years: 2001-2012, Categories: 31
  - e.g. Mayonnaise, 2001. Firms: 72, UPCs: 402
- Observations removed
  - Absolute size of price change greater than 99^{th} percentile
  - Data missing at $t-1$
- Regular price changes
  - Price change set to zero $\Delta \log p_{ict} = 0$
  - Possible measurement error: $\Delta |\log p_{ict}| < 0.001$
  - Promotional flag $Promo_{ict} = 1$
  - Items coming off promotion $Promo_{ict-1} = 1$ & $Promo_{ict} = 0$
- Statistics
  - All statistics computed monthly for each product category c
  - Data is weekly, statistics reported monthly using week three of each month
  - e.g. Frequency $freq_{ct}$ is fraction of c goods changing price at t

$$freq_{ct} = \sum_{i \in c} \mathbf{1}\left[d \log p_{ict} \neq 0\right] / N_{ct}$$

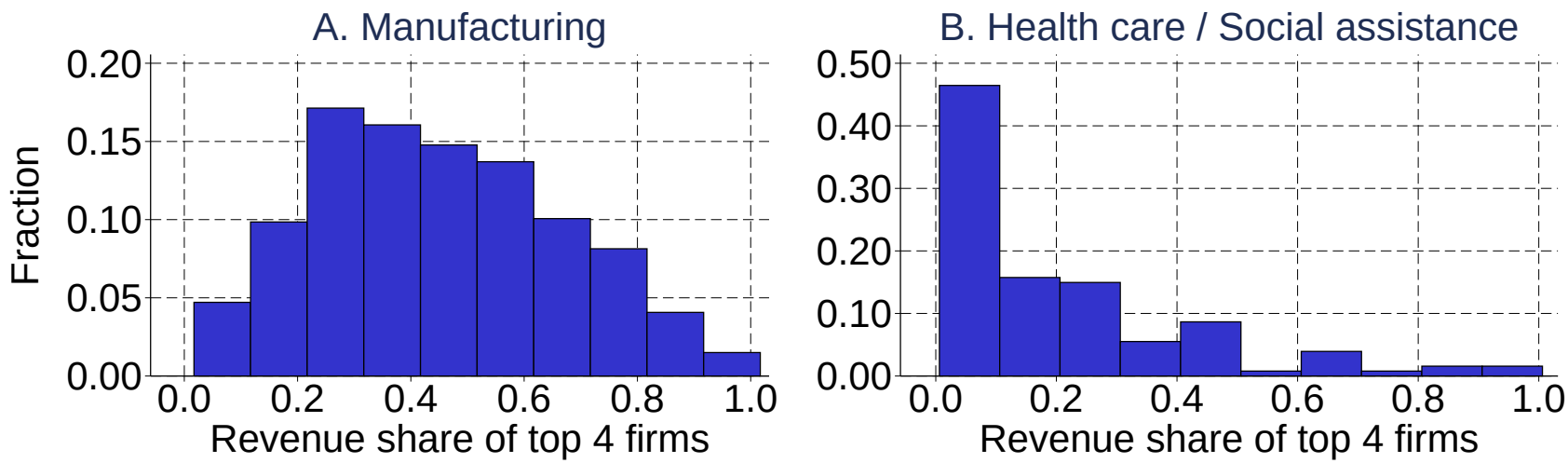
▸ Back - Empirical - Size of price changes ▸ Back - Regression specification ▸ Back - Calibration

Comparison to Census Manufacturing

- Data National NAICS 6-digit revenue share of 4 largest firms

✓ Few industries are national, e.g. Manufacturing

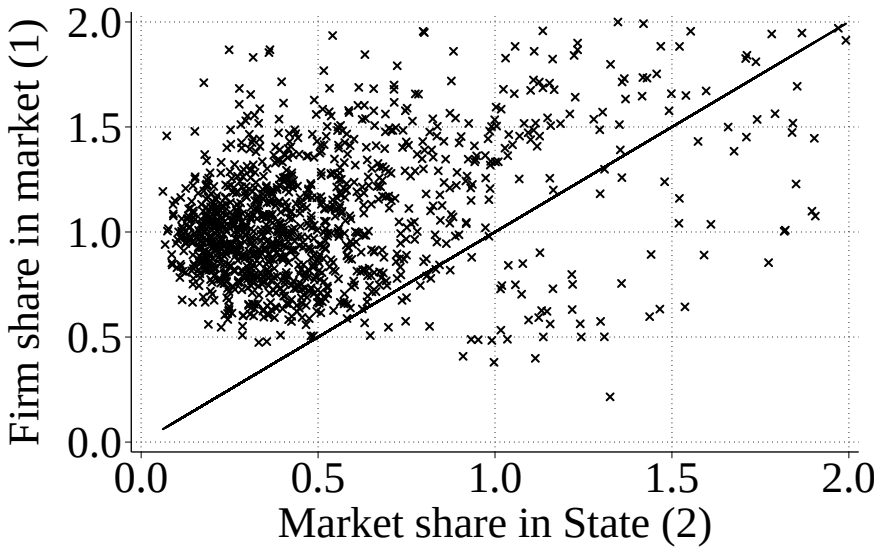
✗ Most industries are local, e.g. Health care

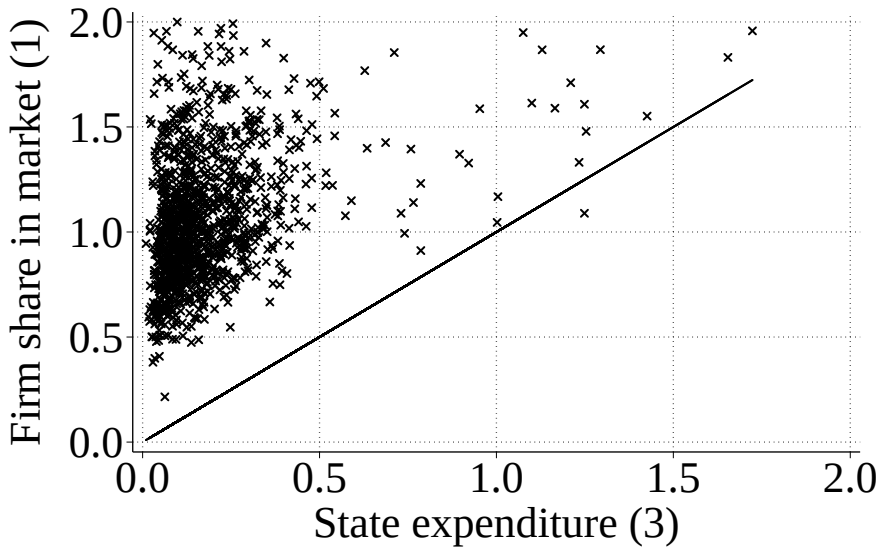


Source: 2007 Economic Census, 6−digit NAICS classification, national level

▸ Back - Introduction ▸ Back - Inverse herfindahl

Decomposing revenue changes at large firms



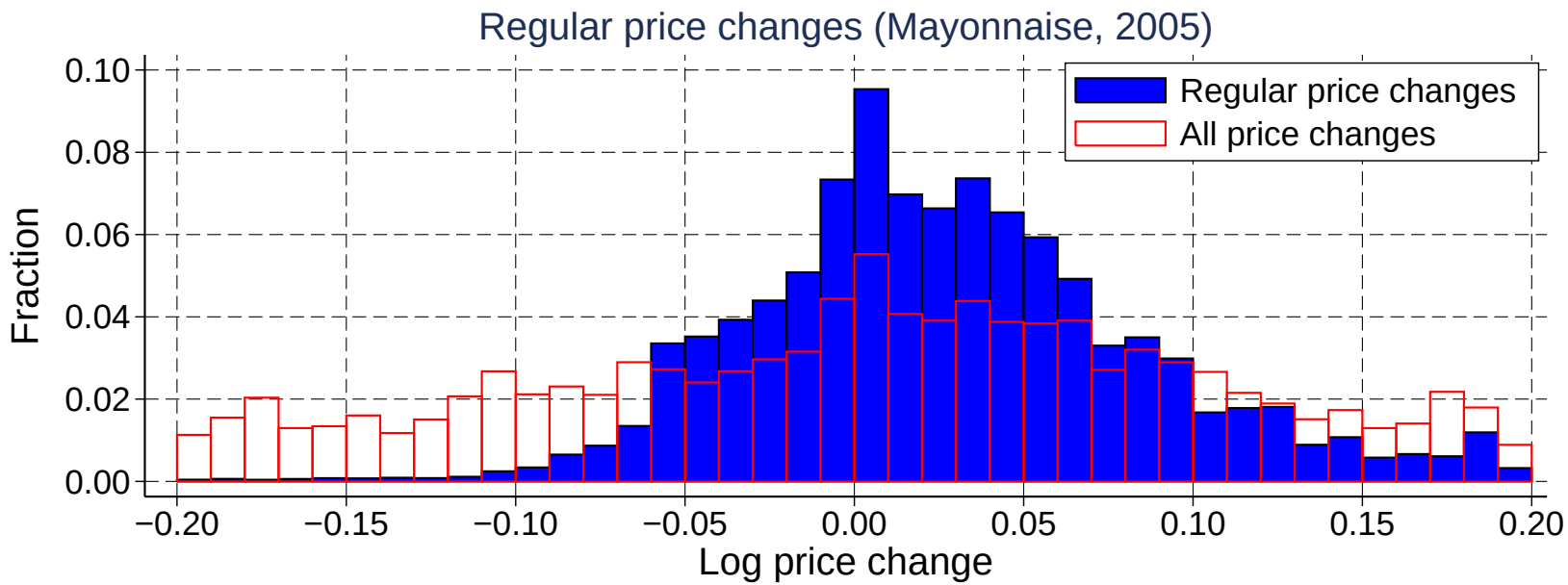


For each state s, product category p, decompose time-series variance in $\Delta \log r_{ipst}$

$$var\left(\Delta \log r_{ipst}\right) = \underbrace{var\left(\Delta \log\left(\frac{r_{ipst}}{r_{pst}}\right)\right)}_{\text{(1) Firm share in market}} + \underbrace{var\left(\Delta \log\left(\frac{r_{pst}}{r_{st}}\right)\right)}_{\text{(2) Market share in state}} + \underbrace{var\left(\Delta \log r_{st}\right)}_{\text{(3) State expenditure}} + \text{Covariances}$$

Back - Calibration strategy

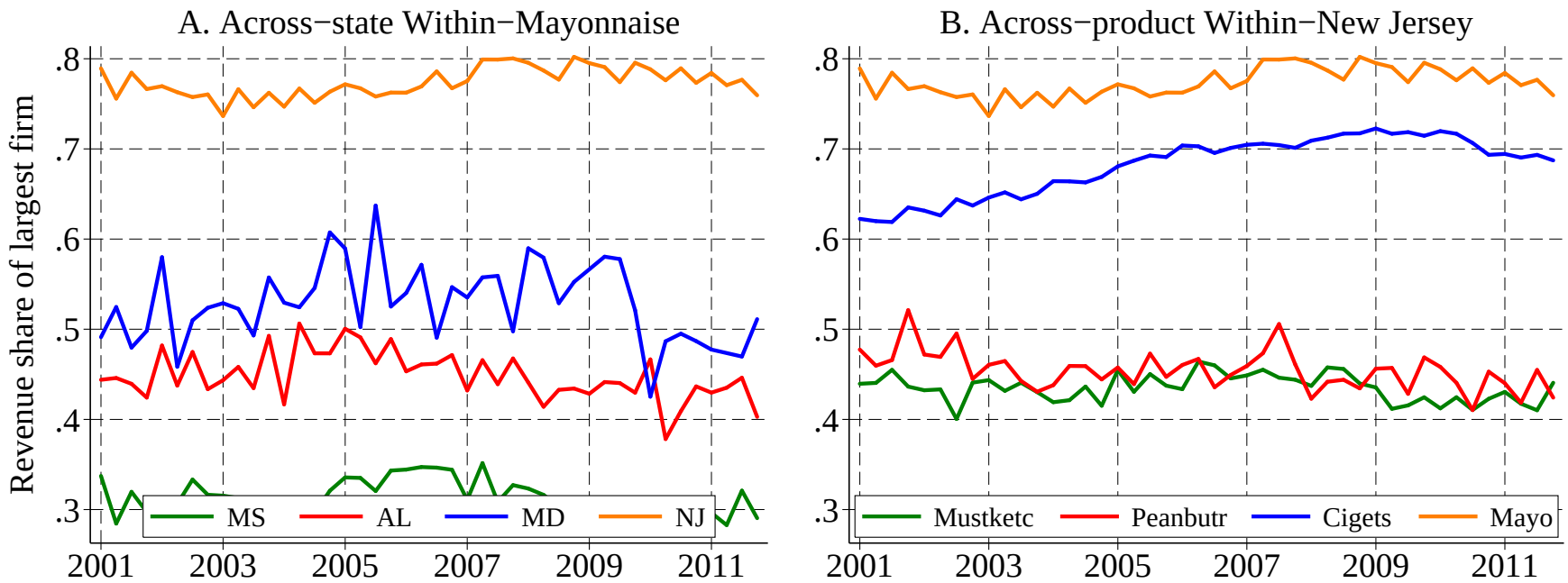
Empirical - Distribution of price changes



- Regular price changes: Mean = .0396, Std dev. = .087, Skew = 1.673, Kurtosis = 11.149
- All price changes: Mean = .0005, Std. dev. = .256, Skew = −.108, Kurtosis = 3.418

▸ Back - Empirical - Size of price changes

3. Variation in market concentration - Share top firm



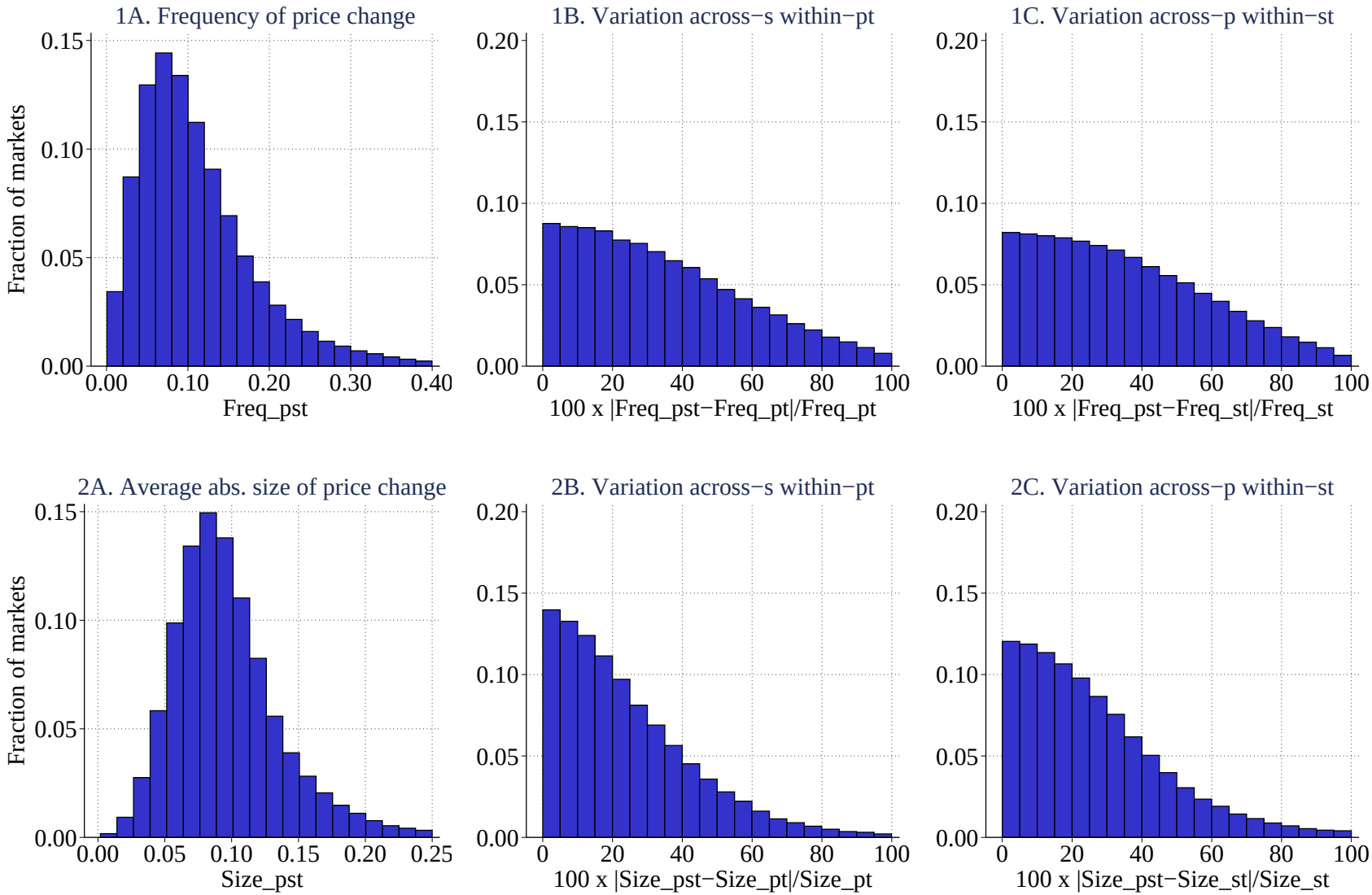
✗ Little time-series variation

✓ Variation across states, within product categories

✓ Variation across product categories, within states

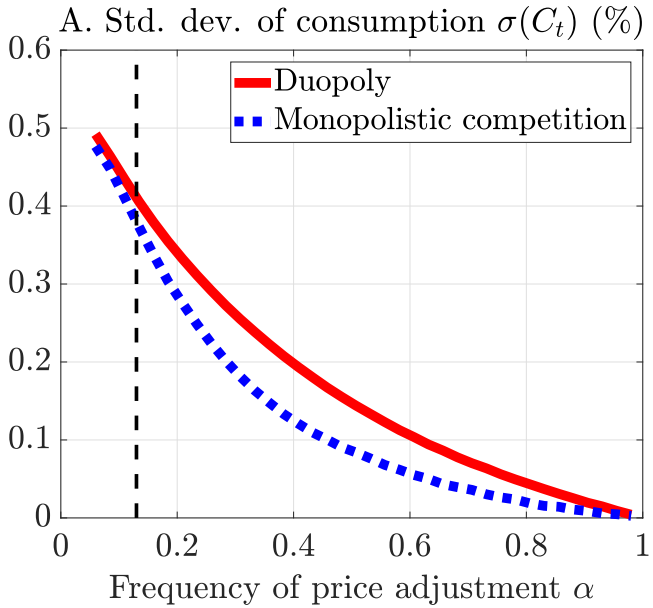
▸ Back - Variation in concentration

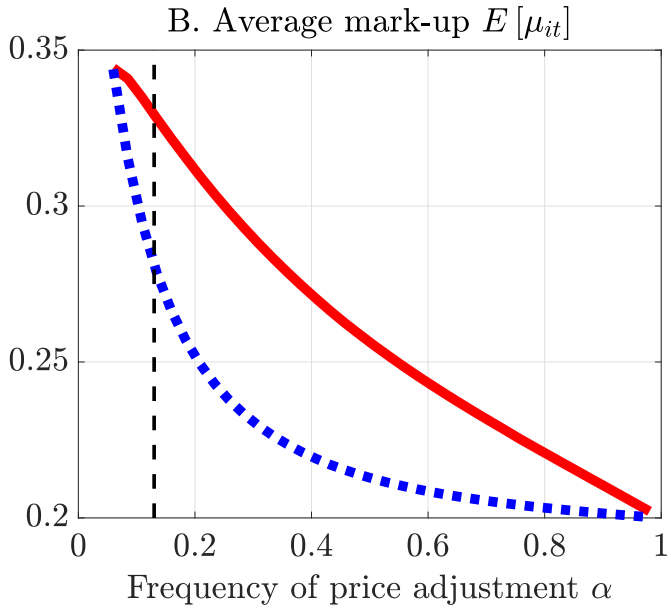
3. Variation in price flexibility



▸ Back - Variation in concentration

Varying nominal rigidity in a Calvo rigidity α

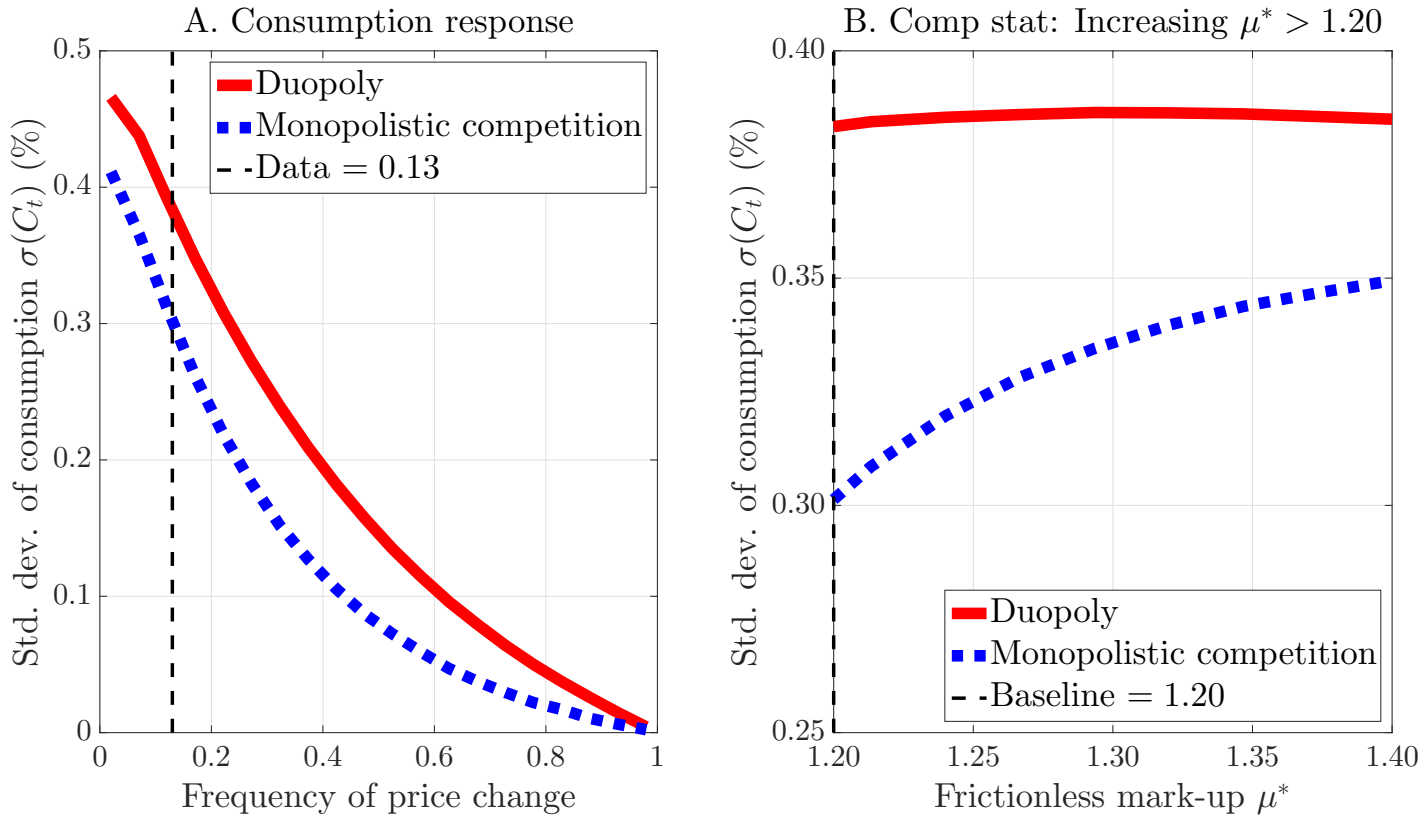




- DC and MC models converge as $\alpha \to 1$
- Optimal exogenous frequency of price adjustment $\alpha^* = 0.23$

▸ Back - Additional results

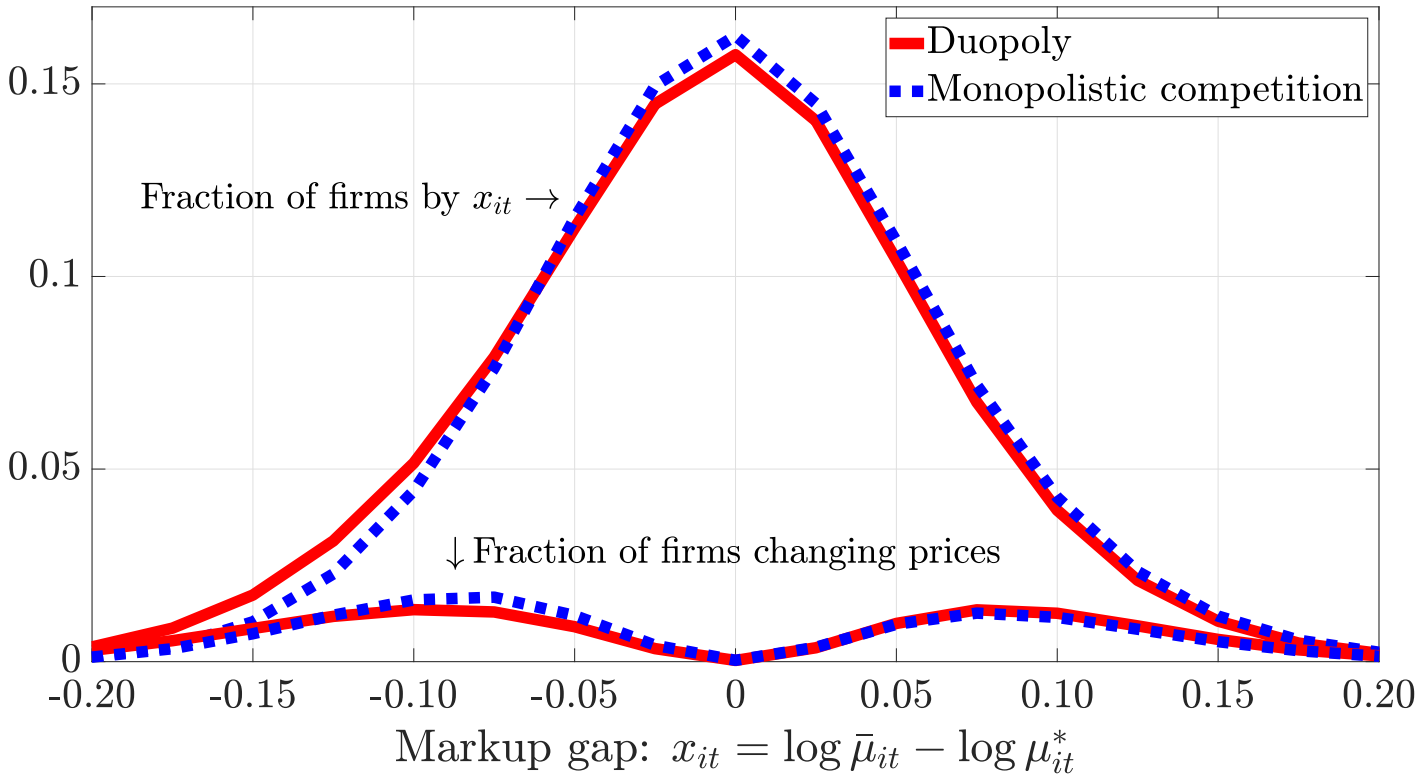
Comparative statics in Calvo model



- MC - Increasing $\uparrow \mu^* \rightarrow$ Less substitutable $\rightarrow P$ responds slowly
- DC - Increasing $\uparrow \mu^* \rightarrow$ Less substitutable $\rightarrow p_i$ more flexible

▸ Back - Additional results

Distribution of price gaps [solid] and changes [dotted]



- MC - Random ξ model is between Golosov-Lucas and Midrigan
- DC - Left skewness due to lower price flexibility at low μ firms

▸ Back - Additional results

Regression - Estimating equations

Across-state, within-product

- Remove quarter t mean for each product category, taken across states

$$\left(y_{pst} - \bar{y}^{s}_{pt}\right) = \alpha_t + \beta_1 \left(x_{pst} - \bar{x}^{s}_{pt}\right) + \beta_2 \left(x_{pst} - \bar{x}^{s}_{pt}\right)^2 + \varepsilon_{pst}$$

Across-product, within-state

- Remove quarter t mean for each state, taken across product categories

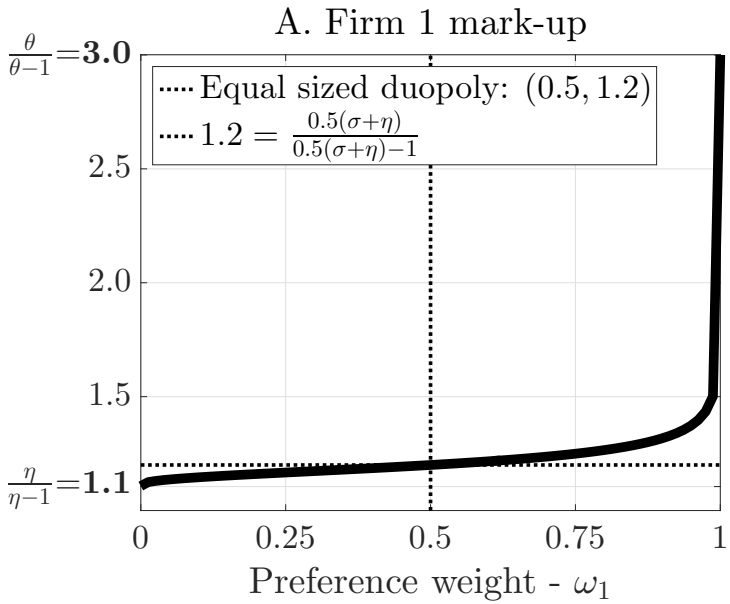
$$\left(y_{pst} - \bar{y}^{p}_{st}\right) = \alpha_t + \beta_1 \left(x_{pst} - \bar{x}^{p}_{st}\right) + \beta_2 \left(x_{pst} - \bar{x}^{p}_{st}\right)^2 + \varepsilon_{pst}$$

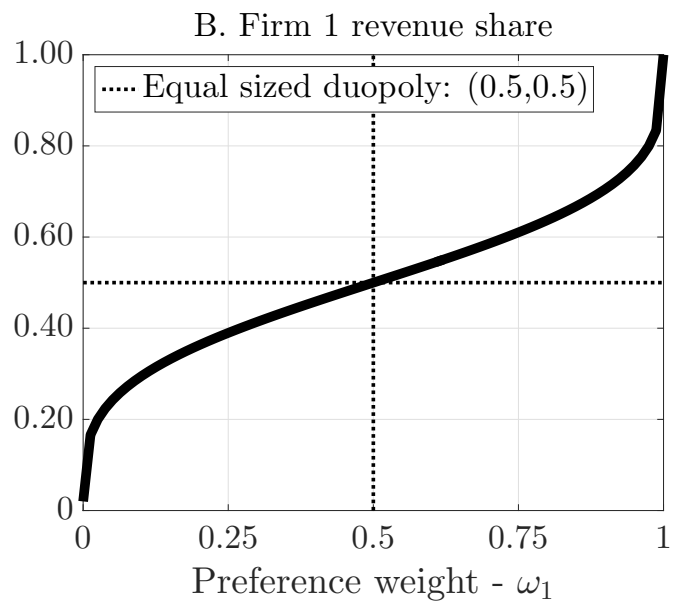
Additional details

- y_{pst} - Size and frequency of price change
- x_{pst} - Measures of market concentration
- Standard errors clustered at State$\times$Product level

▸ Back - Main regression ▸ Data details

Static Nash - Varying ω_1





Preferences

$$C = \left[\int_0^1 C_j^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}} \qquad C_j = \left[\omega_1 c_{1j}^{\frac{\eta-1}{\eta}} + (1-\omega_1) c_{2j}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

- As $\omega_1 \to 1$, μ_1 converges to monopolistically comp. markup under θ
- As $\omega_1 \to 0$, μ_1 converges to monopolistically comp. markup under η

▸ Back - Nested models