Asymmetric Firms and Monetary Policy

IHEID Brown Bag Lunch

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Does Firm Heterogeneity Matter for Monetary Policy?

- Some firms have substantial pricing power
  - These firms respond differently to shocks...
  - Does this affect aggregate price dynamics?

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- Some firms have substantial pricing power
  - These firms respond differently to shocks...
  - Does this affect aggregate price dynamics?
- Markup dispersion implies households allocate income inefficiently
  - Does monetary policy directly affect allocative efficiency?
- There are many indications large firms are getting larger
  - Large firms tend to be efficient, which is good
  - If markets become uncompetitive, then problematic
  - How do we evaluate the tradeoffs?

This Paper

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This Paper

- Solves a NK model where market position influences pricing behavior
  - It adds strategic interaction between firms
- Establishes a relation between aggregate price dynamics and market concentration
  - Compares both margins: (i) fewer firms in an industry and (ii) domination of an industry by one firm (asymmetry)
- Evaluates how shocks affect price and markup dispersion and the allocative efficiency of the economy
  - Helps quantify the efficiency loss from price distortions
  - Shows strategic complementarity can generate losses under certain conditions

Outline

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What Is the Typical Market Structure?

Fact 1: A Few Firms Control Most Market Share in an Industry

- In both Europe and the US, an HHI over 2000 seems typical for an industry
- A value of 2500 is considered "highly concentrated"
- Benkard et al. (2021) finds 44% of local markets in the US have an HHI over 2500, based on consumer survey data
- Top two firms usually control around 60% of market share within narrowly defined markets (both EU and US)

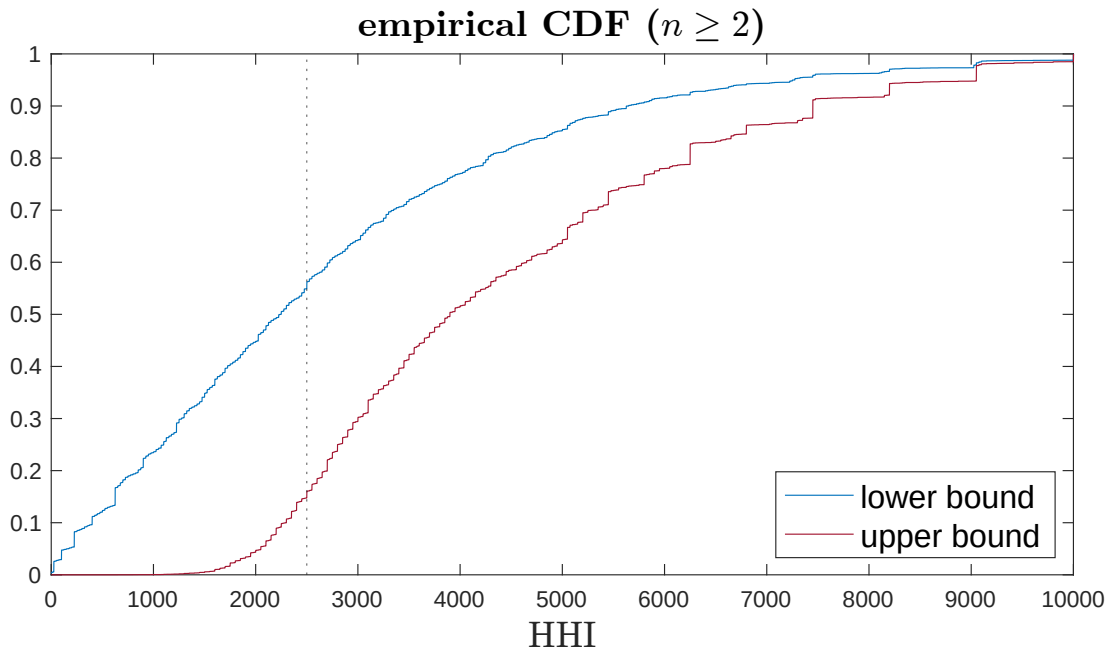
Fact 2: Leading Firm in an Industry Has a Large Advantage

- Typically controls 1.5x-2x the market share of the nearest rival
- Hottman et al. (2016) finds the markup is 24% to 100% higher than the sector average (depending on approach)

Evidence for High Concentration in EU

- HHI = sum of squared market shares across firms in an industry
  - Range goes from 0 (perfect competition) to 10,000 (monopoly)
- EU Commission collects information on the market share of firms and competitors as part of its merger review process
- Affeldt et al. (2018) compiles all cases and the resulting database provides information on 10,000 antitrust markets

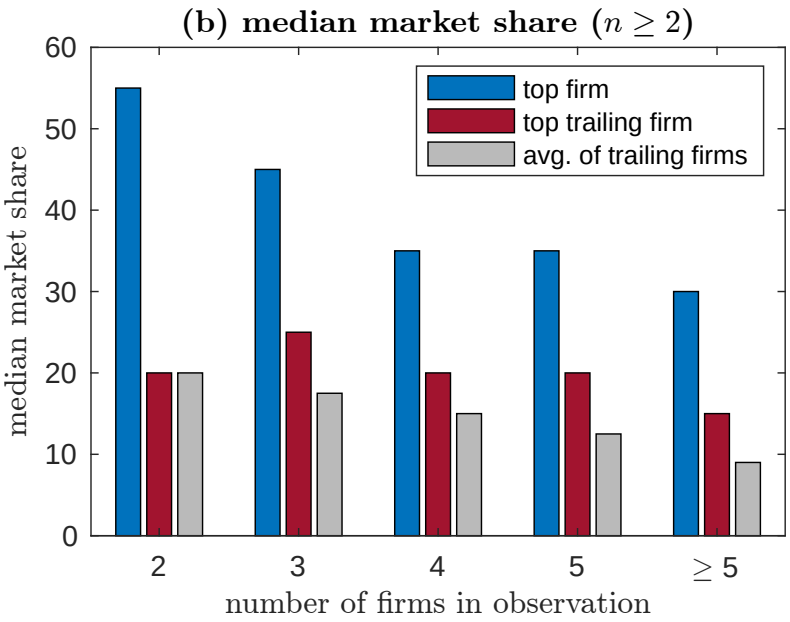
Figure: Antitrust Market HHIs from Affeldt et al.

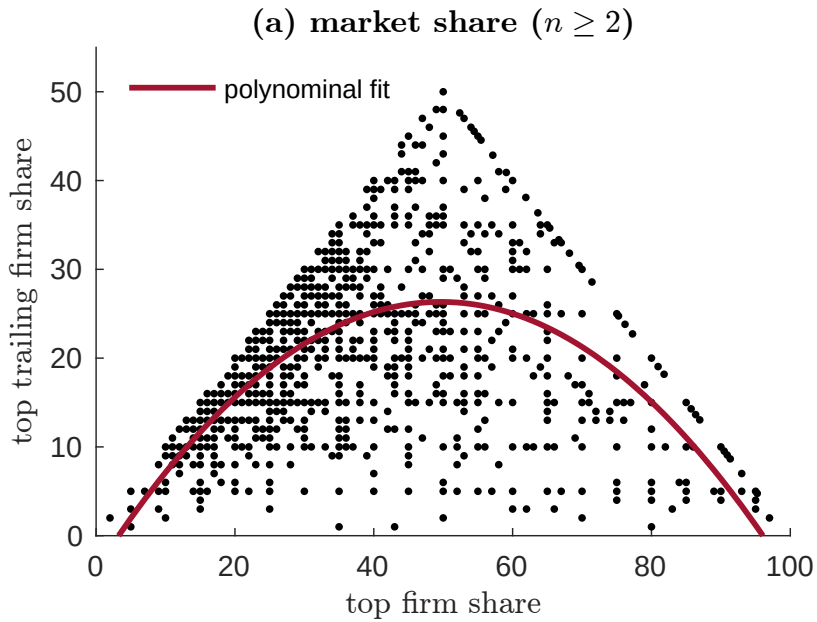


Evidence for Asymmetries Across Firms

- The leading firm in antitrust market typically has a market share around 40 percent (1.6x larger than top rival)
  - Considerable heterogeneity across markets (SD is 20 percent)
  - Unexplained market share relatively small (median is 15 percent)

Figure: Antitrust Market Characteristics from Affeldt et al.





Adding Market Structure to NK Model

- NK model typically uses a CES aggregator to describe demand
  - In this case, continuum of identical firms all have equal market power
- Nested CES (N-CES) adds competition within an industry
  - Firms are discrete, prices and market share can vary
- N-CES implies a link between market share and pricing power

$$\frac{\partial \log(y_{sjt})}{\partial \log(p_{sjt})} = (\varphi - \sigma) x_{sjt} - \varphi \quad \text{where} \quad x_{sjt} \equiv \frac{p_{sjt} y_{sjt}}{\sum_{s=1}^{n} p_{sjt} y_{sjt}} \tag{1}$$

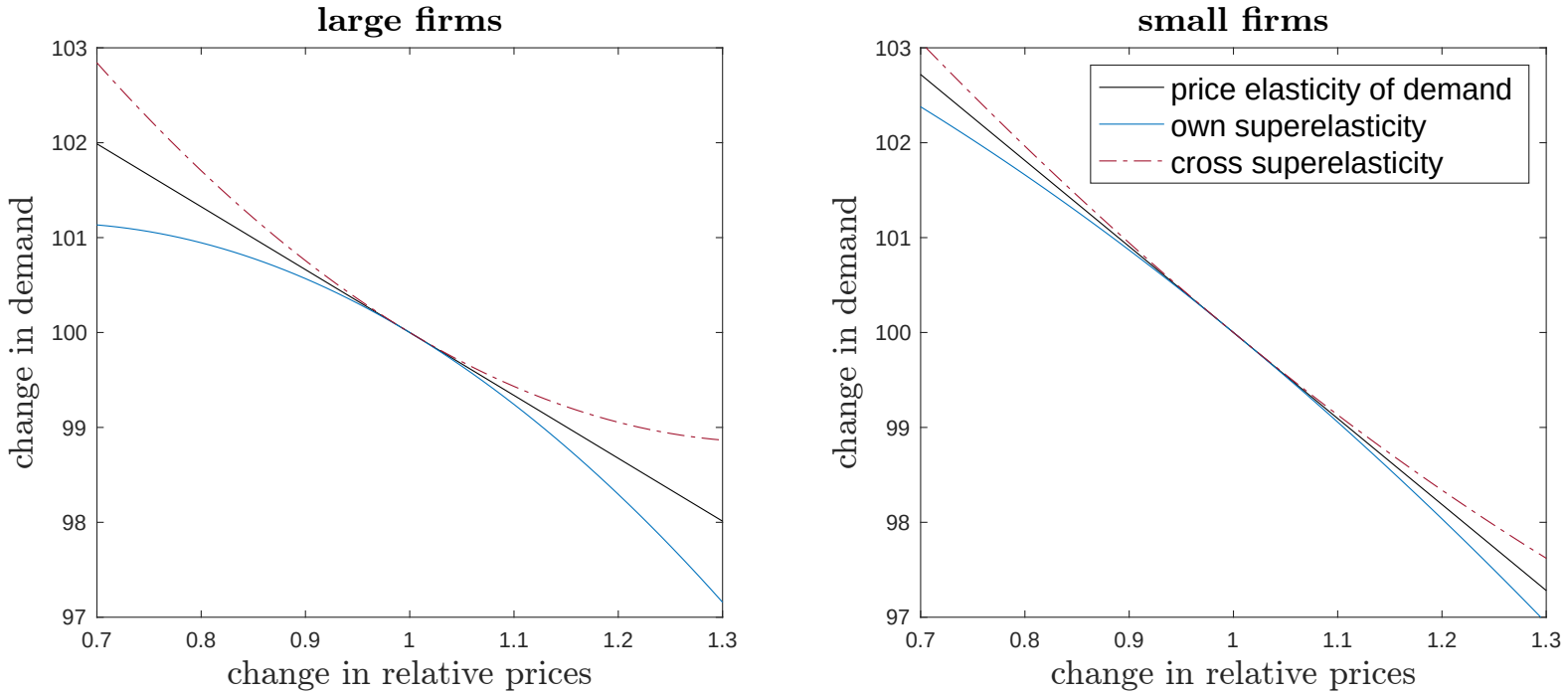
$$= \frac{\varphi - \sigma}{n} - \varphi \quad \text{(if firms are identical)} \tag{2}$$

- When firms are asymmetric, curvature of price elasticity of demand differs

Price Elasticity of Demand

- The slope of the price elasticity of demand sets the markup
  - Different across small and large firms
- The curvature determines the pass-through of cost shocks
- Strategic interaction also affects the curvature

Figure: Price Elasticity of Demand for Large and Small Firms



Evidence on Firm Pricing Behavior

Fact 1: Large Firms Limit Pass-Through of Cost Shocks

- There is strong empirical evidence for this, but most papers are from the trade literature: e.g. Berman et al. (2012), Auer and Schoenle (2016), Amiti et al. (2019)
- Estimates suggest large firms pass through 50-60% of cost shocks, small firms have full pass-through

Fact 2: Large Firms Are Strategic

- Rival prices typically a top response on research surveys looking at motivation for price changes
- Amiti et al. suggests large firms match around 50% of price increases by rival firms
- Small firms do not appear strategic (ibid.)

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Asymmetric Specification

- Model is limited to the interaction of small and large firms

$$s \in \{S, L\}$$

- With N-CES demand, market share is a function of prices

$$x_{sjt} = \left(\frac{p_{sjt}}{p_{jt}} \right)^{1-\varphi} \tag{3}$$

- The industry price index is given by

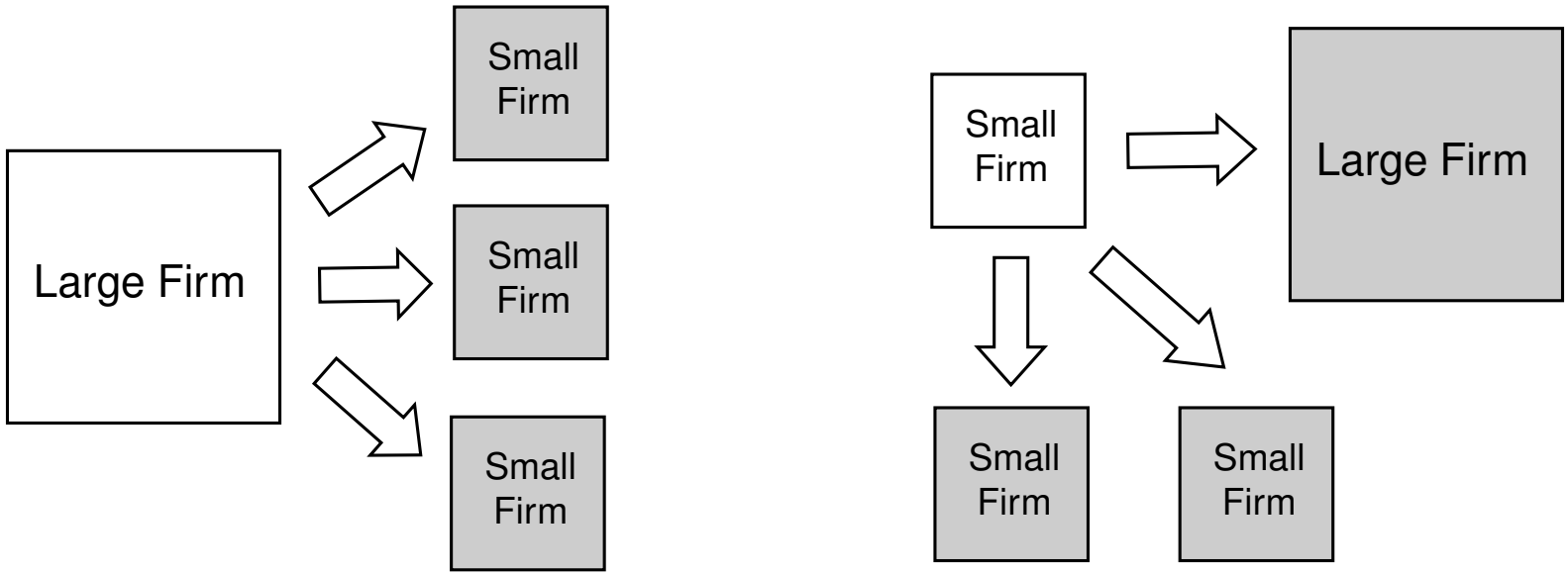
$$p_{jt} = \left[\underbrace{(p^{i}_{sjt})^{1-\varphi}}_{\text{own price}} + \underbrace{(n_s - 1)(p^{-i}_{sjt})^{1-\varphi} + n_{-s}(p^{-i}_{-sjt})^{1-\varphi}}_{\text{rival prices}} \right]^{\frac{1}{1-\varphi}} \tag{4}$$

- Firm considers number of rivals when setting prices
- Own price $\uparrow$ or number of rivals $\uparrow$ $\implies$ market share $\downarrow$

Competition Within an Industry

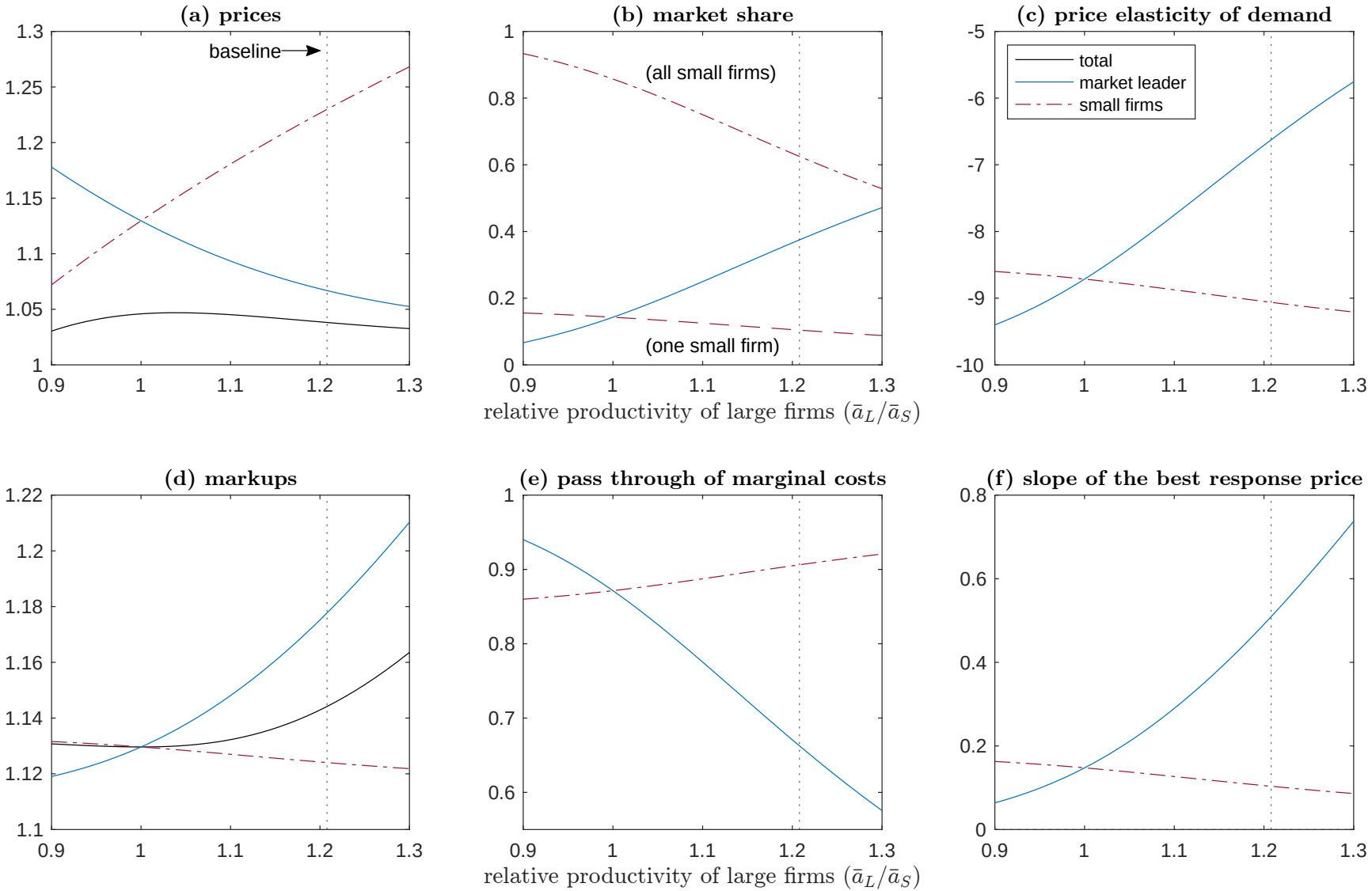
- The model specifies one large firm in a sector and multiple small firms
- Differences in prices across firms explained by a productivity wedge

Figure: Competition from the Firm's Perspective



- Under flexible prices, the firm's problem is $\Pi_{st} = (p_{st} - c_{st})y_{st}$

Flexible Price Equilibrium (Steady State)



Dynamic Problem with Sticky Prices

- Rotemberg price adjustment costs introduced

$$\frac{\Theta_s}{2}\left(\frac{P^i_{st}}{P^i_{st-1}}-1\right)^2 Y_t \quad \text{where} \quad \Theta_s = x_s\Theta \tag{5}$$

- Adjustment costs (Θ_s) are is firm-specific, reflecting market share
- Each firm's objective becomes

$$\mathcal{L} = \mathbb{E}_t \sum_{k=0}^{\infty} \Lambda_{t+k}\left[\left(p_{st+k} - \mathcal{C}_{st+k}\right) y_{st+k} - \frac{\Theta_s}{2}\left(\pi_{t+k}\frac{p_{st+k}}{p_{st+k-1}}-1\right)^2 P_{t+k} Y_{t+k}\right] \tag{6}$$

- Stochastic discounting follows from the household Euler equation

$$\Lambda_{t+k} = \beta^k \frac{P_t}{P_{t+k}}\frac{C_t}{C_{t+k}} \tag{7}$$

Solution Method

- The optimal solution to the firm's problem is log-linearized
- The resulting decision rule is given by

$$\tilde{p}^{i}_{st} = \Gamma_s \tilde{p}^{i}_{st-1} + (1 + \Gamma'_s)\widetilde{c}^{i}_{st} + \Gamma^*_s \tilde{p}^{-i}_{-st} + \widehat{\Gamma}_s \tilde{\pi}_t \tag{8}$$

$$\tilde{p}^{-i}_{-st} = \Gamma_{-s} \tilde{p}^{-i}_{-st-1} + (1 + \Gamma'_{-s})\widetilde{c}^{-i}_{-st} + \Gamma^*_{-s} \tilde{p}^{i}_{st} + \widehat{\Gamma}_{-s} \tilde{\pi}_t \tag{9}$$

- The Γ's collect all time-invariant terms
- Small and large firms know each other's rules (Γ's)
- The full solution incorporates the rival's decision rule

$$\tilde{p}^{i}_{st} = \underbrace{\frac{\Gamma_s}{1 - \Gamma^*_s \Gamma^*_{-s}}}_{\Upsilon_s} \tilde{p}^{i}_{st-1} + \underbrace{\frac{\Gamma^*_s \Gamma_{-s}}{1 - \Gamma^*_s \Gamma^*_{-s}}}_{\Upsilon^*_s} \tilde{p}^{-i}_{-st-1} + \underbrace{\frac{1 + \Gamma'_s}{1 - \Gamma^*_s \Gamma^*_{-s}}}_{\Upsilon'_s} \widetilde{c}^{i}_{st} + \underbrace{\frac{\Gamma^*_s (1 + \Gamma'_{-s})}{1 - \Gamma^*_s \Gamma^*_{-s}}}_{\Upsilon''_s} \widetilde{c}^{-i}_{-st} + \underbrace{\frac{\widehat{\Gamma}_s + \Gamma^*_s \widehat{\Gamma}_{-s}}{1 - \Gamma^*_s \Gamma^*_{-s}}}_{\Upsilon^{\pi}_s} \tilde{\pi}_t$$

- Pricing rule includes past prices of rivals and their marginal costs

Determination of Marginal Costs

- Marginal costs are given by

$$\mathcal{C}_{st} = \frac{1}{e^{a_t}\bar{a}_s P_t^{\alpha}} \left(\frac{z_t}{\alpha}\right)^{\alpha} \left(\frac{w_t}{1-\alpha}\right)^{1-\alpha} \tag{10}$$

- Household setup leads to simple dynamics
- Wages move in line with consumption, which equals output

$$w_t = C_t = Y_t \tag{11}$$

- Household Euler equation and monetary policy are standard

$$1 = \mathbb{E}_t\left[\beta \frac{P_t C_t}{P_{t+1} C_{t+1}} R_t^n\right] \quad \text{where} \quad R_t^n = e^{m_t} R^n \left(\frac{P_t}{P_{t-1}}\right)^{\phi_\pi} \left(\frac{Y_t}{Y}\right)^{\phi_y} \tag{12}$$

- Solution for log-linearized marginal costs implies

$$\widetilde{\mathcal{C}}_{st} = \widetilde{Y}_t - a_t \tag{13}$$

General Equilibrium

- Necessary to solve for the response of aggregate output and inflation to shocks
  - I use the method of undetermined coefficients
  - Two shocks are included: monetary policy (m) and productivity (a)
- The response of inflation and output to monetary policy shock:

$$(i) \quad \tilde{\pi}_t = \Gamma^{\pi} m_t \qquad (ii) \quad \widetilde{Y}_t = \Gamma^{y} m_t \tag{14}$$

- The persistence of the shock implies

$$(i) \quad \mathbb{E}_t[\tilde{\pi}_{t+1}] = \rho_m \Gamma^{\pi} m_t \qquad (ii) \quad \mathbb{E}_t[\widetilde{Y}_{t+1}] = \rho_m \Gamma^{y} m_t \tag{15}$$

- Necessary to solve the forward-looking elements of firm/household problem in expectation, then combine and solve entire system
- When firms are asymmetric, recursive solution needed

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Parameter Settings

Table: Baseline Parameter Values

Parameter	Value	Description
β	0.99	Household time discount (quarterly)
α	0.30	Capital share
σ	1	Elasticity of substitution across goods
φ	10	Elasticity of substitution across varieties
Θ	125	Rotemberg price adjustment costs
n_L	1	Number of large firms in an industry
n_S	6	Number of small firms in an industry
$\bar{a}_L$	0.91	Productivity of large firms
$\bar{a}_S$	1.09	Productivity of small firms
ϕ_π	1.50	Monetary policy inflation reaction
ϕ_y	0.125	Monetary policy output gap reaction
ρ_m	0.85	Persistence of monetary policy shocks
ρ_a	0.90	Persistence of productivity shocks

- Value for Θ implies an average price duration of 8.6 months

Calibration: Targets and Model Results

Table: Industry-Level Targets

Description	Large firms Target	Large firms Value	Small firms Target	Small firms Value	Source
Targeted					
Market share	0.35	0.37	0.12	0.10	Affeldt et al. (2018)
Pass-through	0.65	0.66	0.97	0.91	Amiti et al. (2019)
Slope of best response price	0.48	0.51	0.00	0.10	Ibid.
Markup ($\mu - 1$)	0.24	0.18	0.16	0.12	Hottman et al. (2016)
Implied					
Log price	–	0.06	–	0.21	–

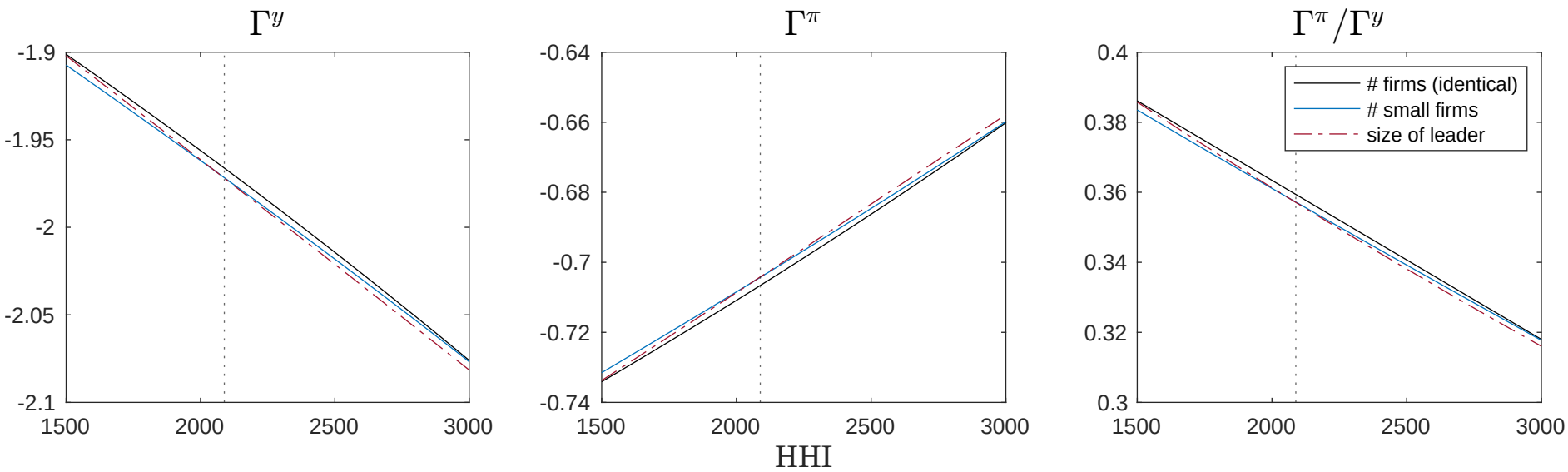
Table: Aggregate Targets

Description	Target (range)	Value	Source
Targeted			
Median Industry HHI	2045 - 2360	2060	Benkard et al. (2021)
Aggregate Markup ($\mu - 1$)	0.13 - 0.16	0.14	IRS SOI
Slope of the Phillips curve	0.33 - 0.50	0.36	Tetlow (2022)
Implied			
Price dispersion (std. dev.)	–	0.07	–
Markup dispersion (std. dev.)	–	0.02	–

Slope of the Phillips Curve

- The slope of the Phillips gives the tradeoff between inflation and output
- With higher concentration, inflation becomes less responsive to monetary policy
- Result is consistent with Wang and Werning (2022), but a large increase in HHI needed to explain flattening of the Phillips curve

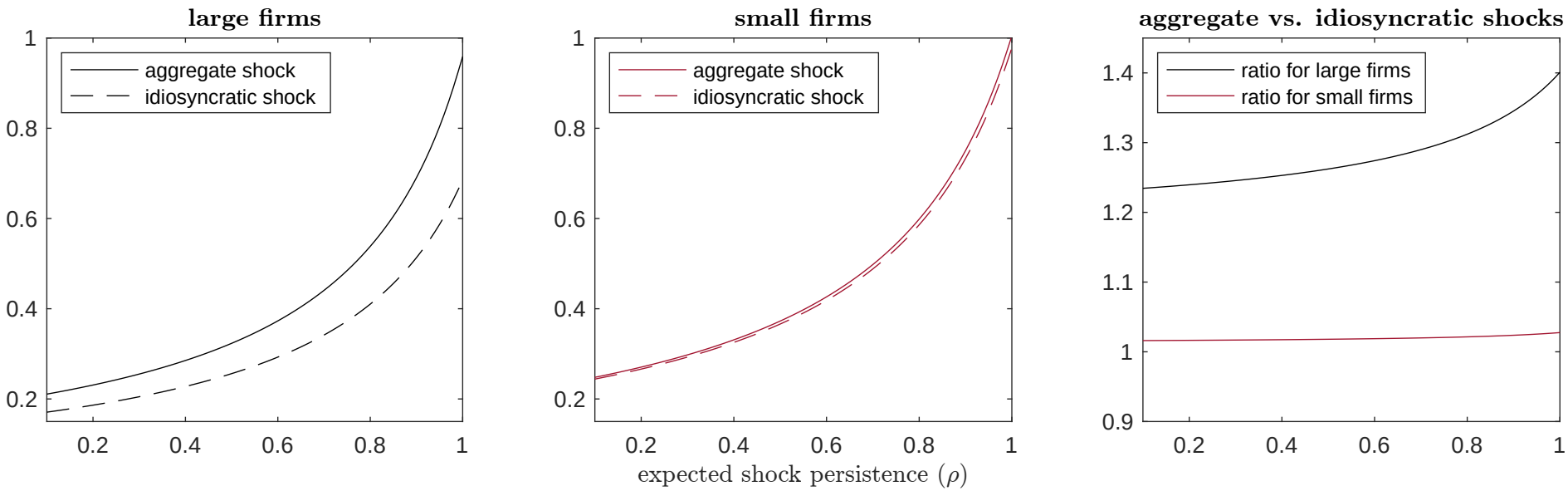
Figure: Response of Output and Inflation to a Monetary Policy Shock



Pass-Through of Marginal Costs

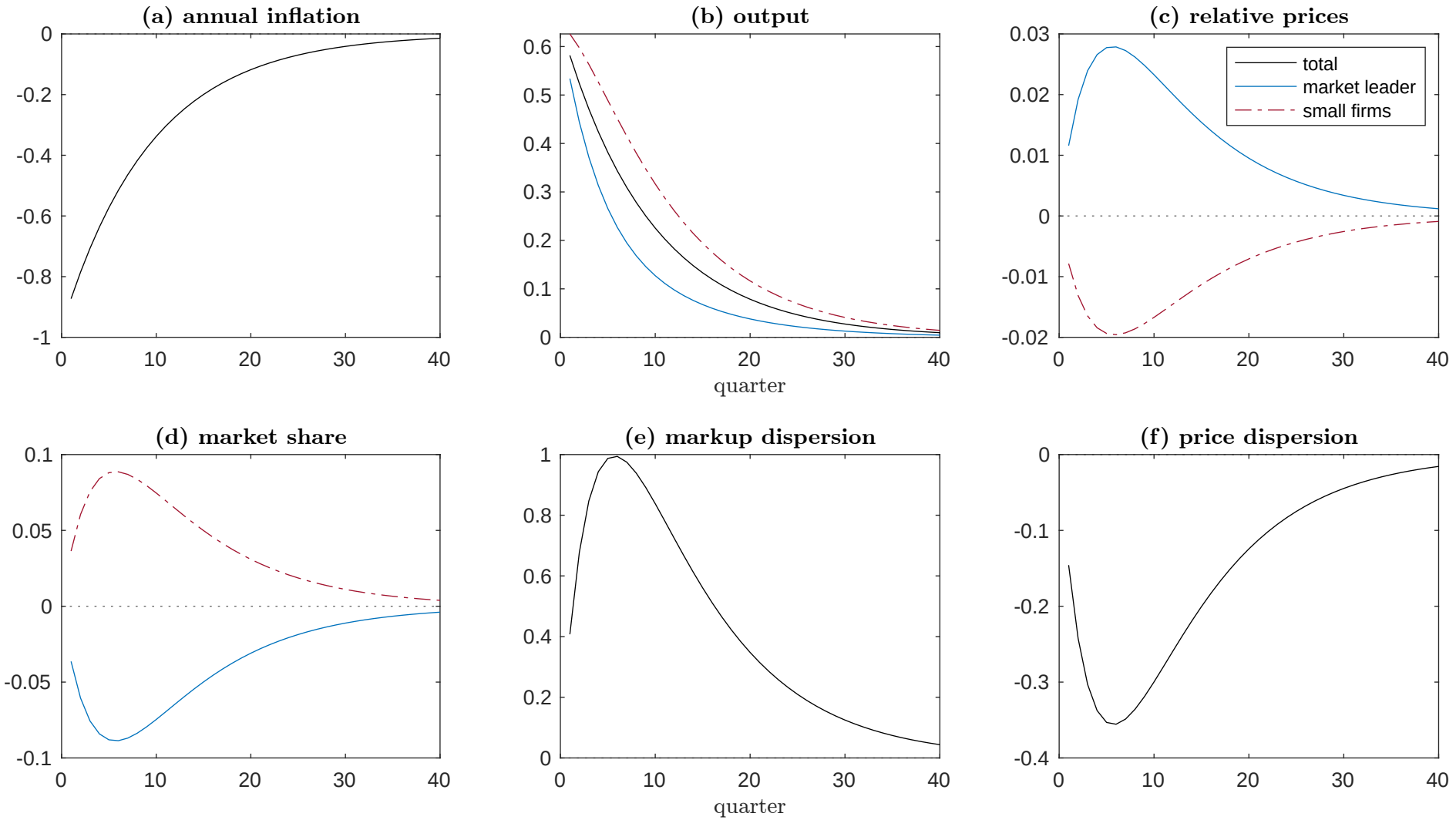
- The model implies a link between the expected persistence of shocks and the pass-through of marginal costs
- The presence of strategic complementarity leads large firms to raise their pass-through when shocks are sector-wide or aggregate
- The difference between two regimes grows as shocks become more persistent

Figure: Pass-Through of Marginal Costs



Response to a Productivity Shock

Figure: Dynamic Response to a 1% Aggregate Productivity Shock



Discussion of Results

- Small firms are more sensitive to the business cycle
  - Consistent with Crouzet and Mehrotra (2020), which finds business cycle fluctuations are around 25 percent larger for small firms
  - The model implies a difference of 35 percent
- There is a positive association between inflation and price dispersion
  - Sheremirov (2020) finds a 1 percentage point increase in inflation results in a 0.026 log point increase in price dispersion[1]
  - The model returns 0.027 using the same measure
    - Sheremirov uses retail data, while model captures producer prices
    - Regular prices may reflect what producers charge, but depends on retail pass-through
  - Standard New Keynesian model with price staggering generates unrealistic level of price dispersion

[1] When market-product category fixed effects are included, 0.050 otherwise

Comparison with Standard NK Model

- Standard New Keynesian model (Galí, 2015) matchs the frequency of price adjustments and slope of the Phillips curve in the baseline
- The measure of price dispersion tracks the share of firms that can reset their price as well as the optimal reset price in each period
- Standard NK model returns more than 10x the observed change in price dispersion

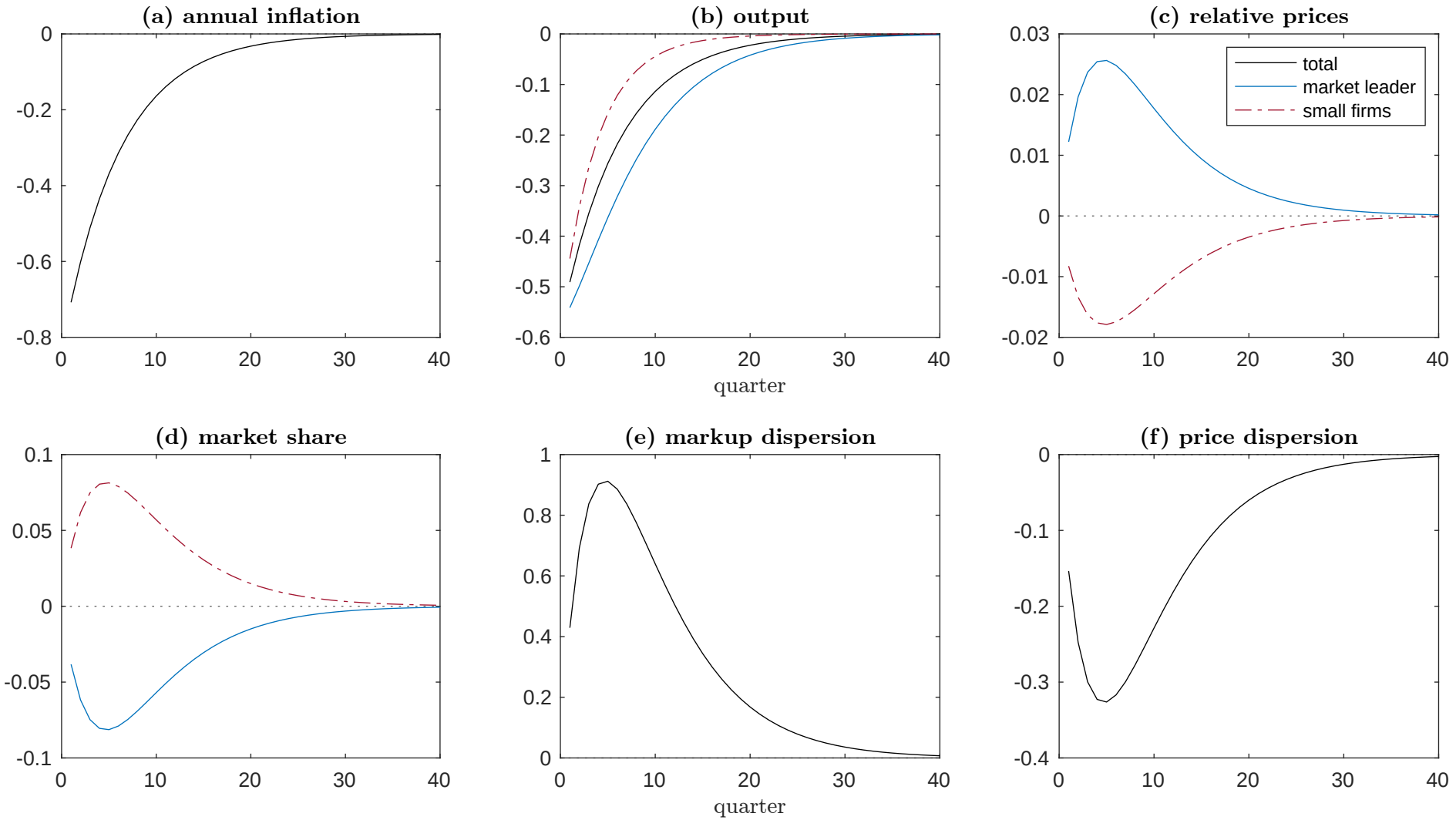
Table: Regression of Price Dispersion on Inflation Given a Productivity Shock

	NK Model	Baseline
Price dispersion	(1)	(2)
Inflation	0.612***	0.027***
	(0.054)	(0.003)
Constant	-0.001***	0.069***
	(0.000)	(0.000)
R-squared	0.769	0.616

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Response to a Monetary Policy Shock

Figure: Dynamic Response to a 1%pt Monetary Policy Tightening



Discussion of Results

- Monetary tightening lowers marginal costs in NK model
  - Large firms do not fully pass through cost saving
- Change in markup dispersion matches Meier and Reinelt (2022)
  - Study finds a contractionary monetary shock increases markup dispersion while easing lowers it
  - Size of changes also consistent with empirical results
- Large firms more sensitive to monetary policy
  - Crouzet and Mehrotra (2020) find no relationship between firm size and change in sales following monetary policy shocks
  - Goes against conventional wisdom, e.g. Gertler and Gilchrist (1994)
  - Recent evidence is very mixed
- Final note: all results are fully symmetric
  - Large firms absorb higher marginal costs given monetary easing

Allocative Efficiency and Shocks

- Apply negative shocks only to large firms, then try same for small

Figure: Negative Productivity Shock to Large Firms

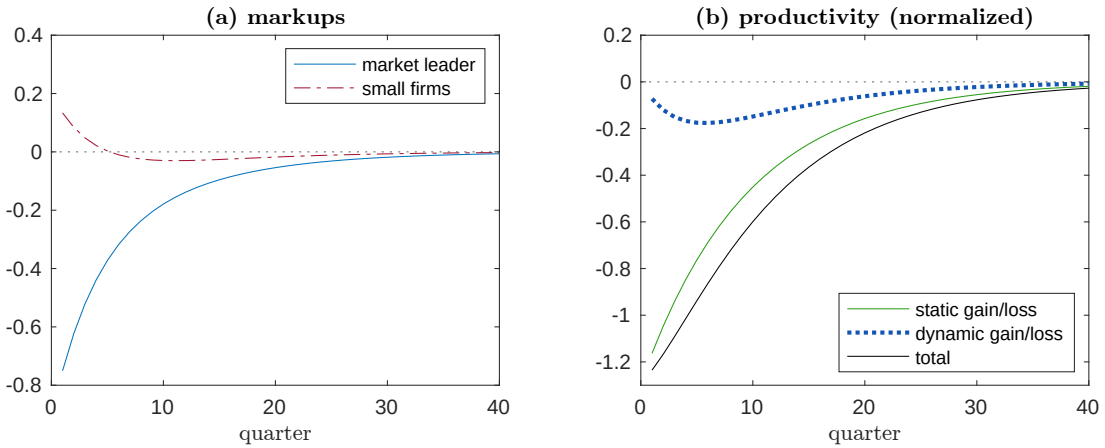
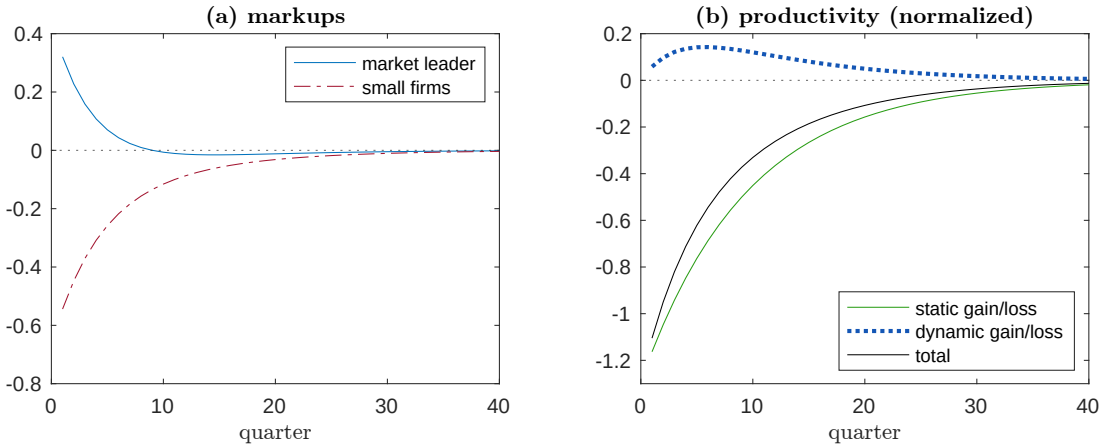


Figure: Negative Productivity Shock to Small Firms



Discussion of Results

- Large firms are more efficient, so the allocation of market share affects aggregate TFP
  - Not much change given aggregate shock, hence on firm-specific shocks
    - Large firms cut markups when faced with a negative shock
    - They raise markups when small firms face a shock
- Given a shock to small firms, what is the extra 'cost' imposed by strategic behavior?
  - Simple to measure: induce monopolistic behavior among large firms
    - Cumulative productivity loss is 4.6%pts of potential output in the baseline where strategic complementarity is present
    - In the monopolistic alternative, the loss is 4.2%pts
    - The difference – 0.4%pts – is the cost imposed by strategic behavior
- Need more evidence on whether small and large firms are affected by shocks differently

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Main Takeaways

- Differences in pricing behavior across firms appear a good starting point when looking at aggregate dynamics
  - Closely matches observed changes in price and markup dispersion
- Rising concentration may explain some flattening of the Phillips curve, but unlikely to have a large impact
- Strategic behavior among large firms increases the pass-through following aggregate shocks
  - The expected persistence of shocks plays a large role in determining the amount of pass-through
- The reallocation of demand across firms following shocks affects aggregate efficiency
  - Strategic behavior contributes, but not a first-order concern

Thank You!
Questions/Comments?

Working version is available at gregauclair.com

Works Cited:

Affeldt, P., Duso, T., & Szücs, F. (2018). *EU Merger Control Database: 1990-2014* (tech. rep.). DIW Berlin, German Institute for Economic Research. https://ideas.repec.org/p/diw/diwddc/dd95.html

Amiti, M., Itskhoki, O., & Konings, J. (2019).International Shocks, Variable Markups, and Domestic Prices. *The Review of Economic Studies*, *86*(6), 2356–2402. https://doi.org/10.1093/restud/rdz005

Auer, R. A., & Schoenle, R. S. (2016).Market structure and exchange rate pass-through. *Journal of International Economics*, *98*, 60–77. https://doi.org/10.1016/j.jinteco.2015.10.003

Benkard, C. L., Yurukoglu, A., & Zhang, A. L. (2021, April). *Concentration in Product Markets* (Working Paper No. 28745). National Bureau of Economic Research. https://doi.org/10.3386/w28745

Berman, N., Martin, P., & Mayer, T. (2012).How do different exporters react to exchange rate changes? *The Quarterly Journal of Economics*, *127*(1), 437–492. http://www.jstor.org/stable/41337214

Crouzet, N., & Mehrotra, N. R. (2020).Small and Large Firms over the Business Cycle. *American Economic Review*, *110*(11), 3549–3601. https://doi.org/10.1257/aer.20181499

Galí, J. (2015). *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications Second edition*. Princeton University Press. https://ideas.repec.org/b/pup/pbooks/10495.html

Gertler, M., & Gilchrist, S. (1994).Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms. *The Quarterly Journal of Economics*, *109*(2), 309–340. https://doi.org/10.2307/2118465

Hottman, C. J., Redding, S. J., & Weinstein, D. E. (2016).Quantifying the Sources of Firm Heterogeneity. *The Quarterly Journal of Economics*, *131*(3), 1291–1364. https://doi.org/10.1093/qje/qjw012

Meier, M., & Reinelt, T. (2022).Monetary Policy, Markup Dispersion, and Aggregate TFP. *The Review of Economics and Statistics*, 1–45. https://doi.org/10.1162/rest_a_01226

Sheremirov, V. (2020).Price dispersion and inflation: New facts and theoretical implications. *Journal of Monetary Economics*, *114*, 59–70. https://doi.org/10.1016/j.jmoneco.2019.03.007

Tetlow, R. J. (2022, November). *How Large is the Output Cost of Disinflation?* (Finance and Economics Discussion Series No. 2022-079). Board of Governors of the Federal Reserve System (U.S.) https://doi.org/10.17016/FEDS.2022.079

Wang, O., & Werning, I. (2022).Dynamic Oligopoly and Price Stickiness. *American Economic Review*, *112*(8), 2815–49. https://doi.org/10.1257/aer.20201739