

Asymmetric Firms and Monetary Policy

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Outline

1 Introduction

2 Model Setup

3 Results

4 Conclusion

Table of contents

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3 Results

4 Conclusion

Why Does Market Asymmetry Matter?

- Some firms have substantial pricing power
 - Do these firms respond differently to shocks?
 - How does this affect aggregate price dynamics?

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 - Does monetary policy directly affect allocative efficiency?

Why Does Market Asymmetry Matter?

- Some firms have substantial pricing power
 - How does this affect aggregate price dynamics?
 - Do these firms respond differently to shocks?
- 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

- Solves a NK model where market position influences pricing behavior
 - Includes strategic interaction between firms

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- 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

This Paper

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

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)

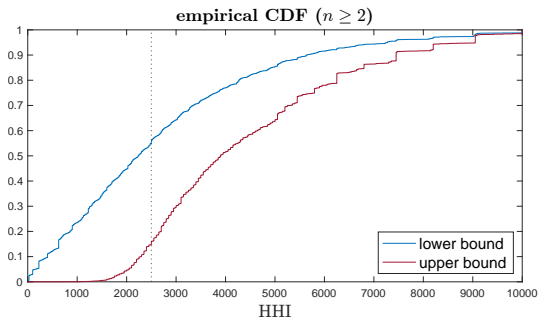
Fact 2: Leading Firm in an Industry Has a Large Advantage

- Typically controls 1.5x-2x the market share of the nearest rival
- Hottman et al. (2016) finds the markup is large: 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) collects cases and the resulting database provides information on 10,000 antitrust markets

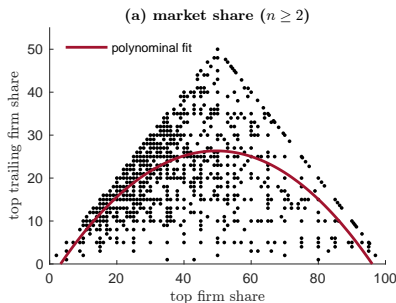
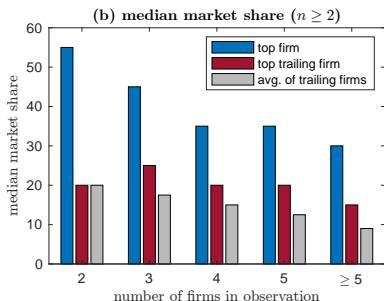
Figure: Antitrust Market HHIs from Affeldt et al.



Evidence for Asymmetries Across Firms

- The leading firm in antitrust market typically has a market share around 40 percent
- 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

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

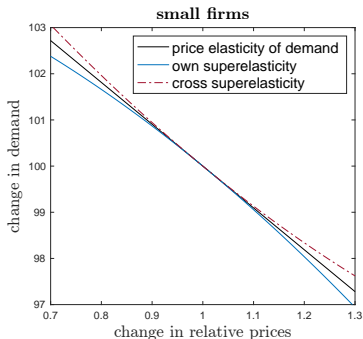
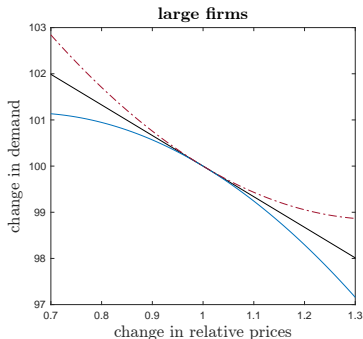
$$= \frac{\varphi - \sigma}{n} - \varphi \quad (\text{if firms are identical}) \quad (2)$$

- 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.)

Table of contents

1 Introduction

2 Model Setup

3 Results

4 Conclusion

Asymmetric Specification

- Model is limited to the interaction of small and large firms
- With N-CES demand, market share is a function of prices

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

- The industry price index is given by

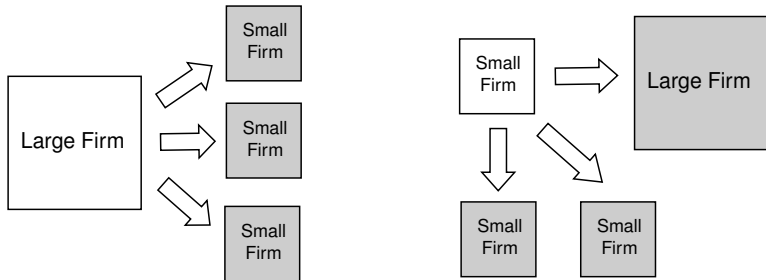
$$p_{jt} = \left[\underbrace{(p_{sjt}^i)^{1-\varphi}}_{\text{own price}} + \underbrace{(n_s - 1)(p_{sjt}^{-i})^{1-\varphi} + n_{-s}(p_{-sjt}^{-i})^{1-\varphi}}_{\text{rival prices}} \right]^{\frac{1}{1-\varphi}} \quad (4)$$

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

Competition within an Industry

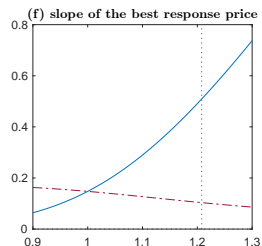
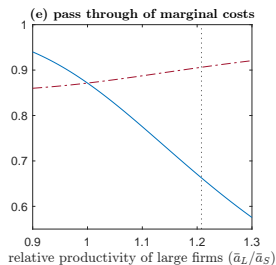
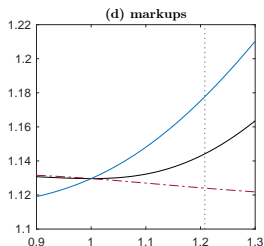
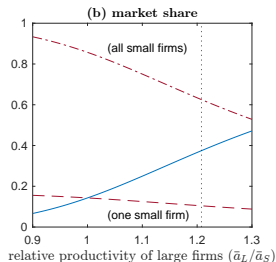
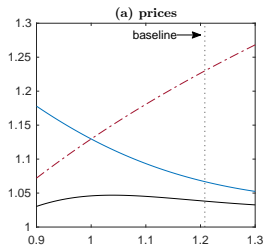
- The model specifies one large firm in a sector and multiple small firms
- Differences in prices across firms explained by a productivity wedge

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



Dynamic Problem with Sticky Prices

- Rotemberg price adjustment costs introduced

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

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

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

- Stochastic discounting follows from the household Euler equation

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

Solution Method

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

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

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

- 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

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

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

Determination of Marginal Costs

- Marginal costs are given by

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

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

$$w_t = C_t = Y_t \quad (11)$$

- Household Euler equation and monetary policy are standard

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

- Solution for log-linearized marginal costs implies

$$\tilde{c}_{st} = \tilde{Y}_t - a_t \quad (13)$$

General Equilibrium

- Necessary to solve for the response of aggregate output and inflation to shocks
- Also necessary to solve for relation between firm-specific marginal costs and output
 - Method of undetermined coefficients
 - Two shocks are included: monetary policy (m) and productivity (a)
- The response of inflation and output to monetary policy shock:

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

- The persistence of the shock implies

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

- 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

Table of contents

1 Introduction

2 Model Setup

3 Results

4 Conclusion

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 | | Small firms | | Source |
|------------------------------|-------------|-------|-------------|-------|-----------------------|
| | Target | Value | Target | Value | |
| <i>Targeted</i> | | | | | |
| 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) |
| <i>Implied</i> | | | | | |
| Log price | – | 0.06 | – | 0.21 | – |

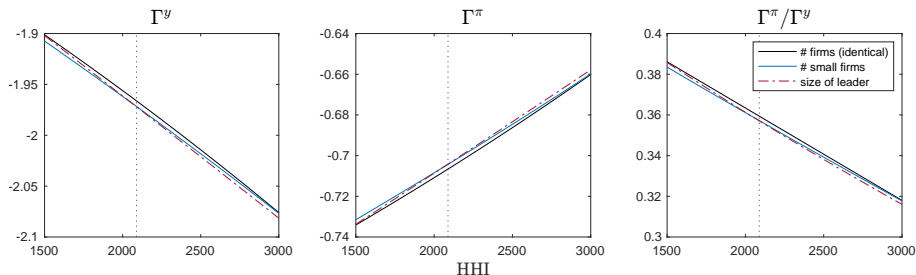
Table: Aggregate Targets

| Description | Target (range) | Value | Source |
|--------------------------------|----------------|-------|-----------------------|
| <i>Targeted</i> | | | |
| 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) |
| <i>Implied</i> | | | |
| 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

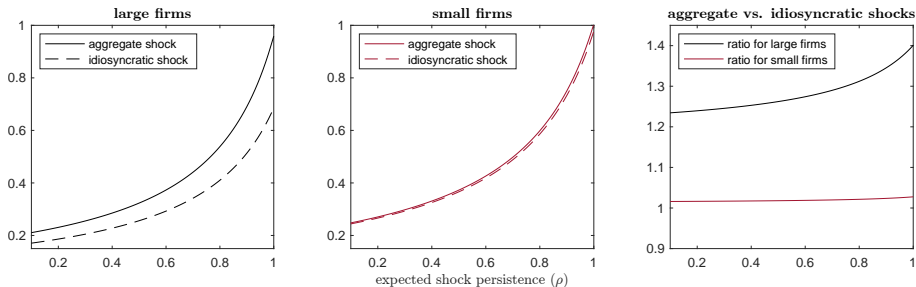
Figure: Response of Output and Inflation to a Monetary Policy Shock



Pass-Through of Marginal Costs

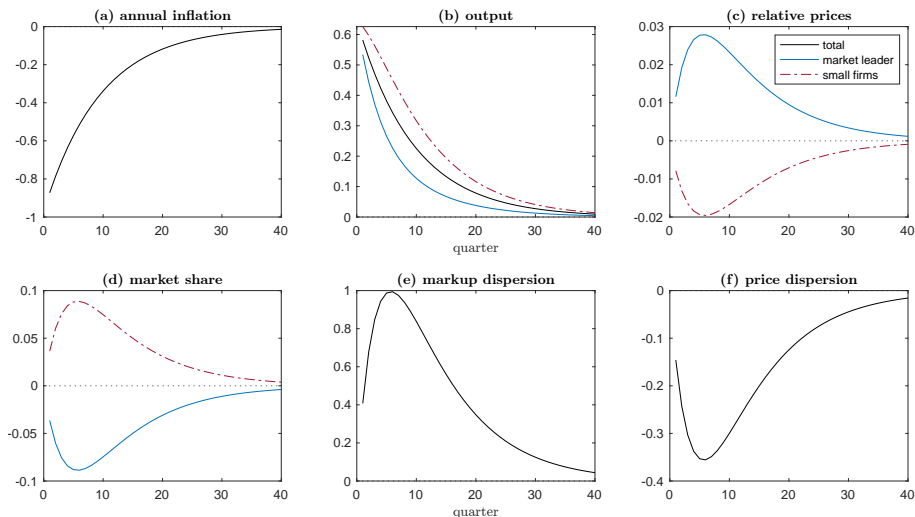
- There is a link between the expected persistence of shocks and the pass-through of marginal costs
- The presence of strategic complementarity leads large firms to raise their pass-through when shocks are sector-wide or aggregate
- The difference between two regimes grows as shocks become more persistent

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 Eberly (2019), which finds business cycle fluctuations are around 25 percent larger for small firms
 - The model implies a differences 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 dispersion¹
 - 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

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

Comparison with Standard NK Model

- I calibrate a standard New Keynesian model (Galí, 2015) to match the frequency of price adjustments and slope of the Phillips curve
- 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

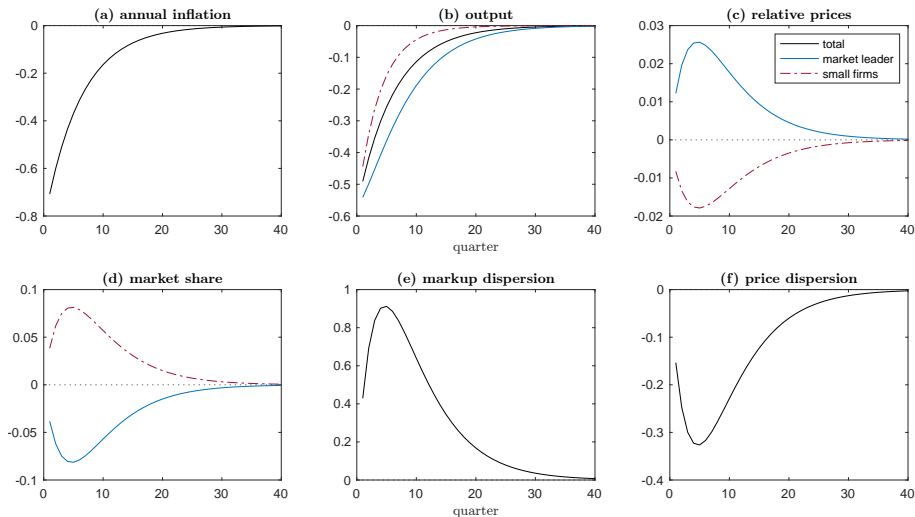
| Price dispersion | NK Model (1) | Baseline (2) |
|------------------|----------------------|---------------------|
| Inflation | 0.612*** (0.054) | 0.027*** (0.003) |
| Constant | -0.001*** (0.000) | 0.069*** (0.000) |
| R-squared | 0.769 | 0.616 |

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
- Large firms more sensitive to monetary policy
 - Goes against conventional wisdom, e.g. Gertler and Gilchrist (1994)
 - Recent evidence is very mixed
 - Crouzet and Eberly (2019) find no relationship between firm size and change in sales following monetary policy shocks
- 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
- Important to remember all results are fully symmetric
 - Large firms absorb higher marginal costs given monetary easing

Allocative Efficiency and Shocks

- Shocks affect only one type of firm

Figure: Negative Productivity Shock to Large Firms

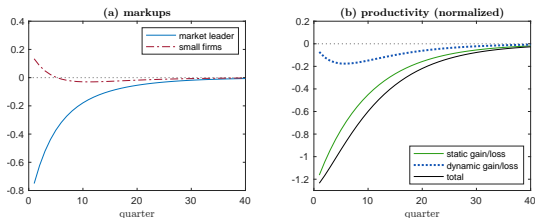
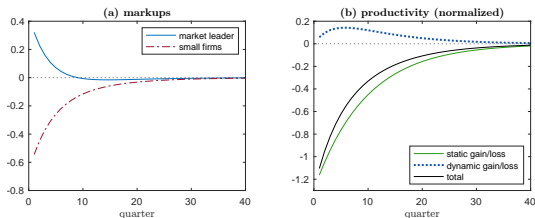


Figure: Negative Productivity Shock to Small Firms



Discussion of Results

- Large firms are more efficient, so the allocation of market share affects aggregate TFP
 - Not much change given aggregate shock, so focus is 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 of imposed by strategic behavior
- Need more evidence on whether small and large firms are affected by shocks differently

Main Takeaways

- Differences in pricing behavior across firms appear a good starting point when looking at aggregate dynamics
- Rising concentration may explain some flattening of the Phillips curve
- Strategic behavior among large firms may explain why the pass-through increases during inflationary episodes
- The expected persistence of shocks plays a large role in determining the amount of pass-through
- The increase in markups by large firms can make a bad situation worse, still the efficiency losses do not appear a first-order concern

Thank You!
Questions/Comments?

Working version is available at gregauclair.com

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