Market structure and monetary non-neutrality

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Introduction

Monetary economics
- How do changes in nominal spending affect output vs. inflation?
- Nominal rigidity + Firms are non-strategic
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- How do changes in nominal spending affect output vs. inflation?
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This paper
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- Markets dominated by a few large firms
  e.g. Mayonnaise, Ohio, 2005:Q1 - Hellman’s 45%, Kraft 33% (IRI data)
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Quantitative question
- How does market structure affect transmission of monetary shocks?
Framework

Quantitative model

- Firm heterogeneity - Idiosyncratic productivity shocks ($z$)
- Exog. changes in nominal spending - Aggregate money shocks ($M$)
- Nominal rigidity - Menu cost of changing prices ($\xi$)
- New - Two strategic firms in each sector. Dynamic oligopoly.
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- Compare: Oligopoly vs. Monopolistic competition
- Calibrate to match same data on good-level price dynamics
  - Frequency of adjustment, Size of adjustment, Average markup
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Main finding
- 2.5 times larger output fluctuations under duopoly
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Main finding
- **2.5 times larger output fluctuations under duopoly**
  (75% flatter Phillips curve. Want: 95% flatter)
Complementarity

Under oligopoly, prices are static complements ($\pi_{12} > 0$)
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+ Menu costs $\rightarrow$ Costly to cut prices
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- **Menu costs** $\rightarrow$ Costly to cut prices
- **Dynamic oligopoly** $\rightarrow$ Sustain $\mathbb{E}[p] > p^*$ in equilibrium
Complementarity

Under oligopoly, prices are static complements \((\pi_{12} > 0)\)

+ Menu costs \(\rightarrow\) Costly to cut prices

+ Dynamic oligopoly \(\rightarrow\) Sustain \(\mathbb{E}[p] > p^*\) in equilibrium

= Prices are dynamic complements (Maskin Tirole ‘88, Lapham ‘94, Jun Vives ‘04)
Complementarity - Monetary non-neutrality

Take a sector with initially dispersed markups: \( \mu = \frac{P}{M} \)

\[ \mu^* < \mu_L < \mathbb{E}[\mu] < \mu_H \]
Complementarity - Monetary non-neutrality

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Steady-state policies sustain \( \mathbb{E}[\rho] > \mu^* \)

- High probability of large price increase \( \uparrow \mu_L \)
- Increase price to \( \mu_L^* \in (\mathbb{E}[\mu], \mu_H) \)
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Take a sector with initially dispersed markups: \( \mu = \frac{p}{M} \)

\[ \mu^* \leftarrow \mu_L < \mathbb{E}[\mu] < \mu_H \]

Steady-state policies sustain \( \mathbb{E}[p] > \mu^* \)
- High probability of large price increase \( \mu_L \)
- Increase price to \( \mu_L^* \in (\mathbb{E}[\mu], \mu_H) \)

Increase in money supply

1. Lower value of \( \mu_H \)
2. Lowers real price of \( \mu_H \)
\[ \rightarrow \text{Both lower the probability and size of } \mu_L \]
Outline

1. Model
2. Policy functions
3. Calibration
4. Decompose inflation
5. Four additional results
   - (i) Large first order output losses due to nominal rigidity
   - (ii) ‘Optimal’—from firms’ perspective—level of nominal rigidity
   - (iii) Avoids issues discovered by Klenow-Willis, Burstein-Hellwig
   - (iv) Empirical relationship b/w concentration and price flexibility
Household

Flow utility

\[ U(C, N) = \log C - N \]

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

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

Total nominal expenditure

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

Labor supply

\[
\frac{W}{P} = -\frac{U_N(C, N)}{U_C(C, N)} \quad \leftrightarrow \quad W = PC = M
\]

Demand

\[
d_{ij} = \left( \frac{p_{ij}}{P_j} \right)^{-\eta} \left( \frac{P_j}{P} \right)^{-\theta} C
\]

where

\[
P_j = \left[ p_{1j}^{1-\eta} + p_{2j}^{1-\eta} \right]^{\frac{1}{1-\eta}}
\]

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

Markups

\[ \mu_{ij} = \frac{p_{ij}}{W/z_{ij}} , \quad \mu_j = \frac{P_j}{W} , \quad \mu = \frac{P}{W} = \frac{1}{c} \]

- Firm
- Sector
- Aggregate
Household - Solution

**Markups**

\[ \mu_{ij} = \frac{p_{ij}}{W / z_{ij}} \quad , \quad \mu_j = \frac{P_j}{W} \quad , \quad \mu = \frac{P}{W} = \frac{1}{C} \]

- **Firm**
- **Sector**
- **Aggregate**

**Profits**

\[ \frac{\pi_{ij}}{W} = \left( \frac{\mu_{ij}}{\mu} \right)^{-\eta} \left( \frac{\mu_j}{\mu} \right)^{-\theta} \frac{1}{\mu} \left( \mu_{ij} - 1 \right) \]

- **Demand** \( d_{ij} \)
- **Per-unit profit**

**where**

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

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

Markups

\[ \mu_{ij} = \frac{p_{ij}}{W / z_{ij}}, \quad \bar{\mu}_{ij} = \frac{p_{ij}}{W' / z'_{ij}} \]

Choice today \quad \text{State tomorrow}

Profits

\[ \frac{\pi_{ij}}{W} = \left( \frac{\mu_{ij}}{\mu_j} \right)^{-\eta} \left( \frac{\mu_j}{\mu} \right)^{-\theta} \cdot \frac{1}{\mu} \left( \mu_{ij} - 1 \right) \]

Demand \( d_{ij} \) \quad \text{Per-unit profit}

where

\[ \mu_j = \left[ \mu_{1j}^{1-\eta} + \mu_{2j}^{1-\eta} \right]^{1/(1-\eta)} \]

\[ \mu = \left[ \int_0^1 \mu_j^{1-\theta} \, dj \right]^{1/(1-\theta)} \]
Firm problem

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

$x = (\bar{\mu}_i, \bar{\mu}_{-i})$

$X = (\lambda, g)$

Simon Mongey, "Market structure and monetary non-neutrality" p.7/24
Firm problem

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- Sector Markups $\bar{\mu}_i, \bar{\mu}_{-i}$
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Equilibrium functions
- Aggregate markup $\mu(X)$
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Timing and Information (Doraszelski Satterthwaite, 2007)

$(x, X)$ determined $\rightarrow$ Draw menu cost $\xi_i \sim U[0, \bar{\xi}]$ $\rightarrow$ Pricing decisions

Public $\rightarrow$ iid + Private Simultaneous

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Competitor’s policies
- Markup conditional on adjustment $\mu^*_{-i}(x, X) \in \mathbb{R}_+$
- Markup adjustment $\gamma_{-i}(x, X, \xi_{-i}) \in \{0, 1\}$
Firm problem

Value

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

Value

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

Value of adjusting price

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

\[ \mu_{-i}(x, X, \xi_{-i}) = \gamma_{-i}(x, X, \xi_{-i}) \mu_i^*(x, X) + \left( 1 - \gamma_{-i}(x, X, \xi_{-i}) \right) \bar{\mu}_{-i} \]

- Competitor adjusts
- Competitor stays

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Firm problem

Value

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

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\[ \mu_{-i}(x, X, \xi_{-i}) = \gamma_{-i}(x, X, \xi_{-i}) \mu^*_i(x, X) + \left(1 - \gamma_{-i}(x, X, \xi_{-i})\right) \bar{\mu}_{-i} \]

Competitor adjusts

Competitor stays

Solution

- Probability of price adjustment
  \[ \gamma_i(x, X) = \int_0^{\xi} \gamma_i(x, X, \xi_i) dF(\xi_i) \]

- Markup conditional on adjustment
  \[ \mu^*_i(x, X) \]
Recursive equilibrium

- Symmetric demand, value, adjustment prob. and markup functions
  \[ d(x, X), V(x, X), \gamma(x, X), \mu^*(x, X) \]
- Transition density for the distribution of sectors \( \lambda' \sim H(\lambda|X) \)
- Aggregate markup function \( \mu(X) \)
  such that

1. Firm policies and values are **Markov-Perfect** at the sectoral level
2. \( W = PC = M + \) Markup definitions \( \leftrightarrow \mu(X) = \frac{1}{C(X)} \)
3. Demand functions are consistent with household optimization
4. Transition function for \( \lambda \) is consistent with policies and processes
5. Aggregate mark-up is consistent with (i) mark-up policies, (ii) \( \lambda \)
Monopolistically competitive market structure

- Continuum of sectors $j \in [0, 1]$

- Continuum of firms within each sector $i \in [0, 1]$

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

- Competitive equilibrium

- Otherwise exactly the same environment
  - Household problem
  - Stochastic environment: $\bar{\zeta}_{ij}$, $z_{ij}$, $g$
  - Set of parameters: $\bar{\zeta}$, $\sigma_z$, $\eta$, $\theta$
Simulation

Results

- **Micro** MPE policies attain high markups in equilibrium
- **Macro** Weaker intensive and extensive response to \( \uparrow M \)

Setup

- No aggregate shocks or inflation \( g_t = 0 \)
- Fix paths for menu costs \( \bar{\zeta}_{it} = \bar{\zeta} \)
- Fix paths for shocks \( \bar{\mu}_{i0} = E[\mu_{it}], \{z_{it}\} \rightarrow \{\bar{\mu}_{it}\} \)
- Plot equilibrium policies
  (A.) Optimal markup \( \mu_{it}^* = \mu^*(\bar{\mu}_{it}, \bar{\mu}_{-it}) \)
  (B.) Probability of adjustment \( \gamma_{it} = \gamma(\bar{\mu}_{it}, \bar{\mu}_{-it}) \)

*Note: Using estimated parameters (next)*
Monopolistic competition

A. Markups

- Frictionless markup

- Optimal markup $\mu^*_i$

B. Probability of adjustment

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

Extensive margin
- Precautionary motive $\gamma_L > \gamma_H$

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Monopolistic competition - $\uparrow M$

A. Markups

- Frictionless markup
- Optimal markup $\mu^*_it$

B. Probability of adjustment

Intensive margin
- Optimal price adjustment increases by $\Delta M$

Extensive margin
- Jump in $\gamma_L$ shifts distribution of price changes to price increases

Profit functions
Duopoly - Case I

### Intensive margin
- Static optimum $\rightarrow$ Cut prices
- Dynamic optimum $\rightarrow$ Raise prices

### Extensive margin
- Adjustment incurs temporary losses, but future gains

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Duopoly - Case II

Intensive margin
- Higher $\mu_H$ requires higher $\mu_L$
- Policies flatten out due to small $\bar{\xi}$

Extensive margin
- Higher $\mu_H$ requires higher $\gamma_L$

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Intensive margin

Extensive margin

Profit functions
Duopoly - Case I - \( \uparrow M \)

### Intensive margin
- Over-adjust to reset markup

### Extensive margin
- Large increases in value / probability of adjustment
Duopoly - Case II - $\uparrow M$

Intensive margin

Extensive margin
Intensive margin

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

Extensive margin

- Dampened increase in $\gamma_L$
Duopoly - Case II - $\uparrow M$

**Intensive margin**

- Optimal adjustment $\Delta p_L = \frac{\mu^*_L}{\mu_L}$ increases by less than $\Delta M$

**Extensive margin**

- Dampened increase in $\gamma_L$

Simon Mongey, "Market structure and monetary non-neutrality"
Calibration - What contributes to larger output effects?

*In the MPE, when does a firm respond to another’s price?*

**Static complementarity**
- More substitutable within sectors $\eta$, less across sectors $\theta$

**Dynamic complementarity**
- Menu costs are large $\uparrow \bar{\xi}$
- Idiosyncratic shocks are small $\downarrow \sigma_z$
- Firms choose when to change price
- Lower $\bar{g}$? Lower $\sigma_g$?

\[
\log g_{t+1} = (1 - \rho_g) \log \bar{g} + \rho_g \log g_t + \sigma_g \epsilon_{t+1}
\]
Quantification - Calibration strategy (monthly)

External
- Money growth parameters $\rho_g = 0.6$, $\sigma_g = 0.002$, $\bar{g} = 1.025^{1/12}$
- Cross-sector elasticity of substitution $\theta = 1.5$

Internal
- Menu cost $\bar{\zeta}$, Size of shocks $\sigma_z$
- Within-sector elasticity of substitution $\eta$

Moments
- Average absolute size of regular price changes (IRI) - 10%
- Average frequency of regular price changes (IRI) - 13%
- Average markup $\mathbb{E} [\mu_{it}] = 1.30$
### Quantification - Parameters and results

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

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3. Smaller shocks deliver observed size of price change
## Quantification - Parameters and results

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<thead>
<tr>
<th>A. Parameter</th>
<th>Duopoly</th>
<th>MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sector demand elasticity $\theta$</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Within-sector demand elasticity $\eta$</td>
<td>10.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Size of menu cost $\bar{\xi}$</td>
<td>0.17</td>
<td>0.21</td>
</tr>
<tr>
<td>Size of idiosyncratic shocks (%) $\sigma_z$</td>
<td>3.80</td>
<td>4.00</td>
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<tr>
<th>B. Moments matched</th>
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<tr>
<td>Average markup $\mathbb{E}[\mu_{it}]$</td>
<td>1.30</td>
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<tr>
<td>Frequency of price change</td>
<td>0.13</td>
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<tr>
<td>Std. deviation consumption $std[\log C_t] \times 100$</td>
<td>0.31</td>
<td>0.13</td>
</tr>
<tr>
<td>Average minus Frictionless markup $\mathbb{E}[\mu_{it}] - \mu^*$</td>
<td>0.10</td>
<td>0.02</td>
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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 $\rightarrow$ 10% Lower output
3. **Smaller shocks** deliver observed size of price change
4. **25 percent** smaller menu costs deliver same flex. (0.07 vs. 0.10% rev)

Simon Mongey, "Market structure and monetary non-neutrality" p.20/24
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<td>0.13</td>
<td>$\uparrow$ 0.19</td>
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<td>Ave. absolute size of price change</td>
<td>0.10</td>
<td>0.10</td>
<td>$\downarrow$ 0.05</td>
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Quantification - Accounting for inflation

\[ \pi_t \approx \sum_{i=1}^{N} \omega_i \left[ \tilde{\gamma}_{it} (x_{it} - \bar{x}_{it}) + \bar{x}_{it} (\gamma_{it} - \bar{\gamma}_{it}) + (\gamma_{it} - \bar{\gamma}_{it}) (x_{it} - \bar{x}_{it}) \right] \]

where \( x_{it} = \log p_{it}^* - \log p_{it-1} \), is the desired price change

<table>
<thead>
<tr>
<th>Fraction of the difference: ( \pi_t^{Mon} - \pi_t^{Duo} )</th>
<th>Intensive %</th>
<th>Extensive %</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fraction of each margin accounted for by different sectors (( \mu_{1j}, \mu_{2j} ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case I Low-Low</td>
</tr>
<tr>
<td>Case II Low-High / High-Low</td>
</tr>
<tr>
<td>Case III High-High</td>
</tr>
</tbody>
</table>

Results

1. Extensive and intensive margin components dampened \( \approx \) equally
2. Case I sectors are ‘special cases’. Many fewer than Case II.
Relation to some of the literature

The duopoly mechanism does not
- Deliver amplification through changing the kurtosis of the distribution of price changes (Alvarez Bihan Lippi 2016)
- Create excess curvature in profits, causing excess sensitivity of firm level prices to idiosyncratic shocks (Klenow Willis, 2016; Burstein and Hellwig 2007)

The duopoly mechanism does
- Depend on the price setting technology: firms choose when to change prices. Under Calvo, dynamic complementarity is weaker.

The duopoly mechanism is qualitatively consistent with previous work
- Strategic complementarities in pricing (Amiti, Itskhoki, Konings (2016)
- Counter-cyclical μ’s and conc. (Barro Tenreyo, ’06; Rotemberg Woodford, ‘91)
- Prices stickier for differentiated (final) goods (Bils Klenow, 2004)
1. Positive menu costs are preferred by firms

2. Menu costs lead to large first order output losses

3. Strategic complementarities in the literature

4. Empirics: More concentrated markets do have less flexible prices
Conclusion

Market structure quantitatively important for understanding
1. Aggregate price flexibility following nominal spending shocks
2. Firm level price flexibility following idiosyncratic shocks
3. Cross-sectional heterogeneity in price flexibility

Market structure empirically important
- More concentrated labor markets have lower wages
  Berger, Herkenhoff, Mongey (2019)
- Increasing concentration and weakening Tobin’s $Q \leftrightarrow$ Investment
  Philippon Gutierrez (2016)

This paper presents a framework for assessing these issues
- Relabel $p_{it} \rightarrow k_{it}$ delivers an oligopolistic Khan-Thomas model
- Exchange rate shocks
- Oligopsony in labor markets
THANK YOU!
Household - Solution

Preferences - ↓ $z_{ij}$, ↑ Cost, ↑ Demand

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

$$C_j = \left[ \left( \frac{c_1j}{z_{1j}} \right)^{\frac{\eta-1}{\eta}} + \left( \frac{c_2j}{z_{2j}} \right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

Demand

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

where

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

$$P = \left[ \int_0^1 P_j^{1-\theta} \, dj \right]^{\frac{1}{1-\theta}}$$
1. Firms value pricing frictions

- More frictions $\rightarrow$ Higher markups
- More frictions $\rightarrow$ Costly to respond to $\Delta z_{ijt}$
  - 23% larger firm value in menu-cost model, 16% larger in Calvo
    - Rationalizes why firms create pricing frictions
    - e.g. Apple announces on Sep 24 price of new iPhone on sale Nov 3
2. First order output loss due to nominal rigidity

\[ Y = \frac{1}{\mu} , \quad \mu = \left[ \int_{0}^{1} \mu_j^{1-\theta} \, dj \right]^{\frac{1}{1-\theta}} , \quad \mu_j = \left[ \mu_1^{1-\eta} + \mu_2^{1-\eta} \right]^{\frac{1}{1-\eta}} \]

<table>
<thead>
<tr>
<th>Mon. Comp.</th>
<th>Duopoly</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Output</td>
<td>0.76</td>
</tr>
<tr>
<td>(2) ... under no dispersion</td>
<td>( \mu_{it} = \mathbb{E}[\mu_{it}] )</td>
</tr>
<tr>
<td>(3) ... with no menu costs</td>
<td>( \mu_{it} = \mu^* )</td>
</tr>
<tr>
<td>(3)-(1) Output loss due to nominal rigidity</td>
<td>2.4%</td>
</tr>
</tbody>
</table>

**Result**
- Nearly 10% output losses due to nominal rigidity in oligopoly
- 1st order \( \sim 80\% \) due to higher markups
- 2nd order \( \sim 20\% \) due to price dispersion
3. 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 $\sigma_z$...this challenge is a serious one” - Nakamura Steinsson (2010)

This paper

- Smaller $\bar{\xi}$ and $\sigma_z$ under duopoly
- Larger $\uparrow std[c_t]$ due to strategic complementarity
- How? Complementarity due to $\mu_{1jt}/\mu_{2jt}$, not $\mu_{it}/\mu_t$
1. Variation across states, within product categories

2. Market concentration is not region specific

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

3. Most variation in price flex. is within product-\( p \), across states-\( s \)

   
   \[
   \text{std } \left[ \log \text{freq}_{spt} \right] \left|_{t} \right. = 0.65 \\
   \text{std } \left[ \log \text{freq}_{spt} \right] \left|_{pt} \right. = 0.54.
   \]
4. More concentrated markets, Less flexible prices

\[ X_{spt} = \hat{\gamma}_{pt} + \hat{\beta}_1 Nfirms_{spt} + \hat{\beta}_2 Rev_{spt} + \hat{e}_{spt}^X \]

\[ \hat{e}_{spt}^X = \frac{\hat{e}_{spt}^X}{\text{std}[\hat{e}_{spt}^X|pt]} \]
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\[ X_{spt} = \hat{\gamma}_{pt} + \hat{\beta}_1 Nfirms_{spt} + \hat{\beta}_2 Rev_{spt} + \hat{\epsilon}^X_{spt} \]

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A. Frequency of price change

B. Average abs. size of log price change
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

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1. Preferences

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

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

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

3. **Free-entry determines size of fringe**  \( \pi_f^f \left( p_1, p_2, z_1, z_2, M, \delta \right) - \phi = 0 \)
\[
\pi_{ij} \left/ \mathcal{W} \right. = \left( \frac{\mu_{ij}}{\mu_j} \right)^{-\eta} \left( \frac{\mu_j}{\mu} \right)^{-\theta} \frac{1}{\mu} \left( \mu_{ij} - 1 \right) = \hat{\pi}_{i} (\mu_{ij}, \mu_{-ij}) \mu^{\theta-1}
\]
\[
\frac{\pi_{ij}}{\mathcal{W}} = \left( \frac{\mu_{ij}}{\mu_j} \right)^{-\eta} \left( \frac{\mu_j}{\mu} \right)^{-\theta} \frac{1}{\mu} \left( \mu_{ij} - 1 \right) = \hat{\pi}_i (\mu_{ij}, \mu_{-ij}) \mu^{\theta-1}
\]
Duopoly - Case I - Profit functions

A. Initial markups

B. Green increases markup

C. Red increases markup

Simon Mongey, "Market structure and monetary non-neutrality"
A. Static best response is to undercut: $\mu^*_H(\mu_L) < \mu_L$. 
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B. Dynamic best response $\mu_H \rightarrow \mu'_H$ reduces short-run profits, .

$$\pi_H(\mu_H, \mu_L) > \pi_H(\mu'_H, \mu_L)$$ but shifts out $\pi_L(\mu_L, \mu'_H)$. 

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C. $\mu_L \rightarrow \mu'_L$ such $\pi_H(\mu'_H, \mu'_L) > \pi_H(\mu^*_H(\mu'_L), \mu'_L) + \bar{\xi}$.
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
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2. Marginal cost

$$mc_i = \frac{W^{1-\alpha_i} (W^*)^{\alpha_i}}{z} + E = \log \left( \frac{W}{W^*} \right) \rightarrow mc_i = \frac{W}{\exp (\alpha_i E)}$$
Data - Markets are highly concentrated

- **Market**  31 IRI product cat. \( (p) \times 46 \) states \( (s) \times 132 \) months \( (t) \)

- **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

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<tr>
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<th>A. Number of firms</th>
<th>B. Effective number of firms</th>
<th>C. Two firm revenue share</th>
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<tbody>
<tr>
<td>Median</td>
<td>40.7</td>
<td>3.73</td>
<td>0.66</td>
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Simon Mongey, "Market structure and monetary non-neutrality"
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
1. **Monopolistic competition, menu-costs**
   - **Monetary**
   - **Inter’l**
     - Itskhoki Gopinath (2010), Itskhoki Mukhin (2016), Berger Vavra (2016)

   **New - Dynamic oligopoly**

2. **Oligopoly, flexible prices**
   - **Trade**
   - **IO**
     - Hottman Redding Weinstein (2016)

   **New - Nominal rigidity**

3. **Dynamic oligopoly, nominal rigidity**

   **New - Equilibrium macroeconomic model**
## Literature - Existing results

<table>
<thead>
<tr>
<th>Panel A.</th>
<th>Ref.</th>
<th>Peak IRF $\frac{\Delta \log \hat{Y}_t}{\Delta \log M_t}$</th>
<th>P.C. slope $\lambda = \frac{\partial \pi_t}{\partial mc_t}$</th>
<th>Freq. $\alpha$</th>
<th>Dur. $1/\alpha$</th>
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</thead>
<tbody>
<tr>
<td>Golosov-Lucas Menu cost</td>
<td>Fig. 4a</td>
<td>0.42</td>
<td>1.36</td>
<td>0.67</td>
<td>1.49</td>
</tr>
<tr>
<td>Nakamura-Steinsson 14-sector</td>
<td>Fig. VIII</td>
<td>0.50</td>
<td>1.00</td>
<td>0.62</td>
<td>1.62</td>
</tr>
<tr>
<td>+ Round-a-bout*</td>
<td>Fig. IX</td>
<td>0.80</td>
<td>0.25</td>
<td>0.39</td>
<td>2.56</td>
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<tr>
<td>Gertler-Leahy Baseline</td>
<td>Fig. 2</td>
<td>0.45</td>
<td>1.22</td>
<td>0.65</td>
<td>1.53</td>
</tr>
<tr>
<td>+ sectoral labor**</td>
<td>Fig. 3</td>
<td>0.75</td>
<td>0.33</td>
<td>0.43</td>
<td>2.30</td>
</tr>
<tr>
<td>Burstein-Hellwig Baseline</td>
<td>Fig. 5</td>
<td>0.34</td>
<td>1.94</td>
<td>0.73</td>
<td>1.37</td>
</tr>
<tr>
<td>+ DRS**</td>
<td>Fig. 5</td>
<td>0.56</td>
<td>0.79</td>
<td>0.58</td>
<td>1.73</td>
</tr>
<tr>
<td>+ Wage rigidity*</td>
<td>Fig. 5</td>
<td>0.70</td>
<td>0.43</td>
<td>0.47</td>
<td>2.11</td>
</tr>
<tr>
<td>Klenow-Willis Baseline</td>
<td>Fig. 4</td>
<td>-</td>
<td>0.51</td>
<td>0.50</td>
<td>1.99</td>
</tr>
<tr>
<td>+ Kimball**</td>
<td>Fig. 4</td>
<td>-</td>
<td>0.40</td>
<td>0.46</td>
<td>2.16</td>
</tr>
<tr>
<td>This paper Monopolistic comp.</td>
<td>Fig. 5</td>
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<td>0.67</td>
<td>1.49</td>
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<td>Duopoly**</td>
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<td>0.74</td>
<td>0.36</td>
<td>0.45</td>
</tr>
</tbody>
</table>

*Forms of pricing complementarity: * = ‘macro’-complementarity, ** = ‘micro’-complementarity*

## Panel B.

| Ref. | CET (RANK) | Tab. D2 | 0.909 | 0.100 | 0.27 | 3.70 |

Simon Mongey, "Market structure and monetary non-neutrality"
Household

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

where

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

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

subject to a nominal budget constraint

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

Simon Mongey, "Market structure and monetary non-neutrality"
Calibration - Identification

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

Increasing $\sigma_z$
(i) Given bounds. Hit bounds more often. $\uparrow$ Frequency
(ii) Hit bounds more often $\rightarrow$ Widen bounds $\uparrow$ Size

Increasing $\eta$
- Increase average markup
(A) For each $\eta$, choose $\bar{\xi}$ and $\sigma_z$ 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 $\sigma_z$ are recalibrated $\sigma(C_t)$ is unaffected
Recursive equilibrium - Computation

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

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

- Reduces aggregate state to $S = (\mu_1, g)$

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

$$V^e(\mu_1, \mu_2, \mu, g) = \int V \left( \frac{\mu_1}{e^{\epsilon_1+g'(g, \epsilon_g)}}, \frac{\mu_2}{e^{\epsilon_2+g'(g, \epsilon_g)}}, \mu, g'(g, \epsilon_g) \right) dF(\epsilon'_1, \epsilon'_2, \epsilon'_g)$$

- Cubic splines in $\mu_1, \mu_2$. Linear splines in $\mu, g$

- Guess initial pricing policies $\mu_{-i}^{(0)}(\mu_i, \mu_{-i}, S)$ and $\gamma_{-i}^{(0)}(\mu_i, \mu_{-i}, S)$

- Given competitor policies, use collocation algorithm to solve for value functions

- Determines new $\mu_{-i}^{(1)}(\mu_i, \mu_{-i})$ and $\gamma_{-i}^{(1)}(\mu_i, \mu_{-i})$

- Continue, until $\mu_{-i}^{(k+1)} = \mu_{-i}^{(k)}$ and $\gamma_{-i}^{(k+1)} = \gamma_{-i}^{(k)}$
A. Profit function $\pi(\mu_1, \mu_2)$

B. Static best response $\mu_2^*(\mu_1)$

C. Second derivative $\pi_{11}(\mu_1, \mu_2)$

D. Cross-partial derivative $\pi_{12}(\mu_1, \mu_2)$

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

<table>
<thead>
<tr>
<th>A. Parameters</th>
<th>Baseline</th>
<th>Alternative $MC$ models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within-sector elasticity of substitution $\eta$</td>
<td>10.5</td>
<td>10.5</td>
</tr>
<tr>
<td>Upper bound of menu cost distribution $\xi \sim U[0, \bar{\xi}]$</td>
<td>0.17</td>
<td>0.17</td>
</tr>
<tr>
<td>Size of shocks (percent) $\sigma_z$</td>
<td>3.8</td>
<td>3.8</td>
</tr>
</tbody>
</table>

| B. Moments | | | | |
| Markup $\mathbb{E}[\mu_{it}]$ | 1.30 | 1.30 | 1.12 | 1.22 | 1.13 |
| Frequency of price change $\mathbb{E}[\mathbf{1}\{p_{it} \neq p_{it-1}\}]$ | 0.13 | 0.13 | 0.19 | 0.13 | 0.13 |
| Log abs. price change $\mathbb{E}[|\log(p_{it}/p_{it-1})|]$ | 0.10 | 0.10 | 0.05 | 0.10 | 0.10 |

| C. Results | | | | |
| Std. deviation consumption (percent) $\sigma(\log C_t)$ | 0.31 | 0.13 | 0.06 | 0.13 | 0.13 |
| Average minus frictionless markup $\mathbb{E}[\mu_{it} - \mu^*]$ | 0.10 | 0.02 | 0.01 | 0.02 | 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

Back - Calibration
Robustness to target $\mathbb{E}[\mu_{it}]$

$$\sigma(C_t) \quad \eta \to \infty \quad \eta \to \theta$$

$\eta = 10.5$

$0.31$  
$0.13$  

Monopolistic competition

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

Simon Mongey, "Market structure and monetary non-neutrality"
Decomposing revenue changes at large firms

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

$$\text{var} (\Delta \log r_{ipst}) = \text{var} \left( \Delta \log \left( \frac{r_{ipst}}{r_{pst}} \right) \right) + \text{var} \left( \Delta \log \left( \frac{r_{pst}}{r_{st}} \right) \right) + \text{var} (\Delta \log r_{st}) + \text{Covariances}$$

(1) Firm share in market  
(2) Market share in state  
(3) State expenditure
Relation to Kimball-style strategic complementarity

- **Duopoly demand function super-elasticity** $\varepsilon \approx 3$
- **Literature** Klenow Willis - $\varepsilon = 10$, Gopinath Itskhoki - $\varepsilon = 4$
Relation to Kimball-style strategic complementarity

- Duopony demand function super-elasticity $\varepsilon \approx 3.5$

  Literature - Berger Vavra (2.4), Gopinath Itskhoki (4), Klenow Willis (10),

- ‘Responsiveness’ measure $\varepsilon / \sigma \approx 0.58$

  Literature - EMX (0.19), Berger Vavra (0.47), Gopinath Itskhoki (0.80)
Empirical - Data details

- **IRI data**
  - An observation is at the *UPC × Category × 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\textsuperscript{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 \( t \)
    \[
    freq_{ct} = \frac{\sum_{i \in c} 1 \left[ d \log p_{ict} \neq 0 \right]}{N_{ct}}
    \]
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

Simon Mongey, "Market structure and monetary non-neutrality"
3. Variation in price flexibility

1A. Frequency of price change

1B. Variation across–s within–pt

1C. Variation across–p within–st

2A. Average abs. size of price change

2B. Variation across–s within–pt

2C. Variation across–p within–st

Simon Mongey, "Market structure and monetary non-neutrality"
Time- vs State-dependent pricing

<table>
<thead>
<tr>
<th></th>
<th>Fixed menu cost</th>
<th>Random menu cost</th>
<th>Calvo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MC</td>
<td>Duo</td>
<td>Duo</td>
</tr>
<tr>
<td>$\sigma(\log(C_t)) \times 100$</td>
<td>0.08</td>
<td>0.31</td>
<td>0.13</td>
</tr>
<tr>
<td>Relative $\sigma(\log(C_t))$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duopoly vs Mon. Comp</td>
<td>2.38</td>
<td>-</td>
<td>1.07</td>
</tr>
<tr>
<td>Calvo vs Menu Cost</td>
<td>-</td>
<td>-</td>
<td>1.32</td>
</tr>
</tbody>
</table>

Oligopoly under Calvo

- Lose selection effect → Larger output responses
- Weaker dynamic complementarity → Smaller output response
- Slightly larger output responses

Calvo: 30% larger under Duopoly vs 200% larger under M.C.
Distribution of price gaps [solid] and changes [dotted]

A. Distribution of markup gaps

B. Distribution of price changes

Back - Additional results
Firm problem

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

Equilibrium functions
- Aggregate markup $\mu(X)$

Timing and Information (Doraszelski Satterthwaite, 2007)

$(x, X)$ determined $\rightarrow$ Draw menu cost $\xi_i \sim U[0, \bar{\xi}]$ $\rightarrow$ Pricing decisions

Public $\quad$ iid + Private $\quad$ Simultaneous

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

Simon Mongey, "Market structure and monetary non-neutrality" p.24/24
Firm problem

**Value**

\[ V_i(x, X, \bar{\xi}_i) = \max_{1_{i}^{adj} \in \{0,1\}} 1_{i}^{adj} \left[ V_i^{adj}(x, X) - \bar{\xi}_i \right] + \left( 1 - 1_{i}^{adj} \right) V_i^{stay}(x, X) \]

**Value of adjusting price**

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

\[ \mu_{-i}(x, X, \bar{\xi}_{-i}) = 1_{-i}^{adj}(x, X, \bar{\xi}_{-i}) \mu_i^{*}(x, X) + \left( 1 - 1_{-i}^{adj}(x, X, \bar{\xi}_{-i}) \right) \bar{\mu}_{-i} \]

- **Competitor adjusts**
- **Competitor stays**

**Solution**

- Probability of price adjustment
  \[ \gamma_i(x, X) = \int_0^{\bar{\xi}} 1_i^{adj}(x, X, \xi_i) dF(\xi_i) \]

- Markup conditional on adjustment
  \[ \mu_i^{*}(x, X) \]