International Shocks and Domestic Prices: How Large Are Strategic Complementarities?

Preliminary and Incomplete

Mary Amiti
NY FRB

Oleg Itskhoki
Princeton

Jozef Konings
Leuven and BNB

University of Oslo and Norges Bank
May 2015
Motivation

• How strong are strategic complementarities across firms in price setting?

  — do firms mostly respond to own cost shocks or put a large weight on the prices of their competitors?

  — a fundamental mechanism in both micro- and macroeconomics
Motivation

• **How strong are strategic complementarities across firms in price setting?**
  
  — do firms mostly respond to own cost shocks or put a large weight on the prices of their competitors?
  
  — a fundamental mechanism in both micro- and macroeconomics

• **A particular application:**
  
  — How do international shocks affect domestic marginal costs, markups and prices?
Our Approach

1. Directly estimate extent of **strategic complementarities** across a broad set of manufacturing industries
   
   (a) Develop a **general accounting framework**
   
   — decompose firm price changes into response to own cost shocks and to changes in competitor prices

   (b) Develop an **identification strategy**
   
   — two major challenges: simultaneity of price setting and measurement error in firm marginal costs

   (c) Construct a **new micro-level dataset** for Belgium manufacturing to carry out this estimation
   
   — intensive data requirements on firm prices, marginal costs, and firm’s competitor prices within sectors

2. Develop a **quantitative framework** to evaluate counterfactual scenarios
   
   — a flexible model tightly calibrated to the Belgian microdata
   
   — explore response of firm markups and prices to various shocks
Main Findings

1. Strong evidence of strategic complementarities:
   (i) response to own marginal cost = 60–65%
   (or idiosyncratic cost pass-through)
   (ii) response to competitor prices = 35–40%
   (or strategic complementarities)

2. These are average (sales-weighted) responses.
   Yet, a lot of heterogeneity in responses across firms:
   — small firms: no strategic complementarities
     (as in standard models)
   — large firms: strong strategic complementarities
     and variable markups

3. Implications for aggregate pass-through
   — decomposition across firms
   — variation across sectors
Related Literature

1. IO-style industry studies:
   - Feenstra et al. (1996, cars), Nakamura and Zerom (2010, coffee), Goldberg and Hellerstein (2013, beer)

2. Domestic prices and exchange rates:
   - Industry-level: Goldberg and Campa (2010)

3. International prices and exchange rates:
   - Gopinath and Itskhoki (2011)
   - Amiti, Itskhoki and Konings (2014)

4. Domestic prices and trade shocks:
   - De Loecker, Goldberg, Khandelwal and Pavcnik (2012)
   - Edmond, Midrigan and Xu (2012)
THEORETICAL FRAMEWORK
Accounting Framework

- Log markup:
  \[ \mu_{it} = p_{it} - mc_{it} \]

- Markup elasticities:
  \[ \Gamma_{it} = -\frac{\partial \mu_{it}}{\partial p_{it}} \quad \text{and} \quad \Gamma_{-i,t} = \frac{\partial \mu_{it}}{\partial P_{-i,t}} \]

- Change in markup:
  \[ \Delta \mu_{it} = -\Gamma_{it} \Delta p_{it} + \Gamma_{-i,t} \Delta p_{-i,t} + \tilde{\varepsilon}_{it} \]

- Decomposition of price change:
  \[ \Delta p_{it} = \frac{1}{1 + \Gamma_{it}} \Delta mc_{it} + \frac{\Gamma_{-i,t}}{1 + \Gamma_{it}} \Delta p_{-i,t} + \varepsilon_{it} \]
A Model of Strategic Complementarities

- Modeling variable markups requires relaxing either CES or monopolistic competition assumptions

- We follow Atkeson and Burstein (2008) by adopting a CES-model with oligopolistic competition
  - nested-CES demand
  - finite number of firms within sector and Cournot competition
  - flexible price setting
  - focus on industry equilibrium
Demand

• Nested-CES demand:

\[ Q_{it} = \xi_{it} P_{it}^{-\rho} P_{t}^{\rho-\eta} D_t, \quad \rho > \eta \geq 1, \]

where \( s \) industry (omitted) and \( i \) firm-product

• Sectoral price index:

\[
P_t \equiv \left[ \sum_{i=1}^{N} \xi_{it} P_{it}^{1-\rho} \right]^{\frac{1}{1-\rho}} \\
= \left[ \xi_{it} P_{it}^{1-\rho} + (1 - \xi_{it}) P_{-i,t}^{1-\rho} \right]^{\frac{1}{1-\rho}}
\]

where \( N \) is a finite number of firms in the industry

• Market share:

\[
S_{it} \equiv \frac{P_{it} Q_{it}}{\sum_{j=1}^{N} P_{jt} Q_{jt}} = \xi_{it} \left( \frac{P_{it}}{P_t} \right)^{1-\rho} \in [0, 1]
\]
Market Structure

- Cournot (quantity) competition across firms results in optimal markup pricing rule:

\[ P_{it} = M_{it} \cdot MC_{it}, \quad \text{where} \]

\[ M_{it} = \frac{\sigma_{it}}{\sigma_{it} - 1} \quad \text{and} \quad \sigma_{it} \equiv \left[ \frac{1}{\eta}S_{it} + \frac{1}{\rho}(1 - S_{it}) \right]^{-1} \]

- Markup elasticity:

\[ \Gamma_{it} = \Gamma_{-i,t} = \frac{(\rho - \eta)(\rho - 1)\sigma_{it}S_{it}(1 - S_{it})}{\rho \eta (\sigma_{it} - 1)} \]

increases in market share (over relevant range)

- Decomposition of price change in the model:

\[ \Delta p_{it} = \frac{1}{1 + \Gamma_{it}} \Delta mc_{it} + \frac{\Gamma_{it}}{1 + \Gamma_{it}} \Delta p_{-i,t} + \frac{\Gamma_{it}}{1 + \Gamma_{it}} \frac{\Delta \xi_{it}}{(\rho - 1)(1 - S_{it})} \]
Cost Structure

- Total Cost:
  \[ TC_{it} = AVC_{it} \cdot Y_{it} + F_{it} \]

- Average Total Cost:
  \[ MC_{it} = AVC_{it} = \frac{TVC_{it}}{Y_{it}} \]

- Marginal cost:
  \[ MC_{it} = W_{it}^{1-\phi_{it}} (V_{it}^* \mathcal{E}_t)^{\phi_{it}} \]

- Marginal cost in log changes:
  \[ \Delta mc_{it} = \phi_{it} \Delta v_{it} + (1 - \phi_{it}) \Delta w_{it} + (v_{i,t-1} - w_{i,t-1}) \Delta \phi_{it} - \Delta \tilde{\omega}_{it}, \]
  \[ \Delta mc_{it}^* = \phi_{it} \Delta v_{it} \]
DATA
Dataset

1. Belgium firm-product level data 1995-2008 on values and quantities
   - PC 8-digit (1,700 products)
   - All manufacturing firms with minimum of 10 employees

2. Import and export data on values and quantities at HS 8-digit (over 10,000 products)

3. Firm-level data on firm characteristics
   - includes material costs, wagebill and employment
Variables

- Domestic Prices:

\[ \Delta p_{ijt} = \Delta \log \frac{\text{Domestic Value}_{ijt}}{\text{Domestic Quantity}_{ijt}} \]

- Marginal Cost Variable:

\[ \Delta mc_{it} = \Delta \log \frac{TVC_{it}}{Y_{it}} \]

- Instrument:

\[ \Delta mc^*_{it} = \phi_{it} \sum_{\ell} \omega_{i\ell t} \Delta v_{i\ell t} \]

where \( \Delta v_{i\ell t} \) is the log change in firm input prices
Variables

- **Competition Variables:**

  \[
  \Delta p_{-i,t} = (1 - \theta_{st})\Delta p_{-i,t}^D + \theta_{st}\Delta p_{st}^F \\
  \Delta p_{-i,t}^D = \sum \omega_{ijt}\Delta p_{ijt} \quad \Delta p_{st}^F = \sum \omega_{ijt}\Delta p_{ijt}^*
  \]

- **Instruments:**

  1. Competitor marginal cost: \( \Delta mc_{-i,t}^* = \sum_{j \neq i} \omega_{jt}\Delta mc_{jt}^* \)
  2. Trade Weighted Industry Exchange Rate: \( \Delta e_{st} = \sum S_{kt}\Delta e_{kt} \)
  3. Change in export prices from EU: \( \Delta iP_{eu}^e_{st} \)
  4. Change in export prices from non-EU: \( \Delta iP_{xeu}^e_{st} \)
EMPIRICAL FINDINGS
Warmup
ERPT regressions

Table: Aggregate ERPT

<table>
<thead>
<tr>
<th>Dep. var.:</th>
<th>$\Delta p_{st}$</th>
<th>$\Delta p_{st}^D$</th>
<th>$\Delta p_{st}^F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta e_{st}$</td>
<td>0.489***</td>
<td>0.311***</td>
<td>0.642***</td>
</tr>
<tr>
<td></td>
<td>(0.061)</td>
<td>(0.085)</td>
<td>(0.059)</td>
</tr>
</tbody>
</table>

Table: Firm-level ERPT

<table>
<thead>
<tr>
<th>Dep. var.:</th>
<th>$\Delta p_{ijt}$</th>
<th>$\Delta p_{ijt}$</th>
<th>$\Delta m_{c_{it}}$</th>
<th>$\Delta m_{c_{it}}^*$</th>
<th>$\Delta v_{it}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta e_{st}$</td>
<td>0.103*</td>
<td>0.514***</td>
<td>0.499**</td>
<td>0.277***</td>
<td>0.748***</td>
</tr>
<tr>
<td></td>
<td>(0.057)</td>
<td>(0.184)</td>
<td>(0.215)</td>
<td>(0.063)</td>
<td>(0.170)</td>
</tr>
<tr>
<td>Weighted</td>
<td>none</td>
<td>value</td>
<td>value</td>
<td>value</td>
<td>value</td>
</tr>
</tbody>
</table>

Recall that $\Delta m_{c_{it}} = \Delta m_{c_{it}}^* + o.t.$ and $\Delta m_{c_{it}}^* = \phi_{it} \Delta v_{it}$
**Preliminary evidence on strategic complementarities:**

<table>
<thead>
<tr>
<th>Dep. var.:</th>
<th>$\Delta m_{cit}$</th>
<th>$\Delta p_{ijt}$</th>
<th>$\Delta p_{ijt}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta e_{st}$</td>
<td>0.056</td>
<td>0.350**</td>
<td>0.029</td>
</tr>
<tr>
<td></td>
<td>(0.129)</td>
<td>(0.153)</td>
<td>(0.138)</td>
</tr>
<tr>
<td>$\Delta e_{st} \times Large_{is}$</td>
<td></td>
<td></td>
<td>0.643**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.325)</td>
</tr>
</tbody>
</table>
Strategic Complementarities

- Our main empirical specification:

\[ \Delta p_{ijt} = \frac{1}{1 + \Gamma_{it}} \Delta mc_{it} + \frac{\Gamma_{-i,t}}{1 + \Gamma_{it}} \Delta p_{-i,t} + \varepsilon_{it} \]

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dep. var: ( \Delta p_{ijt} )</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>( \Delta mc_{it} )</td>
<td>0.347***</td>
<td>0.344***</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
<td>(0.040)</td>
</tr>
<tr>
<td>( \Delta p_{-i,t} )</td>
<td>0.460***</td>
<td>0.355***</td>
</tr>
<tr>
<td></td>
<td>(0.077)</td>
<td>(0.089)</td>
</tr>
<tr>
<td>Industry FE</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

- IV regressions:
  - pass weak instrument test
  - pass over-id test
  - cannot reject the equality to 1 of the sum of the coef.
### Strategic Complementarities

**Firm Heterogeneity**

<table>
<thead>
<tr>
<th>Dep. var: $\Delta p_{ijt}$</th>
<th>Employment $\geq 100$</th>
<th>Top 20%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>$\Delta mc_{it}$</td>
<td><strong>0.975</strong>*</td>
<td>1.034***</td>
</tr>
<tr>
<td></td>
<td>(0.152)</td>
<td>(0.194)</td>
</tr>
<tr>
<td>$\Delta mc_{it} \times Large_{it}$</td>
<td><strong>0.512</strong></td>
<td>−0.467</td>
</tr>
<tr>
<td></td>
<td>(0.248)</td>
<td>(0.323)</td>
</tr>
<tr>
<td>$\Delta P_{-i,t}$</td>
<td><strong>0.069</strong></td>
<td>0.052</td>
</tr>
<tr>
<td></td>
<td>(0.182)</td>
<td>(0.226)</td>
</tr>
<tr>
<td>$\Delta P_{-i,t} \times Large_{it}$</td>
<td><strong>0.543</strong></td>
<td>0.432</td>
</tr>
<tr>
<td></td>
<td>(0.239)</td>
<td>(0.342)</td>
</tr>
</tbody>
</table>
QUANTITATIVE MODEL
Quantitative Model

- Atkeson-Burstein demand and market structure:
  - Nested CES demand with elasticities $\rho > \eta \geq 1$
  - Oligopolistic quantity (Cournot) competition

- Firms differ in size (productivity) and import intensity, with the joint distribution approximating the data

- Industry equilibrium model: firm costs follow exogenous processes. We use the model to calculate the evolution of markups and prices

- We simulate multiple industries calibrated to approximate typical Belgian 4-digit sectors
Cost Structure

• Marginal cost:

\[ MC_{it} = \frac{W_t^{1-\varphi_i} (V_tE_t)^{\varphi_i}}{\Omega_{it}} \]

• Trade-weighted exchange rate (in logs: \( e_t \equiv \log E_t \)):

\[ e_t = e_{t-1} + \sigma_e u_t, \quad u_t \sim iid \mathcal{N}(0, 1) \]

• Idiosyncratic productivity (in logs: \( \omega_{it} \equiv \log \Omega_{it} \))

\[ \omega_{it} = \mu + \omega_{i,t-1} + \sigma_\omega v_{it}, \quad v_{it} \sim iid \mathcal{N}(0, 1), \]

with a reflecting barrier at \( \omega \) to ensure an ergodic Pareto distribution of productivities in the cross-section
Three Types of Firms

1. Belgian (domestic) firms
2. European (non-Belgian) firms
3. Non-European firms

- The groups of firms differ in two respects:
  (i) Exchange rate exposure, \( \varphi_i \)
  (ii) Mass of entrants

- Conditional on entry, the firms in each group have the same market share distribution (Eaton, Kortum and Sotelo 2013)

- Exchange rate exposure of domestic firms:

\[
\varphi_i = \phi_i^E \psi^E + \phi_i^X \psi^X + (1 - \phi_i^E - \phi_i^X) \psi^B
\]
## Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Moment in the data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected number firms:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Belgian</td>
<td>$\bar{N}_B = 48$</td>
<td>Number of Belgian firms</td>
</tr>
<tr>
<td>— European union</td>
<td>$\bar{N}_E = 21$</td>
<td>Sales share</td>
</tr>
<tr>
<td>— Non-EU</td>
<td>$\bar{N}_X = 9$</td>
<td>Sales share</td>
</tr>
<tr>
<td>Elasticity of substitution:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>— across sectors</td>
<td>$\eta = 1$</td>
<td>Pass-through heterogeneity</td>
</tr>
<tr>
<td>— within sectors</td>
<td>$\rho = 8$</td>
<td></td>
</tr>
<tr>
<td>Productivity distribution:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Pareto shape parameter</td>
<td>$k = 6.6$</td>
<td>Size distribution of firms</td>
</tr>
<tr>
<td>— St.dev. of innovation</td>
<td>$\sigma_\omega = 0.034$</td>
<td>$\text{std}(\Delta s_{it}) = 0.0042$</td>
</tr>
<tr>
<td>— Drift</td>
<td>$\mu = -k\sigma_\omega^2/2$</td>
<td>Distribution stationarity</td>
</tr>
<tr>
<td>— Reflecting barrier</td>
<td>$\omega = 0$</td>
<td>Normalization</td>
</tr>
<tr>
<td>St.dev. of $\Delta e_t$</td>
<td>$\sigma_e = 0.06$</td>
<td>Trade-weighted ER</td>
</tr>
<tr>
<td>Exchange rate exposure:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>— European firms</td>
<td>$\varphi_E = 0.8$</td>
<td>Aggregate pass-through</td>
</tr>
<tr>
<td>— Non-EU firms</td>
<td>$\varphi_X = 1$</td>
<td>Aggregate pass-through</td>
</tr>
<tr>
<td>— Belgian firms</td>
<td>$\phi_B\psi_B + \phi_E\psi_E + \phi_X\psi_X$</td>
<td></td>
</tr>
<tr>
<td>— Pass-through</td>
<td>$\psi_B = 0.15$, $\psi_E = 0.6$, $\psi_X = 1$</td>
<td>Pass-through into input prices</td>
</tr>
<tr>
<td>— Import intensity</td>
<td>$\varphi_E, \varphi_X \sim \text{Beta}$</td>
<td>Import intensity</td>
</tr>
</tbody>
</table>
### Moments

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of firms:</td>
<td></td>
<td></td>
<td>Sales share:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Belgian</td>
<td>41 (48) [22,87]</td>
<td>48 [40,57]</td>
<td>— Belgian</td>
<td>0.64 (0.62) [0.39,0.86]</td>
<td>0.62 [0.46,0.77]</td>
</tr>
<tr>
<td>— EU</td>
<td>—</td>
<td>21 [16,27]</td>
<td>— EU</td>
<td>0.26 (0.27) [0.12,0.42]</td>
<td>0.26 [0.14,0.41]</td>
</tr>
<tr>
<td>— Non-EU</td>
<td>—</td>
<td>9 [5,13]</td>
<td>— Non-EU</td>
<td>0.08 (0.11) [0.01,0.25]</td>
<td>0.09 [0.04, 0.22]</td>
</tr>
<tr>
<td>Top Belgian market share</td>
<td>10% (12%) [5%,21%]</td>
<td>11% [6%,23%]</td>
<td>Inverse HHI for Belgian firms</td>
<td>16.4 (20.8) [7.1,38.4]</td>
<td>13.7 [6.5,24.3]</td>
</tr>
<tr>
<td>std($\Delta s_{it}$)</td>
<td>0.0042</td>
<td>0.0042</td>
<td>corr($s_{it}, \phi_i^B$)</td>
<td>0.26 (0.24) [0.04]</td>
<td>0.28</td>
</tr>
<tr>
<td>corr($s_{it}, s_{i,t+12}$)</td>
<td>0.90 (0.85) [0.69, 0.98]</td>
<td>0.88</td>
<td>corr($s_{it}, \phi_i^X / \phi_i^B$)</td>
<td>0.05 (0.08) [-0.03, 0.37]</td>
<td>0.16</td>
</tr>
</tbody>
</table>
Market Share Distribution

Log relative market share, $\log\frac{s(k)}{s(1)}$

Log rank of firm, $\log \text{Rank}(k)$

Model Median
Data Median
Data 10%
Data 90%
(a) Averages by firm rank

(b) Kernel Density (model)
SIMULATION RESULTS
- Sector-level and pooled firm-level regressions reproduce the aggregate pass-through patterns in the data

<table>
<thead>
<tr>
<th></th>
<th>All firms</th>
<th>Domestic firms</th>
<th>Foreign firms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MC</td>
<td>Price</td>
<td>MC</td>
</tr>
<tr>
<td>Sector-level</td>
<td>0.494</td>
<td><strong>0.488</strong></td>
<td>0.286</td>
</tr>
<tr>
<td>Firm-level pooled:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— unweighted</td>
<td>0.460</td>
<td>0.460</td>
<td>0.233</td>
</tr>
<tr>
<td>— sales-weighted</td>
<td>0.473</td>
<td>0.464</td>
<td><strong>0.268</strong></td>
</tr>
</tbody>
</table>
ERPT heterogeneity
Across firm-size deciles

- ERPT into MC (red) and prices (red+blue) by firm-size deciles
Strategic complementarities

<table>
<thead>
<tr>
<th>Dep. var.: $\Delta \log P_{it}$</th>
<th>Without size interaction</th>
<th>With size interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \log MC_{it}$</td>
<td>0.775</td>
<td>0.951</td>
</tr>
<tr>
<td>$\Delta \log MC_{it} \times L_{it}$</td>
<td>—</td>
<td>−0.259</td>
</tr>
<tr>
<td>$\Delta \log P_{-i,t}$</td>
<td>0.201</td>
<td>0.047</td>
</tr>
<tr>
<td>$\Delta \log P_{-i,t} \times L_{it}$</td>
<td>—</td>
<td>0.248</td>
</tr>
</tbody>
</table>

- The model slightly underpredicts the extent of strategic complementarities among the large firms
Strategic Complementarities
Across firm-size deciles

- Estimates of $\frac{1}{1+\Gamma_i}$ and $\frac{\Gamma_{-i}}{1+\Gamma_i}$ by firm size deciles
COUNTERFACTUALS
### Model distributions

<table>
<thead>
<tr>
<th>Firm percentiles</th>
<th>Sales percentile</th>
<th>Market share (%)</th>
<th>Exchange rate exposure</th>
<th>Markup</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>5.3</td>
<td>0.36</td>
<td>0.199</td>
<td>1.147</td>
</tr>
<tr>
<td>50</td>
<td>14.2</td>
<td>0.57</td>
<td>0.244</td>
<td>1.149</td>
</tr>
<tr>
<td>75</td>
<td>29.6</td>
<td>1.13</td>
<td>0.289</td>
<td>1.156</td>
</tr>
<tr>
<td>90</td>
<td>49.3</td>
<td>2.62</td>
<td>0.333</td>
<td>1.174</td>
</tr>
<tr>
<td>95</td>
<td>62.7</td>
<td>4.60</td>
<td>0.363</td>
<td>1.198</td>
</tr>
<tr>
<td>97.5</td>
<td>74.0</td>
<td>7.51</td>
<td>0.392</td>
<td>1.236</td>
</tr>
<tr>
<td>99</td>
<td>85.1</td>
<td>12.45</td>
<td>0.425</td>
<td>1.305</td>
</tr>
<tr>
<td>99.5</td>
<td>90.7</td>
<td>16.62</td>
<td>0.450</td>
<td>1.371</td>
</tr>
<tr>
<td>99.75</td>
<td>94.4</td>
<td>21.67</td>
<td>0.472</td>
<td>1.460</td>
</tr>
</tbody>
</table>
Response to a 10% Depreciation

Marginal costs
Response to a 10% Depreciation

Market share

Markup ERPT

ER exposure

29 / 32
ERPT Decomposition

- Aggregate ER pass-through of 0.35 is split as follows:

<table>
<thead>
<tr>
<th></th>
<th>Small Firms</th>
<th>Large Firms</th>
<th>Marginal Cost Markup</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>39.3%</td>
<td>51.1%</td>
<td>90.4%</td>
</tr>
<tr>
<td></td>
<td>2.2%</td>
<td>7.4%</td>
<td>9.6%</td>
</tr>
<tr>
<td></td>
<td>41.5%</td>
<td>58.5%</td>
<td></td>
</tr>
</tbody>
</table>

- 10% of the largest firms account for 50% of sales and almost 60% of pass-through
- Small firms’ markups are stable, while for large firms they account for about 15% of price adjustment
Heterogeneity across sectors

I. By domestic sales share

- ERPT into MC (red) and prices (red+blue) across sectors
Heterogeneity across sectors

II. By sector import intensity

- ERPT into MC (red) and prices (red+blue) across sectors
Heterogeneity across sectors

III. By market share of the largest domestic firm

- ERPT into MC (red) and prices (red+blue) across sectors
Heterogeneity across sectors

IV. By correlation b/w size and import intensity

- ERPT into MC (red) and prices (red+blue) across sectors
Conclusions

• We provide direct evidence on the strength of strategic complementarities in firm price setting
  — on average, responsiveness to own cost is 60–65% and to competitor prices is 35–40%

• Uncover substantial heterogeneity in the extent of strategic complementarities across firms:
  — small firms do not respond to competitor prices and have complete pass-through of own cost shocks
  — large firms exhibit substantial strategic complementarities and variable markups

• The interplay of these forces with heterogeneous exposure to foreign inputs is crucial for understanding aggregate ERPT
APPENDIX
Generalization to non-CRS case

• Assume marginal cost equals:

\[ MC_{it} = C_{it} Y_{it}^{\alpha} \]

where \( \alpha \) is the DRS parameter (\( \alpha = 0 \) under CRS)

• The decomposition in this case is:

\[ \Delta p_{it} = \frac{1}{1 + \Gamma_{it} + \alpha \tilde{\sigma}_{it}} \Delta c_{it} + \frac{\Gamma_{-i,t} + \alpha \tilde{\sigma}_{-i,t}}{1 + \Gamma_{it} + \alpha \tilde{\sigma}_{it}} \Delta p_{-i,t} + \epsilon_{it} \]

• Under Atkeson-Burstein demand, \( \Gamma_{-i,t} = \Gamma_{it} \) and \( \tilde{\sigma}_{it} = \tilde{\sigma}_{-i,t} + \eta \), so that the sum of the coefficient equals:

\[ \psi_{it} + \gamma_{it} = 1 - \alpha \eta \psi_{it} < 1 \]
Heterogeneity Matters

- **ERPT of firm** \( i \): 
  \[
  \Psi_{it} = \frac{\varphi_{it}}{1 + \Gamma_{it}} + \frac{\Gamma_{-i,t}}{1 + \Gamma_{it}} \Psi_{-i,t}
  \]

- **Aggregate PT** into marginal costs, prices and markups:
  \[
  \Psi_{t}^{MC} = \Phi \equiv \sum S_{it} \varphi_{it},
  \]
  \[
  \Psi_{t}^{P} = \frac{1}{1 - \sum \frac{S_{it} \Gamma_{-i,t}}{1 + \Gamma_{it}}} \sum \frac{S_{it} \varphi_{it}}{1 + \Gamma_{it}},
  \]
  \[
  \Psi_{t}^{M} = -\frac{1}{1 - \sum \frac{S_{it} \Gamma_{-i,t}}{1 + \Gamma_{it}}} \sum \left[ \frac{\Gamma_{it}}{1 + \Gamma_{it}} - \sum \frac{S_{jt} \Gamma_{-j,t}}{1 + \Gamma_{jt}} \right] S_{it} \varphi_{it}
  \]

- **Cross-sectional heterogeneity**: \( \{ \varphi_{it}, S_{it}, \Gamma_{it}, \Gamma_{-i,t} \} \)

- **Aggregate pass-through into domestic prices**:
  \[
  \Psi_{t}^{D} = \frac{1}{1 - \sum D \frac{S_{it}^{D} (1 - S_{t}^{F}) \Gamma_{-i,t}}{1 + \Gamma_{it}}} \sum D S_{it}^{D} \left[ \frac{\varphi_{it}}{1 + \Gamma_{it}} + \frac{S_{t}^{F} \Gamma_{-i,t}}{1 + \Gamma_{it}} \Psi_{t}^{F} \right]
  \]
Price Setting

Fixed Point

• In each industry, given a vector of firm marginal costs \( \{MC_{it}\} \), we find the equilibrium vector of prices \( \{P_{it}\} \).

• This is a fixed point problem:

\[
P_{it} = M_{it} \cdot MC_{it},
\]

\[
M_{it} = \sigma_{it}/(\sigma_{it} - 1),
\]

\[
\sigma_{it} = \left[ \eta^{-1} S_{it} + \rho^{-1}(1 - S_{it}) \right]^{-1},
\]

\[
S_{it} = \xi_{it} \left( \frac{P_{it}}{P_t} \right)^{1-\rho},
\]

\[
P_t = \left[ \sum_{i=1}^{N} \xi_{it} P_{it}^{1-\rho} \right]^{1/(1-\rho)}
\]

All prices are determined simultaneously.

• The solution to this problem can be found numerically by iteration.
Sensitivity
Demand and Market Structure

(a) Markup, \( M_{it} = \frac{\sigma_{it}}{\sigma_{it} - 1} \)

(b) Pass-through, \( \Psi_{it} = \frac{1}{1 + \Gamma_{it}} \)

Figure: Markups and pass-through in a calibrated model

Note: \( \sigma_{it} = \left[ \frac{1}{\eta} S_{it} + \frac{1}{\rho} (1 - S_{it}) \right]^{-1} \) under Cournot
and \( \sigma_{it} = [\eta S_{it} + \rho (1 - S_{it})] \) under Bertrand.