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

Preliminary and Incomplete
(Link to paper)

Mary Amiti
NY FRB

Oleg Itskhoki
Princeton

Jozef Konings
Leuven and BNB

Boston College
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Motivation

• How strong are strategic complementarities across firms in price setting?
  — a fundamental mechanism in both micro- and macroeconomics
Motivation

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

  — 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. Use detailed firm-product level Belgium data to estimate strategic complementarities in price setting
   - intensive data requirements on firm prices, marginal costs, and firm’s competitor prices within sectors
   - while Belgian is special in many respects, the fundamental strategic complementarity forces are likely to be more general

2. Develop an identification strategy to deal with:
   (i) simultaneity of price setting across firms
   (ii) measurement errors in firm marginal costs

3. Develop a quantitative framework to evaluate counterfactual scenarios
   - a flexible model closely-disciplined with micro-level data
   - allows us to study the response of firm markups, marginal costs, and prices to various shocks (e.g., depreciation)
Main Findings

1. Decompose changes in prices into:
   (i) response to own marginal cost = 65% (or idiosyncratic cost pass-through)
   (ii) response to competitor prices = 35% (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 Domestic prices and exchange rates:
   — industry-level: Goldberg and Campa (2010), Auer and Schoenle (2013)
   — product level: Cao, Dong and Tomlin (2012), Pennings (2012)

2 International prices and exchange rates:
   — Gopinath and Itskhoki (2011)
   — Amiti, Itskhoki and Konings (2014)

3 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:
  \[ \Delta \mu_{it} = -\Gamma_{it} \Delta p_{it} + \Gamma_{-i,t} \Delta P_{-i,t} + \tilde{\epsilon}_{it} \]

- Decomposition of price change:
  \[ \Delta p_{it} = \frac{1}{1 + \Gamma_{it}} \Delta mc_{it} + \frac{\Gamma_{-i,t}}{1 + \Gamma_{it}} \Delta P_{-i,t} + \tilde{\epsilon}_{it} \]
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:**

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

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

- **Sectoral price index:**

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

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

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

- **Market share:**

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

  \[ \Delta p_{it} = \frac{1}{1 + \Gamma_{it}} \Delta mc_{it} + \frac{\Gamma_{it}}{1 + \Gamma_{it}} \Delta P_{-i,t} + \frac{\Gamma_{it}}{1 + \Gamma_{it}} \left( \frac{\Delta \xi_{it}}{(\rho - 1)(1 - S_{it})} \right) \]
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:
  \[ MC_{it} = W_{it}^{1-\phi_{it}} (V_{it}^* \mathcal{E}_t)^{\phi_{it}} \overline{\Omega}_{it} \]

- 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:**

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

- **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:  \( \Delta iP_{st}^{eu} \)
  4. Change in export prices from non-EU:  \( \Delta iP_{st}^{xeu} \)
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>0.484***</td>
<td>0.322***</td>
<td>0.631***</td>
</tr>
<tr>
<td></td>
<td>(0.063)</td>
<td>(0.087)</td>
<td>(0.061)</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>$\Delta mc_{it}$</th>
<th>$\Delta mc_{it}^*$</th>
<th>$\Delta v_{it}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta e_{st}$</td>
<td>0.108*</td>
<td>0.525***</td>
<td>0.463**</td>
<td>0.265***</td>
<td>0.727***</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.186)</td>
<td>(0.219)</td>
<td>(0.064)</td>
<td>(0.173)</td>
</tr>
<tr>
<td>Weighted</td>
<td>none value</td>
<td>value</td>
<td>value</td>
<td>value</td>
<td>value</td>
</tr>
</tbody>
</table>

Recall that $\Delta mc_{it} = \Delta mc_{it}^* + ...$ and $\Delta mc_{it}^* = \phi_{it} \Delta v_{it}$
• Preliminary evidence on strategic complementarities:

<table>
<thead>
<tr>
<th>Dep. var.:</th>
<th>$\Delta mc_{it}$</th>
<th>$\Delta p_{ijt}$</th>
<th>$\Delta p_{ijt}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta e_{st}$</td>
<td>0.064</td>
<td>0.350**</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>(0.129)</td>
<td>(0.154)</td>
<td>(0.138)</td>
</tr>
<tr>
<td>$\Delta e_{st} \times Large_{is}$</td>
<td></td>
<td></td>
<td>0.651**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.327)</td>
</tr>
</tbody>
</table>
Strategic Complementarities

- Our main empirical specification:

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

<table>
<thead>
<tr>
<th>Dep. var: ( \Delta p_{ijt} )</th>
<th>OLS</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>( \Delta m_{c_it} )</td>
<td>0.346***</td>
<td>0.345***</td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.042)</td>
</tr>
<tr>
<td>( \Delta P_{-i,t} )</td>
<td>0.477***</td>
<td>0.380***</td>
</tr>
<tr>
<td></td>
<td>(0.081)</td>
<td>(0.091)</td>
</tr>
<tr>
<td>Industry FE</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

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Strategic Complementarities

Firm Heterogeneity

<table>
<thead>
<tr>
<th>Dep. var: $\Delta p_{ijt}$</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta mc_{it}$</td>
<td>$0.964^{***}$</td>
<td>$0.907^{***}$</td>
<td>$1.030^{***}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(0.145)$</td>
<td>$(0.163)$</td>
<td>$(0.171)$</td>
<td></td>
</tr>
<tr>
<td>$\Delta mc_{it} \times \text{Large}_{it}$</td>
<td>$0.571^{**}$</td>
<td>$-0.296$</td>
<td>$-0.401$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(0.222)$</td>
<td>$(0.323)$</td>
<td>$(0.339)$</td>
<td></td>
</tr>
<tr>
<td>$\Delta P_{-i,t}$</td>
<td>$0.027$</td>
<td>$0.143$</td>
<td>$-0.195$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(0.192)$</td>
<td>$(0.226)$</td>
<td>$(0.145)$</td>
<td></td>
</tr>
<tr>
<td>$\Delta P_{-i,t} \times \text{Large}_{it}$</td>
<td>$0.496^{**}$</td>
<td>$0.306$</td>
<td>$0.663^{**}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$(0.209)$</td>
<td>$(0.362)$</td>
<td>$(0.333)$</td>
<td></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

Price setting
Cost Structure

• Marginal cost:

\[ MC_{it} = \frac{W_{t}^{1-\varphi_i} (V_t \mathcal{E}_t)^{\varphi_i}}{\Omega_{it}} \]

• Trade-weighted exchange rate (in logs: \( e_t \equiv \log \mathcal{E}_t \)):

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

• 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 \( \underline{\omega} \) 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><strong>Expected number firms:</strong></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><strong>Elasticity of substitution:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— across sectors</td>
<td>$\eta = 1$</td>
<td></td>
</tr>
<tr>
<td>— within sectors</td>
<td>$\rho = 8$</td>
<td></td>
</tr>
<tr>
<td><strong>Productivity distribution:</strong></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>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><strong>St. dev. of $\Delta e_t$</strong></td>
<td>$\sigma_e = 0.06$</td>
<td>Trade-weighted ER</td>
</tr>
<tr>
<td><strong>Exchange rate exposure:</strong></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>Pass-through into input prices</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>$\phi_E, \phi_X \sim Beta$</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><strong>Number of firms:</strong></td>
<td></td>
<td></td>
<td><strong>Sales share:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— Belgian</td>
<td>41 (48)</td>
<td>48</td>
<td>— Belgian</td>
<td>0.64 (0.62)</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>[22,87]</td>
<td>[40,57]</td>
<td>— Belgium</td>
<td>[0.39,0.86]</td>
<td>[0.46,0.77]</td>
</tr>
<tr>
<td>— EU</td>
<td>—</td>
<td>21</td>
<td>— EU</td>
<td>0.26 (0.27)</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[16,27]</td>
<td>— EU</td>
<td>[0.12,0.42]</td>
<td>[0.14,0.41]</td>
</tr>
<tr>
<td>— Non-EU</td>
<td>—</td>
<td>9</td>
<td>— Non-EU</td>
<td>0.08 (0.11)</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[5,13]</td>
<td>— Non-EU</td>
<td>[0.01,0.25]</td>
<td>[0.04, 0.22]</td>
</tr>
<tr>
<td><strong>Top Belgian market share</strong></td>
<td>10% (12%)</td>
<td>11%</td>
<td><strong>Inverse HHI for Belgian firms</strong></td>
<td>16.4 (20.8)</td>
<td>13.7</td>
</tr>
<tr>
<td></td>
<td>[5%,21%]</td>
<td>[6%,23%]</td>
<td></td>
<td>[7.1,38.4]</td>
<td>[6.5,24.3]</td>
</tr>
<tr>
<td><strong>std(Δs_{it})</strong></td>
<td>0.0042</td>
<td>0.0042</td>
<td><strong>corr(s_{it}, φ_i^B)</strong></td>
<td>0.26 (0.24)</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[0,0.44]</td>
<td></td>
</tr>
<tr>
<td><strong>corr(s_{it}, s_{i,t+12})</strong></td>
<td>0.90 (0.85)</td>
<td>0.88</td>
<td><strong>corr(s_{it}, φ_i^X / φ_i^B)</strong></td>
<td>0.05 (0.08)</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>[0.69, 0.98]</td>
<td></td>
<td></td>
<td>[-0.03, 0.37]</td>
<td></td>
</tr>
</tbody>
</table>
Market Share Distribution

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

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>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>$\Delta \log P_{\neg i,t}$</td>
<td>0.201</td>
<td>0.047</td>
</tr>
<tr>
<td>$\Delta \log P_{\neg i,t} \times L_{it}$</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

Prices
Response to a 10% Depreciation

Marginal costs
Response to a 10% Depreciation

Markups
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>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal Cost</td>
<td>39.3%</td>
<td>51.1%</td>
<td>90.4%</td>
</tr>
<tr>
<td>Markup</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 65% and to competitor prices is 35%

• 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
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:

\[
\psi^M_{t} = \phi \equiv \sum S_{it} \varphi_{it},
\]

\[
\psi^P_{t} = \frac{1}{1 - \sum S_{it} \Gamma_{-i,t}} \sum \frac{S_{it} \varphi_{it}}{1 + \Gamma_{it}},
\]

\[
\psi^M_{t} = - \frac{1}{1 - \sum S_{it} \Gamma_{-i,t}} \sum \left[ \frac{\Gamma_{it}}{1 + \Gamma_{it}} - \sum \frac{S_{jt} \Gamma_{-j,t}}{1 + \Gamma_{jt}} \right] S_{it} \varphi_{it}
\]

- Cross-sectional heterogeneity: $\{ \varphi_{it}, S_{it}, \Gamma_{it}, \Gamma_{-i,t} \}$

- Aggregate pass-through into domestic prices:

\[
\psi^D_{t} = \frac{1}{1 - \sum D S_{it} (1 - S^F_t) \Gamma_{-i,t}} \sum D S^D_{it} \left[ \frac{\varphi_{it}}{1 + \Gamma_{it}} + \frac{S^F_t \Gamma_{-i,t}}{1 + \Gamma_{it}} \psi^F_t \right]
\]
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:

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

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

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

\[
S_{it} = \xi_{it}(P_{it}/P_{t})^{1-\rho},
\]

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

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 $\sigma_{it} = \left[ \eta S_{it} + \rho (1 - S_{it}) \right]$ under Bertrand.