Understanding Movements in Aggregate and Product-Level Real-Exchange Rates

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Canada-US: CPI-based RER and Relative Unit Labor Costs
Relative prices: Perfect competition / constant markups

- Change in price = change in marginal cost.

- For traded goods produced in common location:

\[ \Delta \frac{eP^*_n}{P_n} = 0 \]

  - \( P_n \) domestic price, \( P^*_n \) foreign price, \( e \) nominal exchange rate.
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  - $P_n$ domestic price, $P_n^*$ foreign price, $e$ nominal exchange rate.

- If all goods freely traded, implies aggregate RER constant over time.
Relative prices: Two alternative models

- Non-traded goods (locally produced or traded + distribution services):
  - Constant markups: \( \Delta \frac{eP_n^*}{P_n} = \Delta \) relative marginal costs.
Relative prices: Two alternative models

- **Non-traded goods (locally produced or traded + distribution services):**
  - Constant markups: \( \Delta \frac{eP_n^*}{P_n} = \Delta \text{ relative marginal costs.} \)

- **Imperfect competition with variable markups:**
  - \( \Delta \frac{eP_n^*}{P_n} \neq 0 \) reflects movements in relative markups.
  - Pricing-to-market by exporters.

  "optimal" changes in markups or sticky prices in local currency.
This paper

- Data: Document extent of movements in relative prices from pricing-to-market using price data for non-durables in Canada and US.
  - Price of individual products sold in multiple locations
    - Advantage over using aggregate price indices
  - Identify traded versus nontraded products
  - Wholesale price (instead of retail price)

- Key assumption: goods produced in common location and sold in multiple locations are subject to common % change in marginal cost
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- Model of international trade and pricing-to-market to rationalize facts
  - Role of the international border in giving rise to pricing-to-market?
  - When parameterized to match volumes of intl trade between Canada and U.S., reproduce degree of pricing-to-market in data?
This Paper: Data

- Substantial pricing-to-market across regions for traded products.
  - On average, \( \frac{eP_n^*}{P_n} \) tracks movements in Canada/US unit labor costs.
  - Consistent with Mussa (1986) and Engel (1999).

- Nominal prices change frequently and by large magnitudes.

- Substantial idiosyncratic component of pricing-to-market (analogous to Bils and Klenow 2004 for US consumer prices)

- More prevalent across than within countries.
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Data: Related Papers

  - We measure extent to which movements in relative prices reflect pricing-to-market.
  - Unique features of our data: matched products, wholesale prices, country-of-origin to identify traded/nontraded.

  - We document substantial "idiosyncratic" pricing-to-market not correlated with exchange rate.

- Variable markups and incomplete exchange rate pass-through: Nakamura (2008), Goldberg-Hellerstein (08), Gopinath-Itskhoki (08).
  - Our focus: movements in relative markups across locations (i.e. differences in pass-through).
This Paper: Model

- Simple Ricardian model of international trade and pricing-to-market with flexible prices.
  - Bertrand competition with limit pricing $\Rightarrow$ variable markups.
  - International trade costs segments competitors across countries.

- If producers face different competitors across regions.
  - Pricing-to-market in response to idiosyncratic and aggregate shocks.
This Paper: Model

- Analytic results: key ingredients to account for product-level and aggregate price observations
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- Parameterized model that matches trade volumes and individual price movements: 10% idiosyncratic movements in relative markups across location, average increase in Canada-U.S. markups 70% as large as increase in Canada-U.S. relative costs

- Use model to assess method of identifying trade costs with price data (Engel-Roger 1996)

1. Need to distinguish between traded and nontraded goods
2. More pricing-to-market across than within countries – not informative
3. Pricing-to-market in response to change in relative labor costs – informative
Outline of Talk

- Data description.
- Basic facts on product-level and aggregate RERs.
- Simple model of international trade and pricing-to-market.
- Pricing implications: analytic results.
- Additional model predictions versus data.
- Pricing implications: quantitative results.
Data

- Large grocery chain in Canada and US.
- Stores in multiples US states and Canadian provinces (British Columbia, Alberta and Manitoba).
- 93 product categories of nondurable branded products.
  - Processed food, beverages, personal care, cleaning products.
  - Abstract from retailer brands.
Data

- Focus on pricing-to-market, $\Delta eP^*_n / P_n$, at producer level.

- Wholesale price (replacement cost of good for retailer).
  - Closest measure of producer prices in our data.
  - Smaller nontraded component than retail price.
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- Aggregate weekly prices into quarterly prices (average).
  - Relative prices even more volatile using weekly data.
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- Aggregate weekly prices into quarterly prices (average).
  - Relative prices even more volatile using weekly data.

- Aggregate store prices into regional price (median).
  - 5 pricing regions in British Columbia, 14 in Northern California.
Matching products in Canada and US

- Identical UPC code (1,213 matches) or
Matching products in Canada and US

- Identical UPC code (1,213 matches) or
- Different UPC code, same manufacturer, same brand, other common characteristic (e.g. not required: same size, exact product description).
  - Underlying assumption to infer pricing-to-market: same % change in marg. cost for matched products if produced in common location.
  - Purex Baby Soft, Purex Baby Soft Classic Detergent.
  - Crest toothpaste sensitivity protection, Crest sensitivity toothpaste whitening scope.
  - Schweppes Raspberry Ginger Ale 2Lts, Schweppes Ginger Ale 24Oz.

- 14,000 matches across countries.
- Findings robust to using identical (but fewer) matches.
Country of production in Canada and US

- For matched products:
  - Identify country of origin in May-June 2008 using product label information.
  - Information from Vancouver and North California (focus on this area).
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- 1,000 identical matches, 11,000 conservative matches.
- 50% of product expenditures in Canada, 35% in US.

Caveat: change in country of production over time.

Based on interviews with retail managers, small variation in country of production over time.
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- **Sets of matched products:**
  - Common products produced only in US:
    - Pantene shampoo, Ziploc bags, Rold Gold Pretzels.
  - Common products produced only in Canada:
    - Sapporo beer, Atkins advantage bar, Seagram whisky.
  - Common products produced in both countries:
    - Coca-Cola, Haagen-Dazs ice-cream, Yoplait Yoghurt, Bounce softener.
  - Common products produced in other ROW countries:
    - Myojo instant noodles (Japan), Absolut Vodka (Sweden), Delverde pasta (Italy).

- More than 50% matched products are domestically produced (and non-exported) in each country.
Expenditure Shares

- Expenditure shares in the US:
  - Locally produced: 89%
  - Canada: 2%
  - ROW: 9%

- Expenditure shares in Canada:
  - Locally produced: 67%
  - US: 30%
  - ROW: 3%

- Similar to OECD-based bilateral import shares in gross output of food, beverages, chemicals.
Prices

- Products $n = 1, 2, 3, \ldots$

- Sold in country $i = 1$ (US) and $i = 2$ (Canada), in region $r = A, \ldots, R$.

- Product-level RER:
  \[ Q_{nijrr'} t = e_{ijt} P_{nirt} / P_{njr'} t \text{ where } e_{ii} = 1 \]

- Percentage change in product-level RER:
  \[ \Delta Q_{nijrr'} t = \log (Q_{nijrr'} t) - \log (Q_{nijrr'} t_{-1}) \]
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- Aggregate RER: average $\Delta Q_{n21rr't}$ across many products.
Aggregate RER: All Exports

- Average of product-level RERs across products and countries.
  - Systematic increase in Canada-U.S. markups.
Aggregate RER: All Exports

- Average of product-level RERs across products within countries.
  - Movements in product-level RER’s average-out within countries.
Aggregate RER: Identical and US exports
Aggregate RER: All Exports, Retail Prices
Prices change frequently and by large magnitudes

- Movements in $\Delta eP_{n2}/P_{n1}$ not from $\Delta P_{n1} = \Delta P_{n2} = 0$, $\Delta e \neq 0$

  - Raw weekly wholeprice data: prices change on average every 2 weeks.
  
  - Fraction of product/weeks in which either Canadian price or US price change $= 0.72$.

  - Probability that Canadian and US price remain both unchanged in a quarter close to zero.

  - $\Delta eP_{n2}/P_{n1}$ very volatile, more than relative unit labor costs.
Example: US exported product in “Tea”
Example: US exported product in “Tea”
Distribution of product-level RERs: Exported products

- Product-level RER = \( \Delta Q_{nijr't} = \Delta e_{ijt} + \Delta P_{nirt} - \Delta P_{njr't} \).
Distribution of product-level RERs: Exported products

Product-level RER = $\Delta Q_{nijr't} = \Delta e_{ijt} + \Delta P_{nirt} - \Delta P_{njr't}$.  

![Graph](image-url)
Product-level real exchange rates: Robustness

- Broader geographical coverage than BC and North Cali

\[
\text{Std}^{\Delta Q_{ijrr'}} = \alpha + \beta \log \text{Distance}_{ijrr'} + \gamma \mathbb{I}_{i \neq j}
\]

- Average \text{Std}^{\Delta Q_{ijrr'}} within countries: 6%.

- Border doubles \text{Std}^{\Delta Q_{ijrr'}}
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- De-mean price by product-category price or nominal wage.
  - \(\text{Std}^{\Delta Q_{inter}}\) not driven by category-wide shocks (e.g. seasonalities).

- Retail prices (modal prices change less frequently).
Summary of findings

- Substantial pricing-to-market across regions for traded products.
  - On average, Canada/US markups track movements in Canada/US relative labor costs.
  - Pricing-to-market not from sticky prices: nominal prices change frequently.
  - Large idiosyncratic component of pricing-to-market: international relative prices three times as volatile as exchange rate.
  - More prevalent across than within countries.
Model Overview

- Geography:
  - 2 countries (3 in paper), 2 regions per country.
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- **Shocks:**
  - Permanent cost differences across producers (comparative advantage).
  - Temporary regional/product-level demand and cost shocks.
  - Changes in aggregate relative unit labor costs.
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- Constant markups, Bertrand competition with limit pricing.
Model Overview

- Atkeson and Burstein (2008) plus:
  - Bertrand limit pricing (as in AER P&P).
  - Multiple regions.
  - Multinational production.
  - Time varying idiosyncratic shocks.
  - Asymmetric countries.
Consumption composite across many varieties:

\[ y_{irt} = \left[ \int_0^1 (y_{nirt})^{1-1/\eta} \, dn \right]^{\eta/(\eta-1)} \]
Consumption

- Consumption composite across many varieties:
  \[ y_{ir} = \left[ \int_0^1 (y_{nir})^{1-1/\eta} \, dn \right]^{\eta/(\eta-1)} \]

- \( K \) potential producers per variety
  - Perfect substitutes
  - Regional taste shock

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  - No arbitrage across regions.
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Product demand shocks, \( a_{knirt} \):
  - Lognormal, variance \( \sigma^2_a \), correlation across regions \( \rho_a \).
Production

- Producers:
  - $K_1$ from country 1, $K_2$ from country 2.
Production

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- Technology linear in labor, $y = l/z$.

- $z_{knt} = \underbrace{\tilde{Z}_{kn}}_{\text{Permanent, } (\tilde{u}_{kn})^\theta, \tilde{u}_{kn} \text{ exponential}} \ast \underbrace{\tilde{Z}_{knt}}_{\text{Temporary, lognormal } \sigma_z^2}$
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- Marginal cost, $c$, for firms in country 1:
  1. $W_1 z$ domestic sales
  2. $DW_1 z$ exports
Production

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- Partial equilibrium: Movements in unit labor costs $W_i$ lognormal $\sigma_w$
Pricing: Perfect Competition benchmark

- Within each region, only producer with lowest $c/a$ sells.

- Price = marginal cost.

  \[ P_{nirt} = c_{nirt}^{1st}. \]

- Price changes:

  \[ \Delta P_{nirt} = \Delta c_{nirt}^{1nd}. \]
Product-level RERs: Perfect Competition

- Variance of relative price changes of individual products.

- Exporters:
  \[
  \text{Variance}^{\Delta Q_{\text{intra}}} = \text{Variance}^{\Delta Q_{\text{inter}}} = 0
  \]
  - Face same cost shock on domestic and foreign sales.
Product-level RERs: Perfect Competition

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  - Face same cost shock on domestic and foreign sales.

- Domestically produced goods consumed in both countries:
  \[
  \text{Variance}^{\Delta Q_{\text{inter}}} > 0
  \]
  - Face different cost shock on domestic and foreign sales.
Aggregate RER: Perfect Competition

- Average $\Delta Q^{\text{inter}}$ across many products.
- Exported products, $\Delta Q = 0$.
- Domestically produced products, $\Delta Q = \Delta \left( \frac{W_2}{W_1} \right)$. 
Aggregate RER: Perfect Competition

- Average $\Delta Q^{\text{inter}}$ across many products.

- Exported products, $\Delta Q = 0$.

- Domestically produced products, $\Delta Q = \Delta \left( \frac{W_2}{W_1} \right)$.

- Country of origin key to discriminate constant vs variable markup model.
Pricing: Bertrand Competition

- Within region, only firm with lowest $c/a$ sells.

\[ P_{nirt} = \min \left\{ \frac{\eta}{\eta - 1} \frac{c_{1st}}{a_{nirt}}, \frac{a_{1st}}{a_{2nd}} \frac{c_{2nd}}{c_{nirt}} \right\} \]

- $a_{2nd}$ and $c_{2nd}$, “latent competitor” shocks.
Pricing: Bertrand Competition

- Within region, only firm with lowest $c/a$ sells.

\[ P_{nirt} = \min \left\{ \frac{\eta}{\eta - 1} c_{nirt}^{1st}, \frac{a_{nirt}^{1st}}{a_{nirt}^{2nd}} c_{nirt}^{2nd} \right\} \]

- $a_{nirt}^{2nd}$ and $c_{nirt}^{2nd}$, "latent competitor" shocks.

- Assume for analytic results:
  - Monopoly price not binding.
  - Small time-varying shocks $\Rightarrow$ Unchanged active and latent competitors.

\[ \Delta P_{nirt} = \Delta a_{nirt}^{1st} - \Delta a_{nirt}^{2nd} + \Delta c_{nirt}^{2nd}. \]
Product-level RERs: Bertrand competition

- Price changes:
  \[
  \Delta P_{nirt} = \Delta a_{nirt}^{1st} - \Delta a_{nirt}^{2nd} + \Delta c_{nirt}^{2nd}.
  \]
  - Demand shocks
  - Cost shocks

- Correlation of price changes across two regions
  - Demand: correlation \( \rho_a \).
  - Cost: \[
  \text{correl}=1 \text{ if face same latent competitor (fraction } r) \\
  \text{correl}=0 \text{ if face different latent competitor (fraction } 1 - r) \]

- Variance \( \Delta Q \) = \( 2 \times \text{Variance}^{\Delta P} \left( 1 - \text{correlation}^{\Delta P_{r1},\Delta P_{r2}} \right) \)
Product-level RERs: Bertrand competition

- Variance $\Delta Q = 4\sigma_a^2 (1 - \rho_a r) + 2 (\sigma_z^2 + \sigma_w^2) \times (1 - r)$
  
  - Demand shocks \( \sigma_a^2 \) and \( \rho_a \)
  - Cost shocks \( \sigma_z^2 \) and \( \sigma_w^2 \)

- Pricing-to-market if low \( \rho_a \) and/or low \( r \).

Demand shocks less correlated across/within countries \( \rho_{\text{inter}} < \rho_{\text{intra}} \).

Variance $\Delta Q_{\text{inter}} > \Delta Q_{\text{intra}}$ does not imply \( D > 1 \).
Product-level RERs: Bertrand competition

- Variance $\Delta Q = 4\sigma_a^2 (1 - \rho_a r) + 2(\sigma_z^2 + \sigma_w^2) \times (1 - r)$

  - Demand shocks
  - Cost shocks

- Pricing-to-market if low $\rho_a$ and/or low $r$.

- Pricing-to-market more prevalent across than within countries if:
  - Less likely to face same competitor across than within countries ($r_{\text{inter}} < r_{\text{intra}}$).
  - High intern/intra-national trade costs.
  - Demand shocks less correlated across/within countries ($\rho_{\text{inter}} < \rho_{\text{intra}}$).
Product-level RERs: Bertrand competition

- **Variance** $\Delta Q = 4\sigma_a^2 (1 - \rho_a r) + 2 (\sigma_z^2 + \sigma_w^2) \ast (1 - r)$
  - demand shocks
  - cost shocks

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- $\text{Variance}^{\Delta Q}_{inter} > \text{Variance}^{\Delta Q}_{intra}$ does not imply $D > 1$. 
Aggregate RER: Bertrand Competition

- On average, \( \Delta c_{njAt}^{2nd} = \Delta W_j \) of latent competitor.

\[
\text{Average } \Delta Q^{inter} = \begin{cases} 
0 & \text{if face} = \text{latent competitor} \\
\frac{\Delta W_2}{W_1} & \text{if face} \neq \text{local latent competitor}
\end{cases}
\]
On average, $\Delta c^{2nd}_{njAt} = \Delta W_j$ of latent competitor.

Average $\Delta Q^{inter} = \begin{cases} 
0 & \text{if face = latent competitor} \\
\Delta W_2 / W_1 & \text{if face } \neq \text{ local latent competitor}
\end{cases}$

$\Delta Q = (1 - r) \Delta W_2 / W_1$
Aggregate RER: Bertrand Competition

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  \end{cases}$

  $\Delta Q = (1 - r) \Delta W_2 / W_1$

- Low $r$ (due to high $D$), likely to face local competitor in each country.
  - Prices responsive to local wage in each country.
Aggregate RER: Bertrand Competition

- On average, $\Delta c_{njAt}^{2nd} = \Delta W_j$ of latent competitor.

$$\text{Average } \Delta Q^{\text{inter}} = \begin{cases} 0 \text{ if face } = \text{ latent competitor} \\ \Delta W_2 / W_1 \text{ if face } \neq \text{ local latent competitor} \end{cases}$$

$$\Delta Q = (1 - r) \Delta W_2 / W_1$$

- Low $r$ (due to high $D$), likely to face local competitor in each country.
  - Prices responsive to local wage in each country.

- $\Delta Q > 0$ for traded products implies $D > 1$. 
Model implication I: Idiosyncratic and aggregate pricing-to-market

- **Low \( r \):**
  - More idiosyncratic pricing-to-market, high \( \text{Var}^{\Delta Q_{\text{inter}}} \) and low \( \text{Correl}_{\Delta P}^{\text{inter}} \).
  - More aggregate pricing-to-market, high aggregate \( \Delta Q \).

- **Prediction:**
  - Categories with low \( \text{Correl}_{\Delta P}^{\text{inter}} \) should display high aggregate \( \Delta Q \).
Model implication I: Idiosyncratic and aggregate pricing-to-market

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<thead>
<tr>
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</tbody>
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Model implication II: Size of country and pricing-to-market

- $K_1 > K_2$, less pricing-to-market by US producers.
  - More likely same latent American competitor in both countries.

Findings: Correl $\Delta P_{\text{non-US exported products}} < \text{Correl } \Delta P_{\text{US exported products}}$.

Model implication II: Size of country and pricing-to-market

- $K_1 > K_2$, less pricing-to-market by US producers.
  - More likely same latent American competitor in both countries.

Quantitative analysis

- Add third production country — ROW, trade cost $D^*$. 

- Add choice of serving foreign market via exports or MP subject to productivity loss (Ramondo-Rodriguez Clare 2008).

- Calibration targets:
  - Trade patterns.
  - Product-level RER for US exporters.

- Model reproduces other salient features of the data.
  - Product-level RER for Can, ROW exporters and non-exporters.
  - Large aggregate RER movements for US, Can, ROW exporters and non-exporters.
  - Asymmetry in RER fluctuations between producers from different locations.
Parameterization

- **11 parameters:**
  - $\theta, K_1, K_2, K_3, D, D^*, \lambda$ - trade patterns
  - $\sigma_z, \sigma_a, \rho_{a}^{\text{intra}}$ - shocks
  - $\eta$ - elasticity of substitution.

- $\Delta W_{1t}, \Delta W_{2t}, \text{and } \Delta W_{3t}$
Parameterization: Trade

- Parameters that determine international trade shares:
  - Pick $\theta$, $K_1$, $K_3$
  - Calibrate $K_2$, $D$, $D^*$, $\lambda$

  Import share in Canada from US = 25%

  Import share in US from Canada = 2%

  Average Import share in US and Canada from ROW = 10%

  \[
  \frac{\text{Expenditures in matched domestic products}}{\text{Expenditures in matched exported products}} \text{ in Canada} = 1
  \]

- Only $K_3/D^*$ matters.

- Results unchanged with $K_1$. 
Parameterization: Price changes

- Parameters determining product-level price movements:
  - $\sigma_z, \sigma_a, \rho_a$

- Target: US exporters
  - $\text{Std}^{\Delta P} = 8\%$
  - $\text{Std}^{\Delta Q \text{ intra}} = 5.5\%$
  - $\rho_a^{\text{inter}} = 0$
  - Baseline: $\rho_a^{\text{intra}} = 0$
  - Also set $\rho_a^{\text{intra}}$ to match $\text{Std}^{\Delta Q \text{ inter}} = 11\%$.

- $\Delta W_{1t} = 0$, $\Delta W_{2t} = \Delta W_{3t} > 0$, increase in Canadian/US unit labor costs 2004-2006.
Parameterization: Elasticities

- Elasticity of substitution across varieties.
  - $\eta = 1.01$: as in our analytical approximation
  - Implied average markup $= 30\%$.
  - Also report our findings when $\eta = 2$.

- Dispersion of permanent costs: $\theta$
  - $\theta = 0.3$, high range in Eaton and Kortum (2002).
  - Higher $\theta$ reduces switching of producers and latent competitors over time.
## Parameter Values

### Panel A: Parameter values

**Parameters that determine trade patterns**

<p>| | | |</p>
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<thead>
<tr>
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<tr>
<td>1</td>
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</tr>
<tr>
<td>2</td>
<td>$K_2$</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>$K_3$</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>$D$</td>
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</tr>
<tr>
<td>5</td>
<td>$D^*$</td>
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<td>$\lambda$</td>
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<td>7</td>
<td>$\theta$</td>
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**Parameters that determine price movements**

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<tr>
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<th>$\sigma_z$</th>
<th>Uncorrelated demand shocks</th>
<th>Correlated demand shocks</th>
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</thead>
<tbody>
<tr>
<td>8</td>
<td>$\sigma_z^2/(\sigma_z^2 + \sigma_a^2)$</td>
<td>0.054</td>
<td>0.034</td>
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<tr>
<td>9</td>
<td>$\rho_a$</td>
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### Product-level RERs: Uncorrelated demand shocks

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<tr>
<td><strong>US Exporters</strong></td>
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<tr>
<td>St. dev. Intra-national</td>
<td>5.7</td>
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<tr>
<td>St. dev. Inter-national</td>
<td>9.8</td>
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<td><strong>Canadian Exporters</strong></td>
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</tr>
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<td>St. dev. Intra-national</td>
<td>5.6</td>
</tr>
<tr>
<td>St. dev. Inter-national</td>
<td>10.4</td>
</tr>
<tr>
<td><strong>ROW Exporters</strong></td>
<td></td>
</tr>
<tr>
<td>St. dev. Intra-national</td>
<td>5.6</td>
</tr>
<tr>
<td>St. dev. Inter-national</td>
<td>10.5</td>
</tr>
<tr>
<td><strong>Domestically produced</strong></td>
<td></td>
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<tr>
<td>St. dev. Intra-national</td>
<td>5.6</td>
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<td>St. dev. Inter-national</td>
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<td>10.4</td>
</tr>
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</table>
Aggregate RERs

Figure 5: Model Aggregate Real Exchange Rates

- **US exporters**
  - Unit labor cost
  - Aggregate RER

- **Canada exporters**
  - Unit labor cost
  - Aggregate RER

- **Rest of the world exporters**
  - Unit labor cost
  - Aggregate RER

- **Domestically produced and non-traded**
  - Unit labor cost
  - Aggregate RER
Conclusions

  - Guide design of models of international price setting.

- Construct model of pricing-to-market and international trade that helps rationalize data.
  - International border segments competitors across countries, pricing-to-market in response to idiosyncratic shocks and changes in relative labor costs.

- Future research.
  - Richer IO: other demand systems, producer-retailer interactions, long-term relations.
  - Pricing-to-market has potential welfare implications, partly determined by trade and exchange-rate policies.