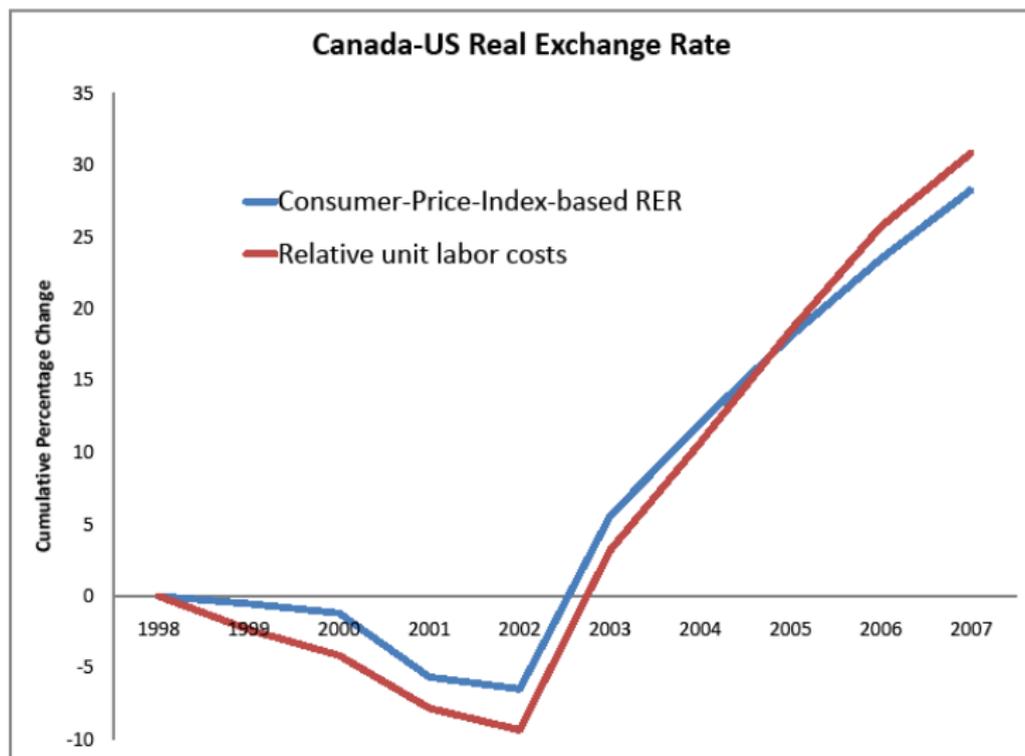


Understanding Movements in Aggregate and Product-Level Real-Exchange Rates

Ariel Burstein (UCLA) and Nir Jaimovich (Stanford)

October 2009

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: $\Delta \frac{eP_n^*}{P_n} = \Delta$ 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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 - ▶ *Key assumption: goods produced in common location and sold in multiple locations are subject to common % change in marginal cost*
- 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).

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 - ▶ *Not* from $\Delta P_n^* = \Delta P_n = 0$, $\Delta e \neq 0$
 - ★ Nominal prices change frequently and by large magnitudes.
 - ★ $\Delta \frac{eP_n^*}{P_n}$ three times as volatile as exchange rate.
 - ★ Substantial idiosyncratic component of pricing-to-market (analogous to Bils and Klenow 2004 for US consumer prices)

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 - ▶ More prevalent across than within countries.

Data: Related Papers

- Facts on international prices using product-level data:
Crucini-Telmer-Zachariadis (05), Crucini-Shintani (2008), Broda-Weinstein (08), Gopinath-Gourinchas-Hsieh (2008).
 - ▶ We measure extent to which movnts in rel prices reflect prng-to-mkt
 - ▶ Unique features of our data: matched products, wholesale prices, country-of-origin to identify traded/nontraded.
- Fitzgerald-Haller (2008): evidence of prng-to-mkt by Irish exporters
 - ▶ 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.
 - ▶ Builds on Dornbusch (1987), Bernard, Eaton, Jensen, and Kortum (2003), and Atkeson and Burstein (2008).
 - ▶ 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 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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- Analytic results: key ingredients to account for product-level and aggregate price observations
- 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 w/ 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.
- Time period: 2004-2006.

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.
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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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 - ▶ 50% of product expenditures in Canada, 35% in US.

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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.

Country of production in Canada and US

- 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 $n = 1, 2, 3, \dots$
- Sold in country $i = 1$ (US) and $i = 2$ (Canada), in region $r = A, \dots, R$.
- Product-level RER:

$$Q_{nijrr't} = e_{ijt} P_{nirt} / P_{njr't} \text{ where } e_{ij} = 1$$

- Percentage change in product-level RER:

$$\Delta Q_{nijrr't} = \log(Q_{nijrr't}) - \log(Q_{nijrr't-1})$$

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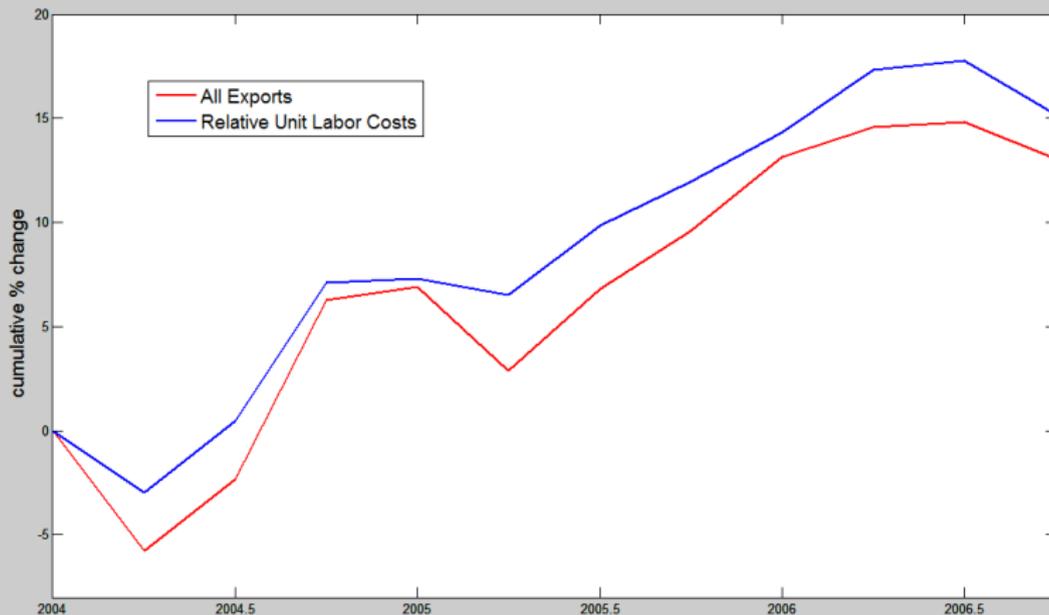
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- Aggregate RER: average $\Delta Q_{n21rr't}$ across many products.

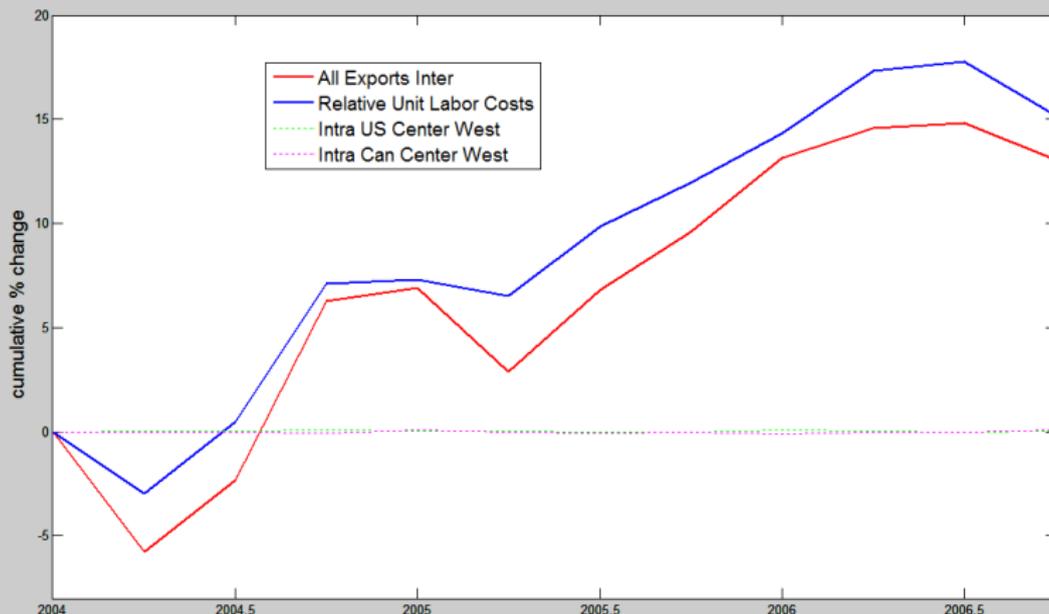
Aggregate RER: All Exports

- Average of product-level RERs across products and countries.
 - ▶ Systematic increase in Canada-U.S. markups.

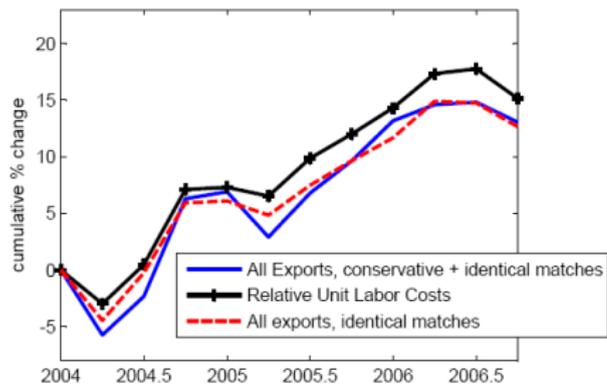


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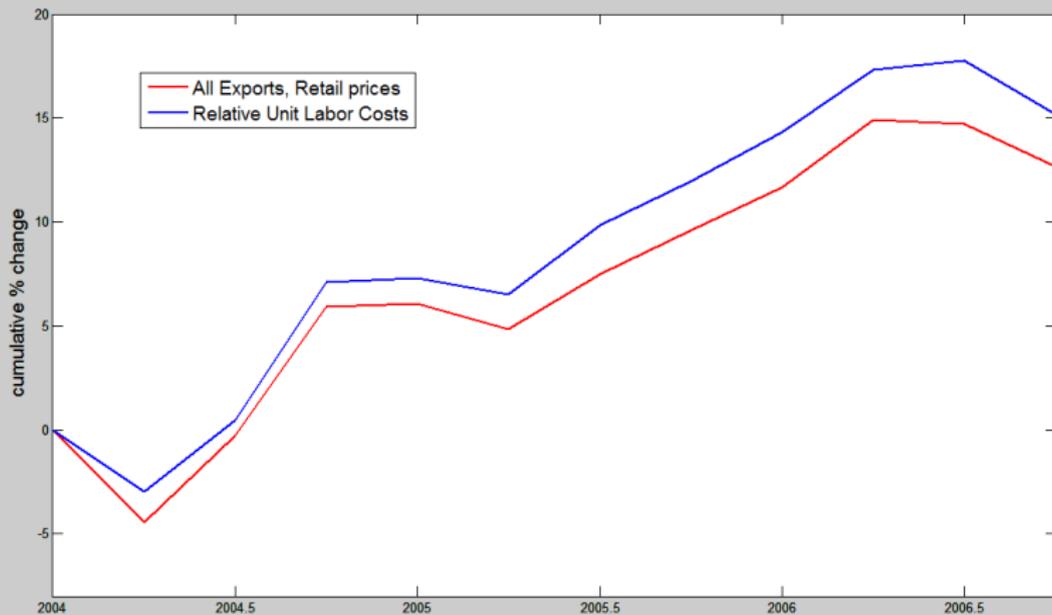
- Average of product-level RERs across products within countries.
 - ▶ Movements in product-level RER's average-out within countries.



Aggregate RER: Identical and US exports



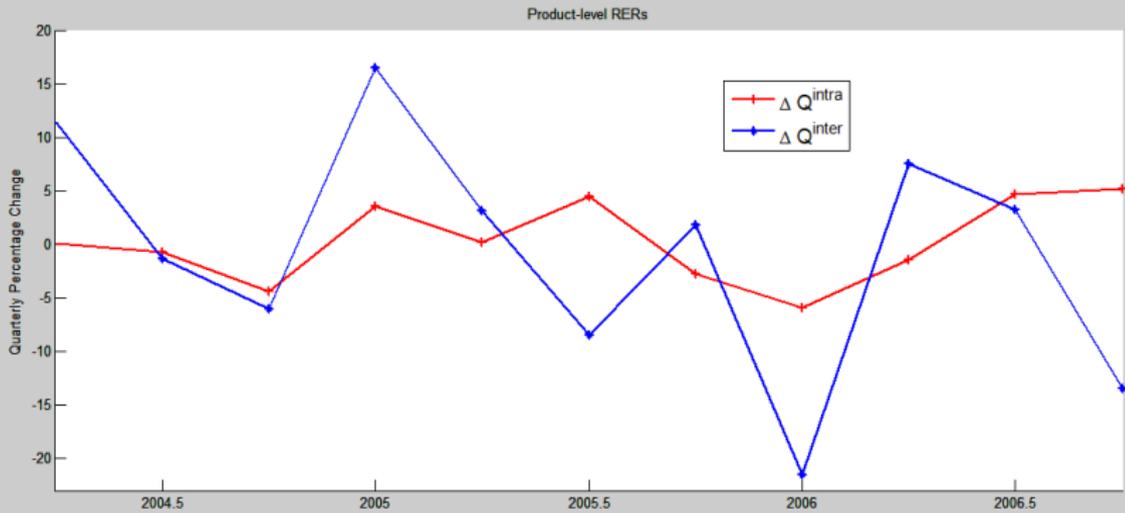
Aggregate RER: All Exports, Retail Prices



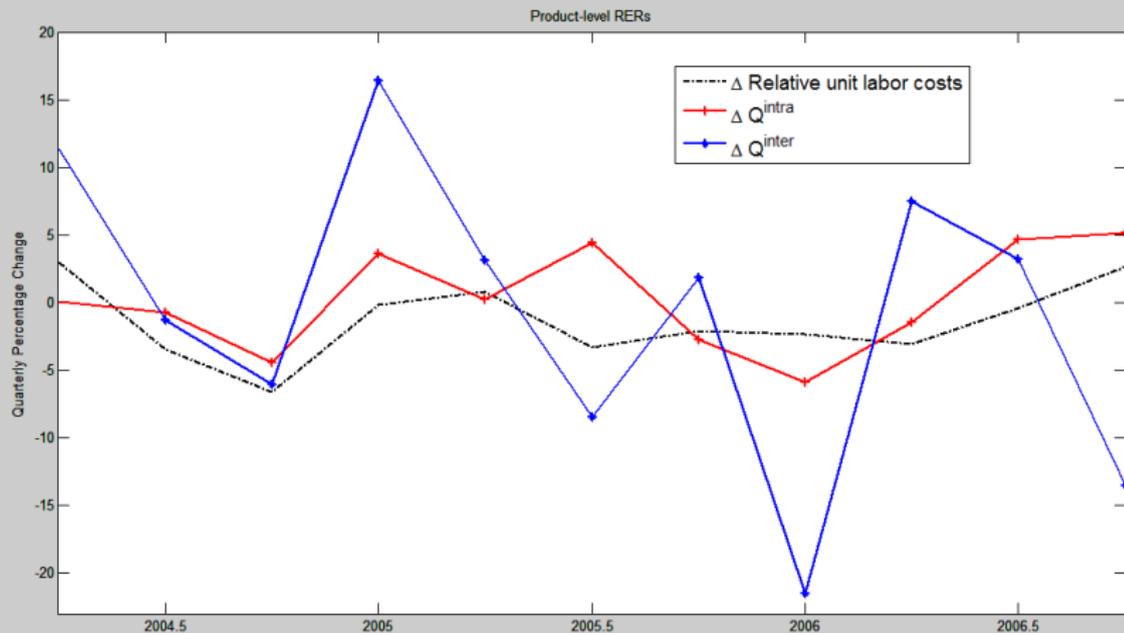
Prices change frequently and by large magnitudes

- 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”

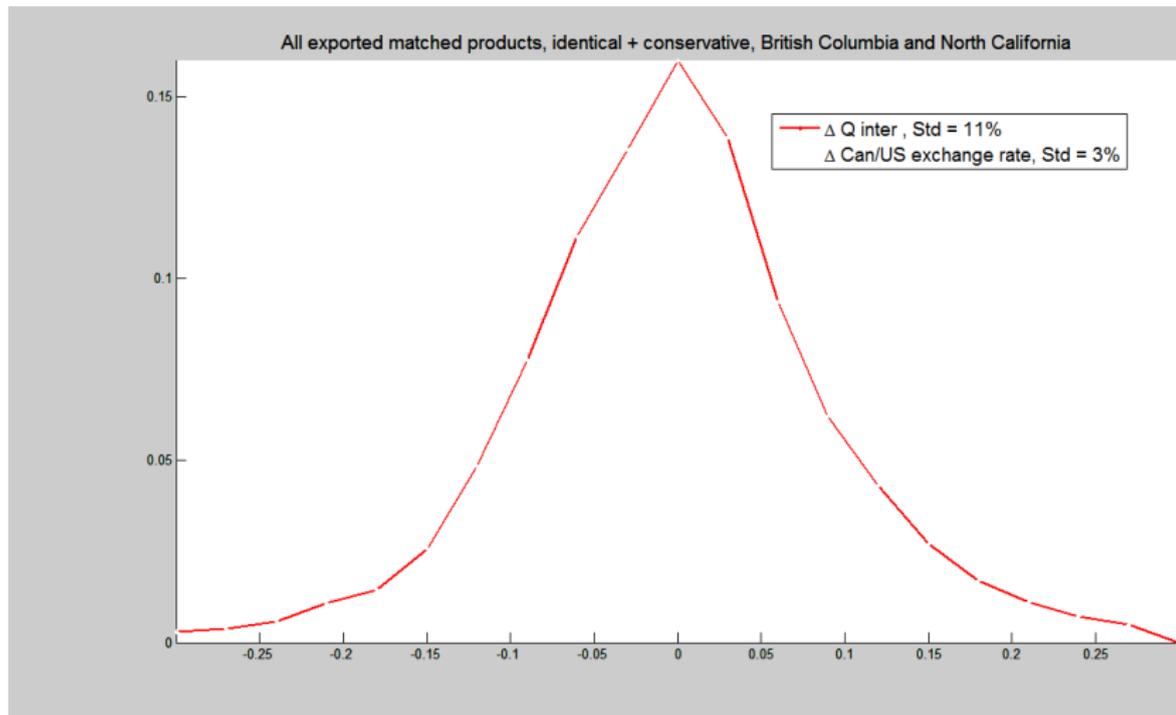


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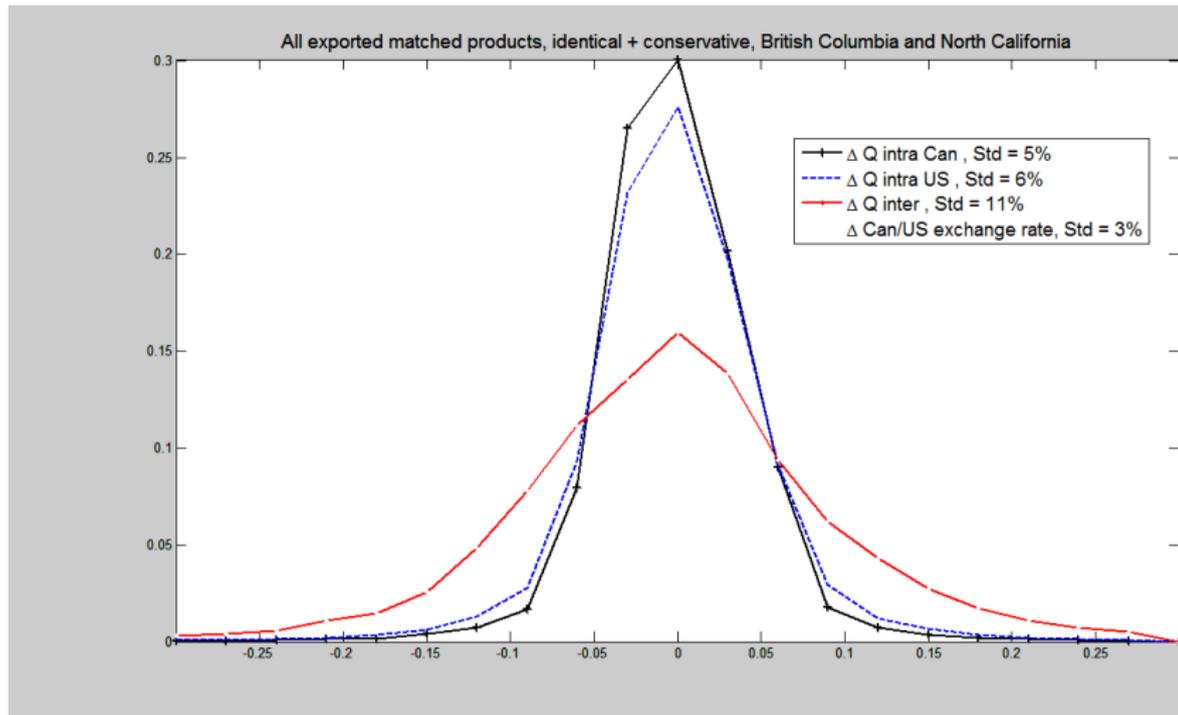
Distribution of product-level RERs: Exported products

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



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Product-level real exchange rates: Robustness

- Broader geographical coverage than BC and North Cali

$$\text{Std}^{\Delta Q_{ijrr'}} = \underbrace{\alpha}_{0.0035^{***}} + \underbrace{\beta}_{0.004^{***}} \log \text{Distance}_{ijrr'} + \underbrace{\gamma}_{0.054^{***}} \mathbb{I}_{i \neq j}$$

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

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- Identical UPC matches, more/less restrictive matches.
 - 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

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 - ▶ 2 countries (3 in paper), 2 regions per country.

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 - ▶ Changes in aggregate relative unit labor costs.

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 - ▶ Changes in aggregate relative unit labor costs.
- 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.
 - ▶ Match product-level and aggregate RER facts.

Consumption

- Consumption composite across many varieties:

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- Consumers purchase product with highest a_{knirt} / P_{knirt} .
 - ▶ No arbitrage across regions.
- Product demand shocks, a_{knirt} :
 - ▶ Lognormal, variance σ_a^2 , correlation across regions ρ_a .

Production

- Producers:
 - ▶ K_1 from country 1, K_2 from country 2.

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

- ▶ $z_{knt} = \underbrace{\bar{z}_{kn}}_{\text{Permanent, } (\bar{u}_{kn})^\theta, \bar{u}_{kn} \text{ exponential}} * \underbrace{\tilde{z}_{knt}}_{\text{Temporary, lognormal } \sigma_z^2}$

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- Marginal cost, c , for firms in country 1:

- 1 $W_1 z$ domestic sales
- 2 $DW_1 z$ exports

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- ② $DW_1 z$ exports

- Partial equilibrium: Movements in unit labor costs W_i ; lognormal σ_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.

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- 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 ΔQ^{inter} across many products.
- Exported products, $\Delta Q = 0$.
- Domestically produced products, $\Delta Q = \Delta (W_2 / W_1)$.

Aggregate RER: Perfect Competition

- Average ΔQ^{inter} across many products.
- Exported products, $\Delta Q = 0$.
- Domestically produced products, $\Delta Q = \Delta (W_2 / W_1)$.
- Country of origin key to discriminate constant vs variable markup model

Pricing: Bertrand Competition

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

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

- ▶ a_{nirt}^{2nd} and c_{nirt}^{2nd} , “latent competitor” shocks.

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- ▶ 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:

$$\Delta P_{nirt} = \underbrace{\Delta a_{nirt}^{1st} - \Delta a_{nirt}^{2nd}}_{\text{demand shocks}} + \underbrace{\Delta c_{nirt}^{2nd}}_{\text{cost shocks}} .$$

- Correlation of price changes across two regions

- ▶ Demand: correlation ρ_a .

- ▶ Cost: $\begin{cases} \text{correl}=1 \text{ if face same latent competitor (fraction } r) \\ \text{correl}=0 \text{ if face different latent competitor (fraction } 1 - r) \end{cases}$

- $\text{Variance}^{\Delta Q} = 2 * \text{Variance}^{\Delta P} \left(1 - \text{correlation}^{\Delta P_{r1}, \Delta P_{r2}} \right)$

Product-level RERs: Bertrand competition

- $\text{Variance}^{\Delta Q} = \underbrace{4\sigma_a^2 (1 - \rho_a r)}_{\text{demand shocks}} + \underbrace{2(\sigma_z^2 + \sigma_w^2) * (1 - r)}_{\text{cost shocks}}$
- Pricing-to-market if low ρ_a and/or low r .

Product-level RERs: Bertrand competition

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- Pricing-to-market if low ρ_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 ($r^{inter} < r^{intra}$).
 - ★ High intern/intra-national trade costs.
 - ▶ Demand shocks less correlated across/within countries ($\rho^{inter} < \rho^{intra}$).

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 - ▶ Demand shocks less correlated across/within countries ($\rho^{inter} < \rho^{intra}$).
- $\text{Variance}^{\Delta Q \text{ inter}} > \text{Variance}^{\Delta Q \text{ intra}}$ does not imply $D > 1$

Aggregate RER: Bertrand Competition

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

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

Aggregate RER: Bertrand Competition

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

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

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

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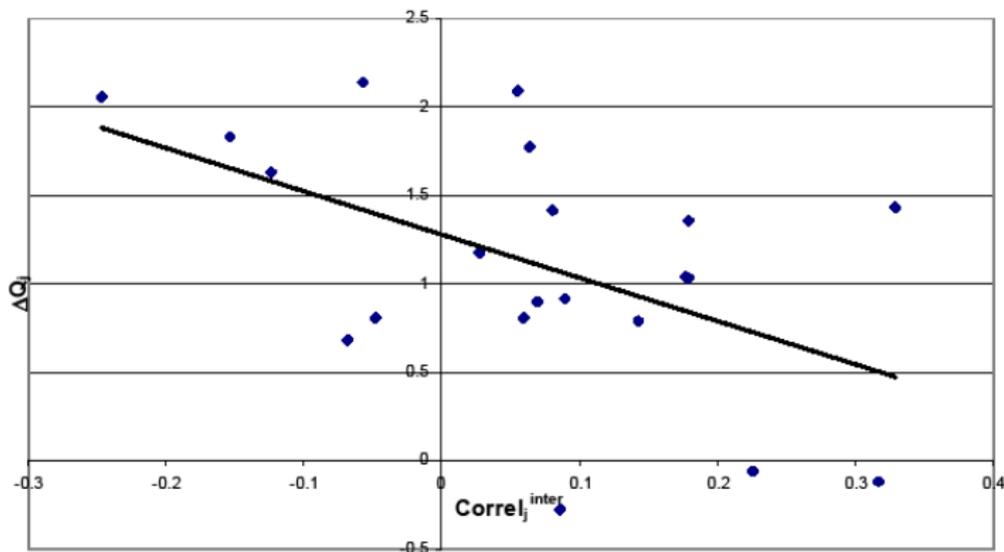
$$\Delta Q = (1 - r) \Delta W_2 / W_1$$

- 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 ΔQ .
- Prediction:
 - ▶ Categories with low $\text{Correl}_{\Delta P}^{\text{inter}}$ should display high aggregate ΔQ .

Model implication I: Idiosyncratic and aggregate pricing-to-market



| | <i>Coeff.</i> | <i>Std. Err.</i> | <i>t Stat</i> |
|--------------|---------------|------------------|---------------|
| Intercept | 1.277 | 0.148 | 8.625 |
| X Variable 1 | -2.441 | 0.938 | -2.603 |

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.

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: $\text{Correl}_{\Delta P}^{\text{inter}}$ non-US exported products $<$ $\text{Correl}_{\Delta P}^{\text{inter}}$ US exported products.
 - ▶ Knetter (1993): Pricing-to-market less prevalent for US exporters.

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
 - ▶ $\sigma_z, \sigma_a, \rho_a^{intra}$ - shocks
 - ▶ η - elasticity of substitution.
- $\Delta W_{1t}, \Delta W_{2t},$ and ΔW_{3t}

Parameterization: Trade

- Parameters that determine international trade shares:

- ▶ Pick θ , K_1 , K_3
- ▶ Calibrate K_2 , D , D^* , λ

Import share in Canada from US = 25%

Import share in US from Canada = 2%

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

$\frac{\text{Expenditures in matched domestic products}}{\text{Expenditures in matched exported products}}$ 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 ρ_a^{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: θ
 - ▶ $\theta = 0.3$, high range in Eaton and Kortum (2002).
 - ▶ Higher θ reduces switching of producers and latent competitors over time.

Parameter Values

Panel A: Parameter values

Parameters that determine trade patterns

| | | |
|---|-----------|------|
| 1 | K_1 | 28 |
| 2 | K_2 | 4 |
| 3 | K_3 | 5 |
| 4 | D | 1.58 |
| 5 | D^* | 1.15 |
| 6 | λ | 0.35 |
| 7 | θ | 0.3 |

Parameters that determine price movements

| | | Uncorrelated | Correlated |
|----|--|---------------|------------|
| | | demand shocks | |
| 8 | σ_z | 0.054 | 0.034 |
| 9 | $\sigma_z^2 / (\sigma_z^2 + \sigma_a^2)$ | 0.780 | 0.333 |
| 10 | ρ_a | 0 | 0.64 |

Product-level RERs: Uncorrelated demand shocks

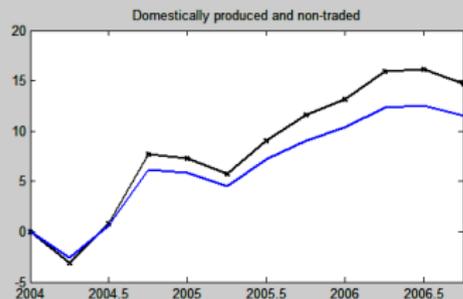
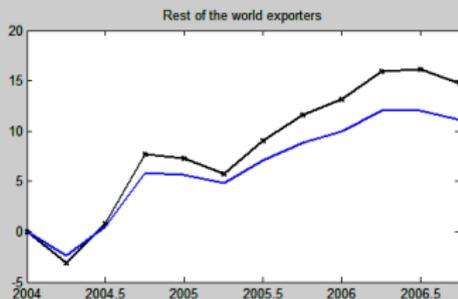
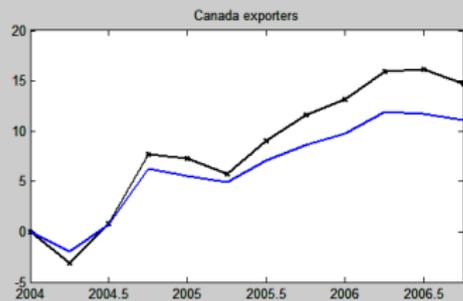
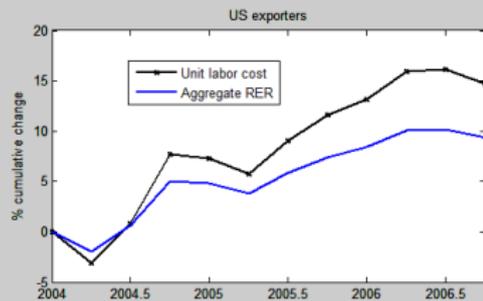
| | Uncorrelated demand shocks |
|-------------------------------------|---------------------------------------|
| <i>US Exporters</i> | % |
| St. dev. Intra-national | 5.7 |
| St. dev. Inter-national | 9.8 |
| <i>Canadian Exporters</i> | |
| St. dev. Intra-national | 5.6 |
| St. dev. Inter-national | 10.4 |
| <i>ROW Exporters</i> | |
| St. dev. Intra-national | 5.6 |
| St. dev. Inter-national | 10.5 |
| <i>Domestically produced</i> | |
| St. dev. Intra-national | 5.6 |
| St. dev. Inter-national | 10.4 |

Product-level RERs: Correlated demand shocks

| | Uncorrelated demand shocks | Correlated demand shocks |
|-------------------------------------|---------------------------------------|-------------------------------------|
| <i>US Exporters</i> | % | % |
| St. dev. Intra-national | 5.7 | 5.7 |
| St. dev. Inter-national | 9.8 | 10.7 |
| <i>Canadian Exporters</i> | | |
| St. dev. Intra-national | 5.6 | 5.6 |
| St. dev. Inter-national | 10.4 | 11.1 |
| <i>ROW Exporters</i> | | |
| St. dev. Intra-national | 5.6 | 5.6 |
| St. dev. Inter-national | 10.5 | 11.0 |
| <i>Domestically produced</i> | | |
| St. dev. Intra-national | 5.6 | 5.7 |
| St. dev. Inter-national | 10.4 | 11.0 |

Aggregate RERs

Figure 5: Model Aggregate Real Exchange Rates



Conclusions

- New facts on aggregate and product-level pricing-to-market using non-durable price data from a US-Canada retailer.
 - ▶ 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.