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

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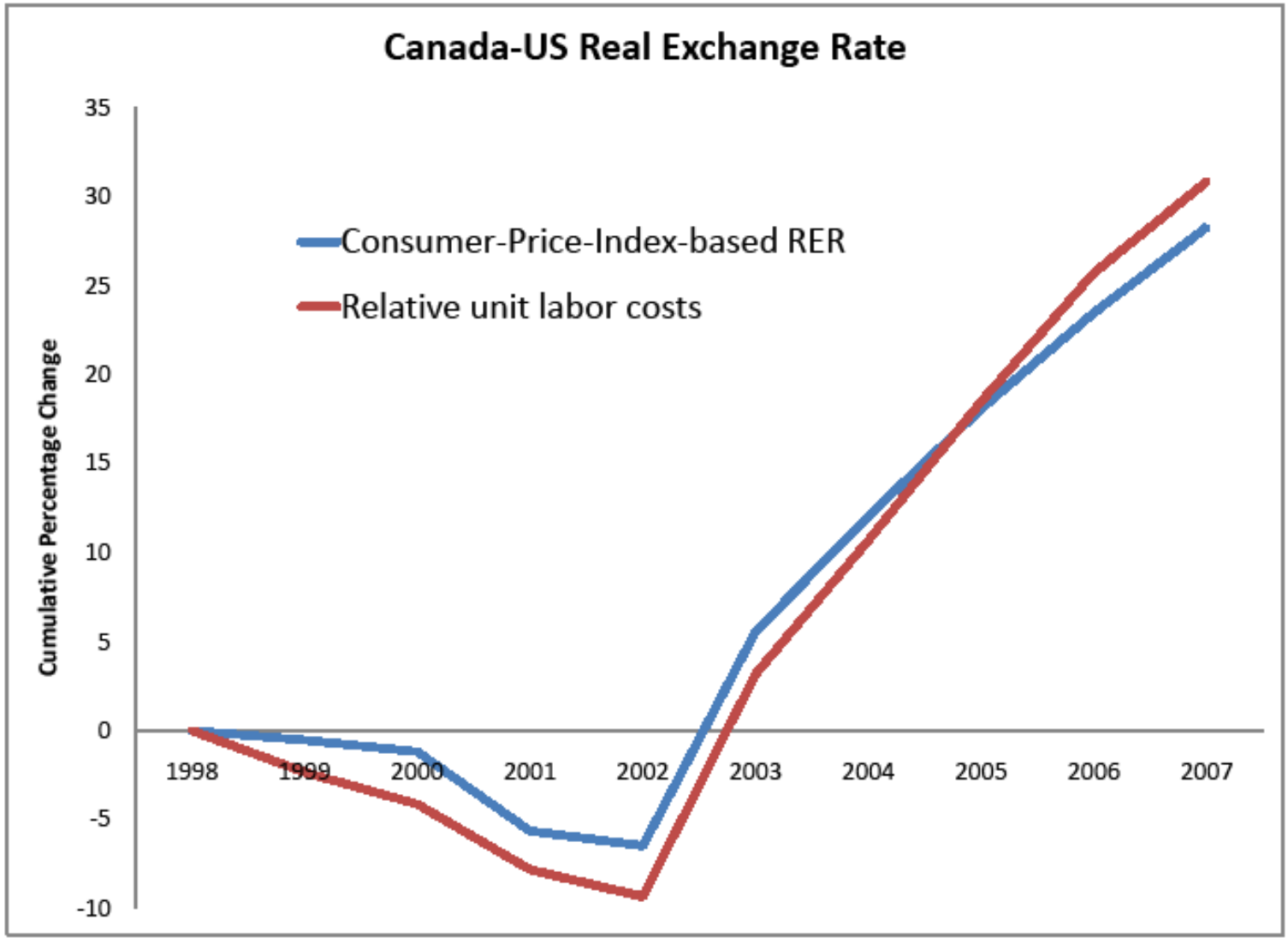
Canada-US: CPI-based RER and Relative Unit Labor Costs



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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- 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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  - 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*
- 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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    - ★ Substantial idiosyncratic component of pricing-to-market (analogous to Bils and Klenow 2004 for US consumer prices)
  - 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 –> 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, $\Delta e P_n^* / P_n$, 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.
- 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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  - Information from Vancouver and North California (focus on this area).
  - $1,000$ 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 $n = 1, 2, 3, ..$
- Sold in country $i = 1$ (US) and $i = 2$ (Canada), in region $r = A, .., R$.
- Product-level RER:

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

- Percentage change in product-level RER:

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

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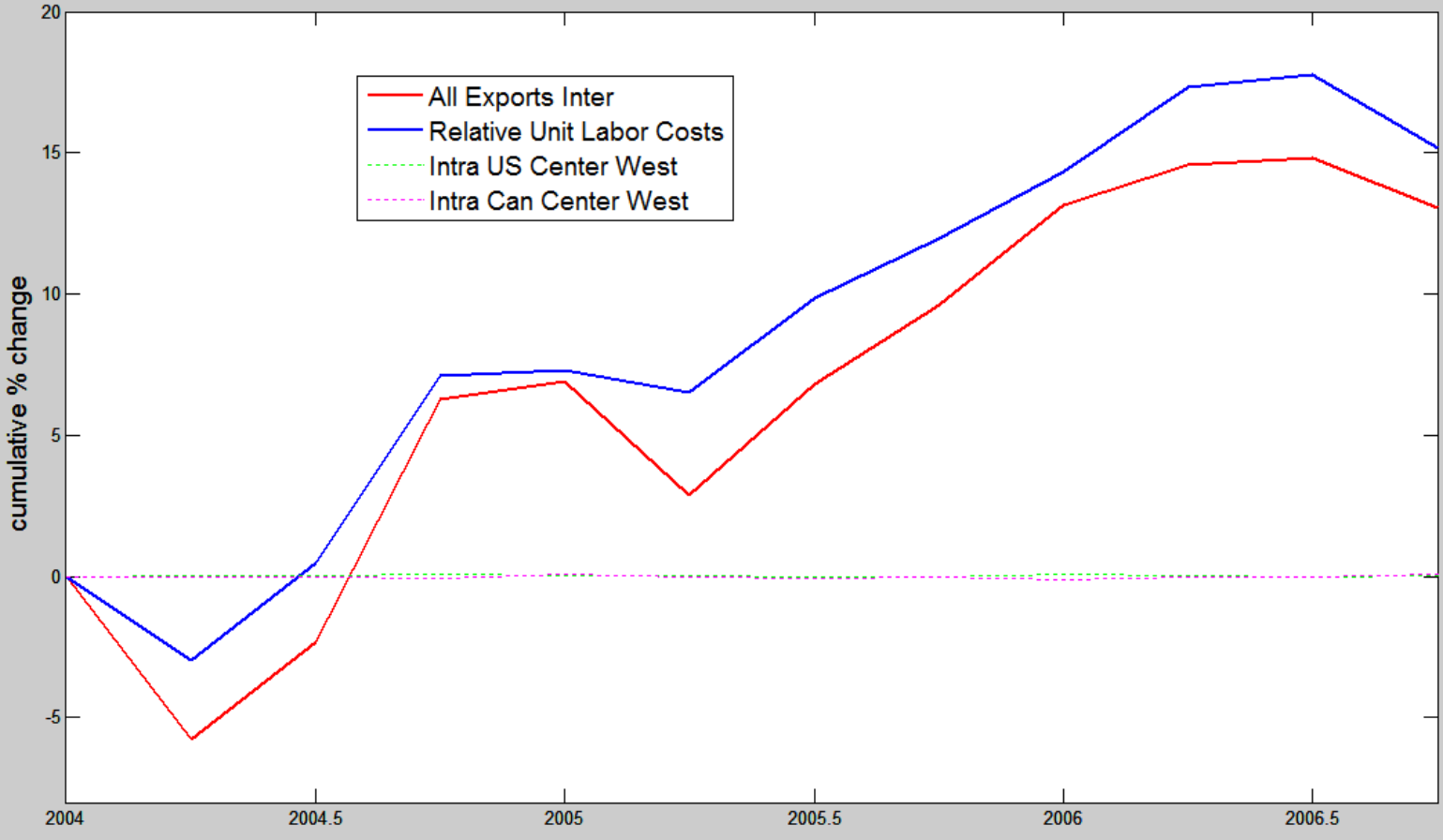
- Aggregate RER: average $\Delta Q_{n21rr't}$ across many products.

Aggregate RER: All Exports

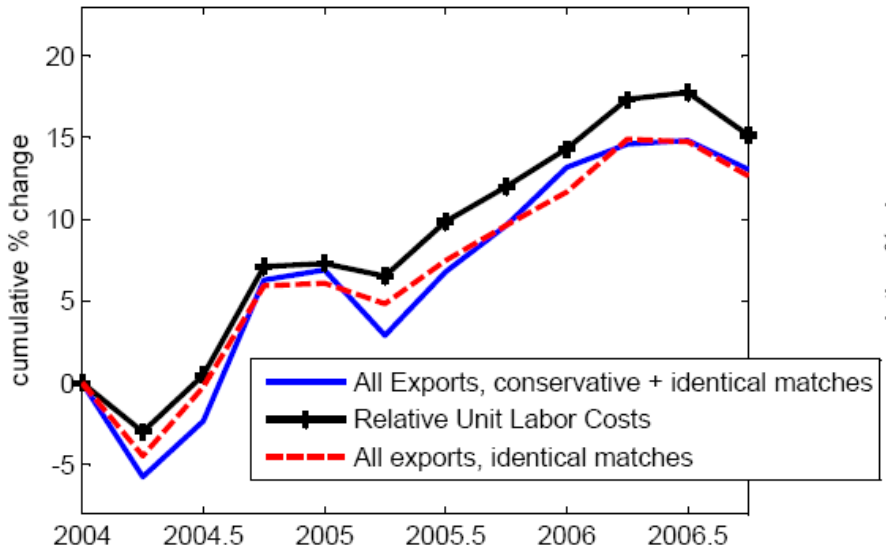
- Average of product-level RERs across products and countries.
  - Systematic increase in Canada-U.S. markups.

Aggregate RER: All Exports

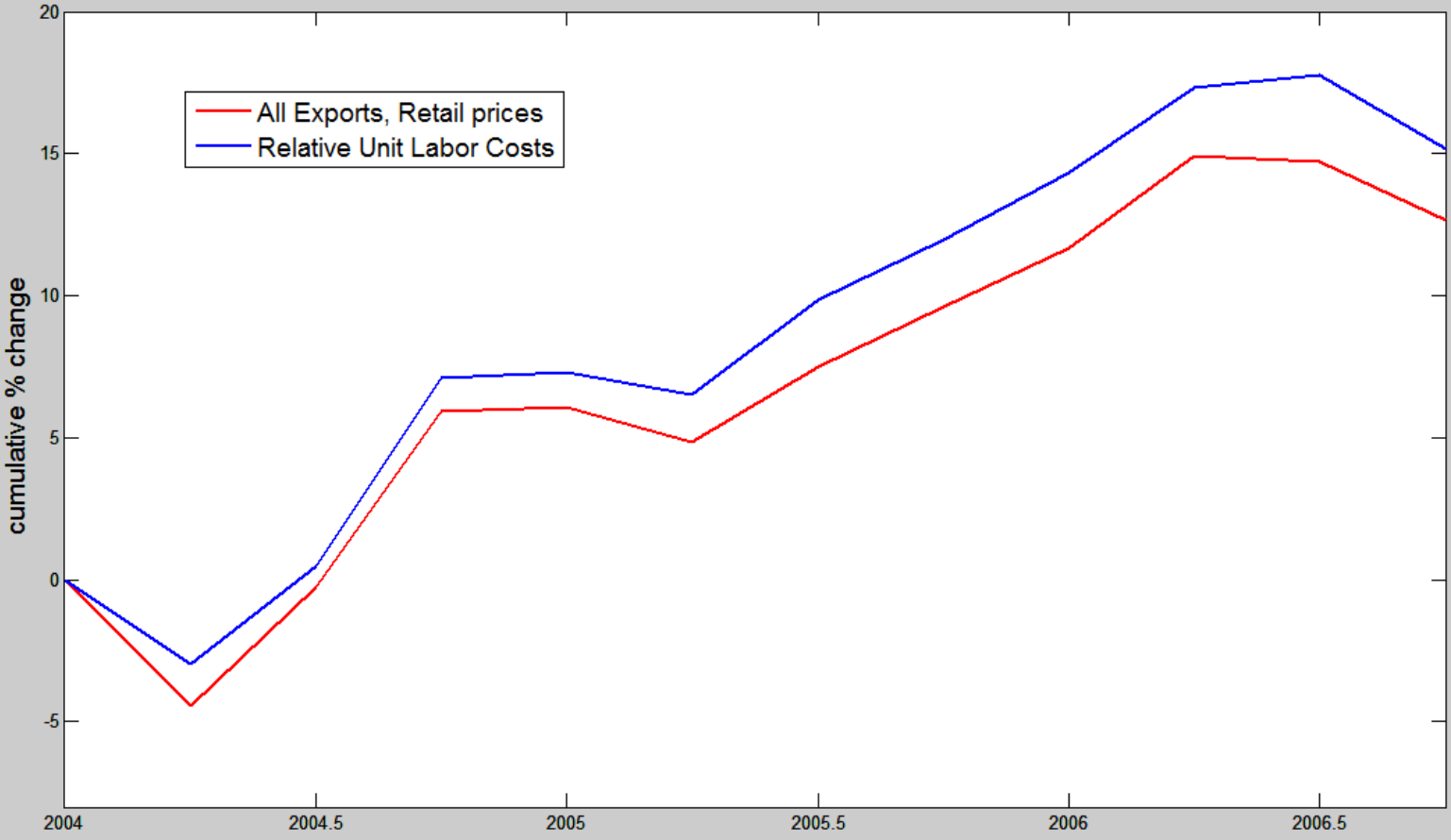
- Average of product-level RERs across products within countries.
  - Movements in product-level RER's average-out within countries.



Aggregate RER: Identical and US exports



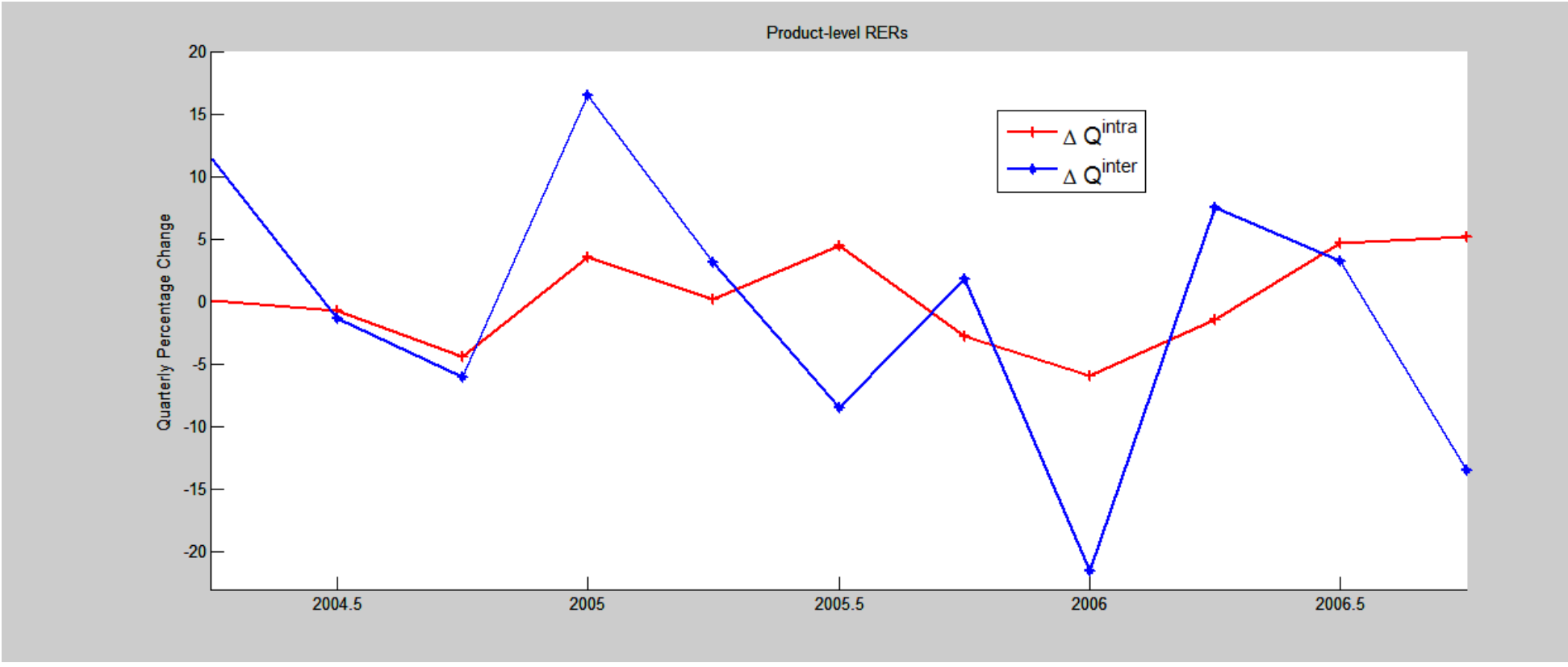
Aggregate RER: All Exports, Retail Prices



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"



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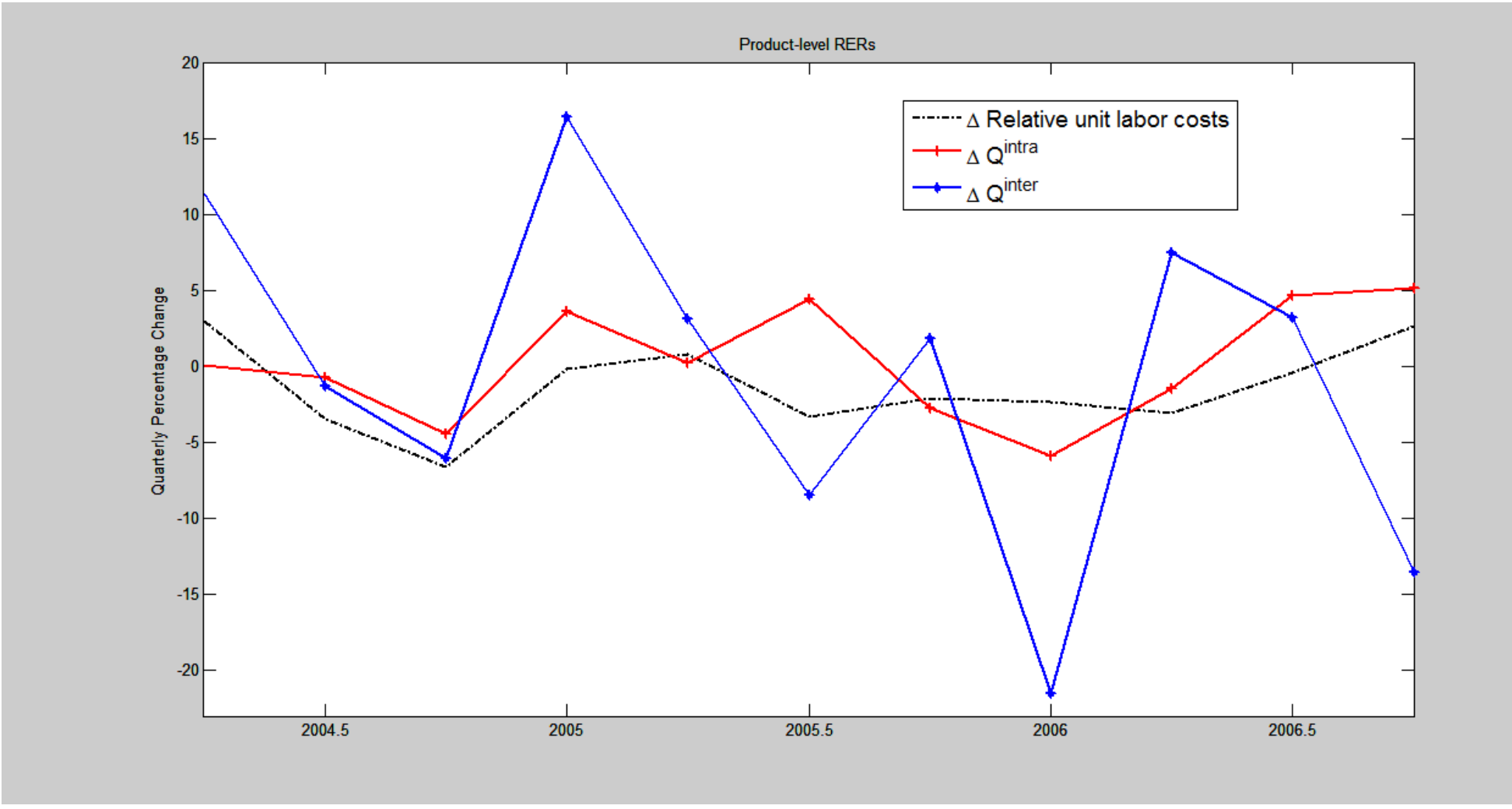
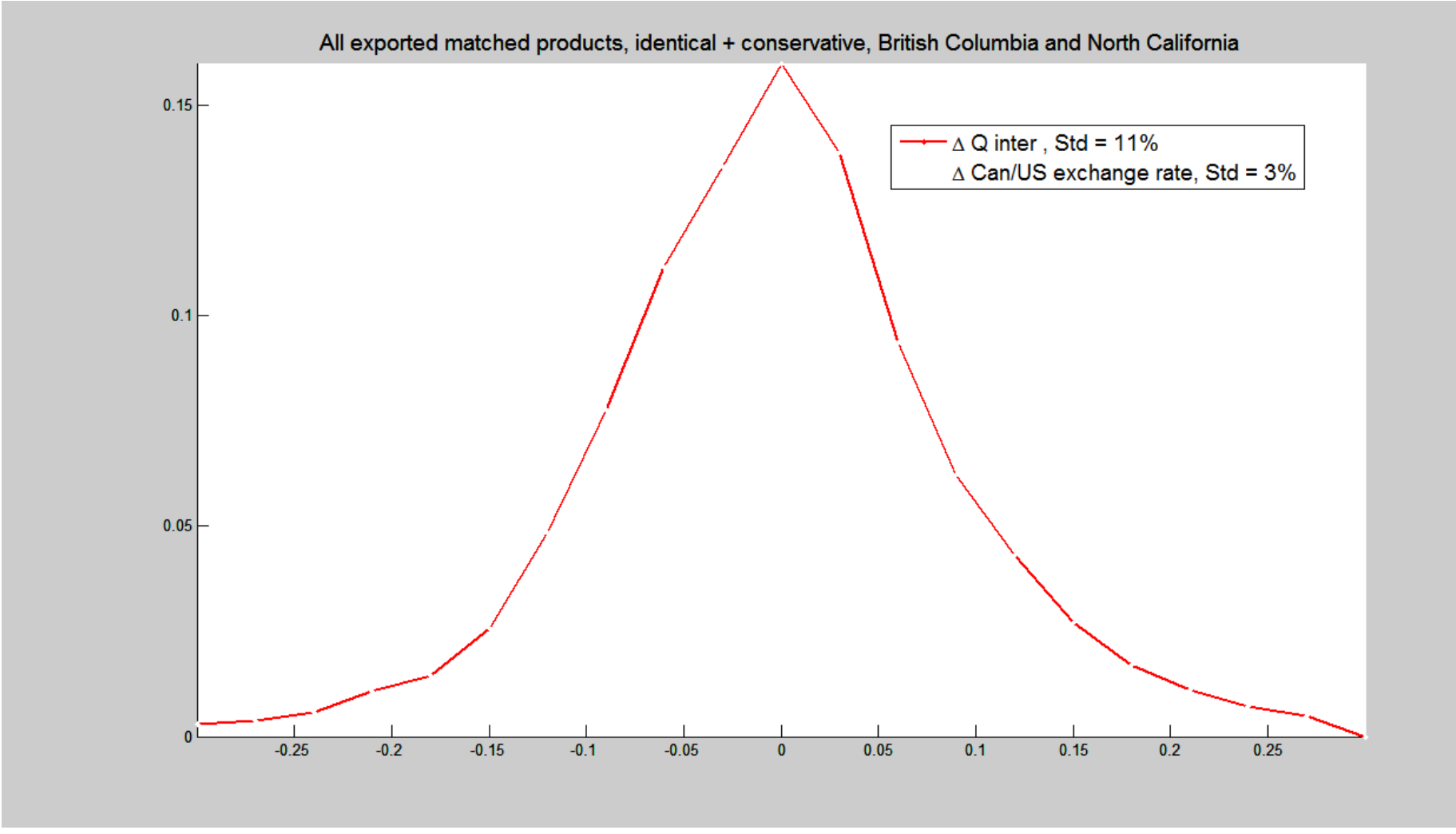


Distribution of product-level RERs: Exported products

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



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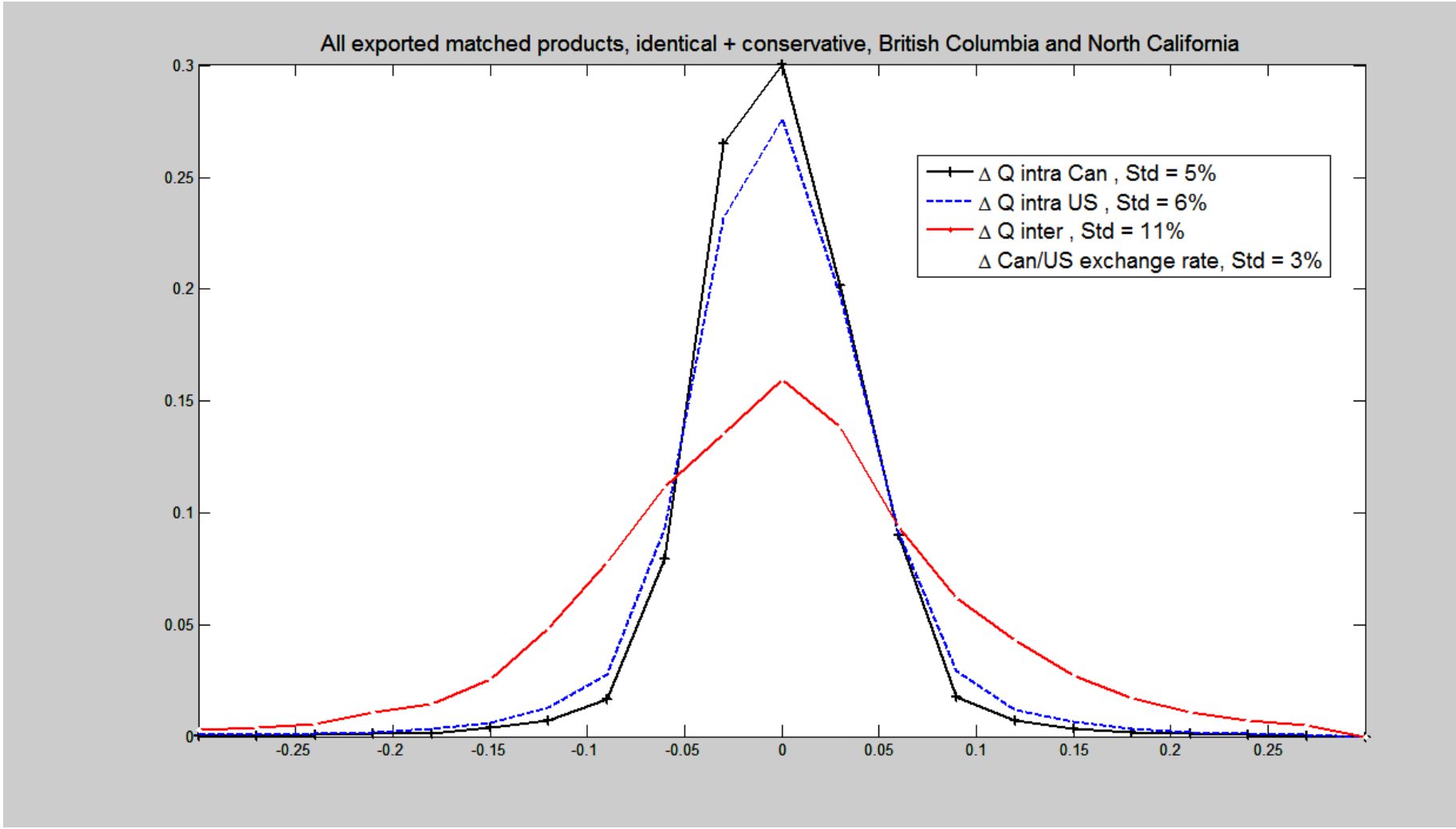

Product-level real exchange rates: Robustness

- Broader geographical coverage than BC and North Cali

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

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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.

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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:

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

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  - Regional taste shock

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- Product demand shocks, a_{knirt}:
  - Lognormal, variance σ_a^2, correlation across regions ρ_a.

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  - 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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  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, $\Delta Q = \Delta \left(W_2 / W_1 \right)$.

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

Pricing: Bertrand Competition

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

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

  - 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:

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

- Correlation of price changes across two regions
  - Demand: correlation ρ_a.
  - Cost: $\begin{cases} \text{correl=1 if face same latent competitor (fraction } r) \\ \text{correl=0 if face different latent competitor (fraction } 1-r) \end{cases}$
- $\text{Variance}^{\Delta Q} = 2 * \text{Variance}^{\Delta P} \left(1 - \text{correlation}^{\Delta P_{r1}, \Delta P_{r2}}\right)$

Product-level RERs: Bertrand competition

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

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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 ($\rho^{inter} < \rho^{intra}$).
- Variance$^{\Delta Q \text{ inter}}$ >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.

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

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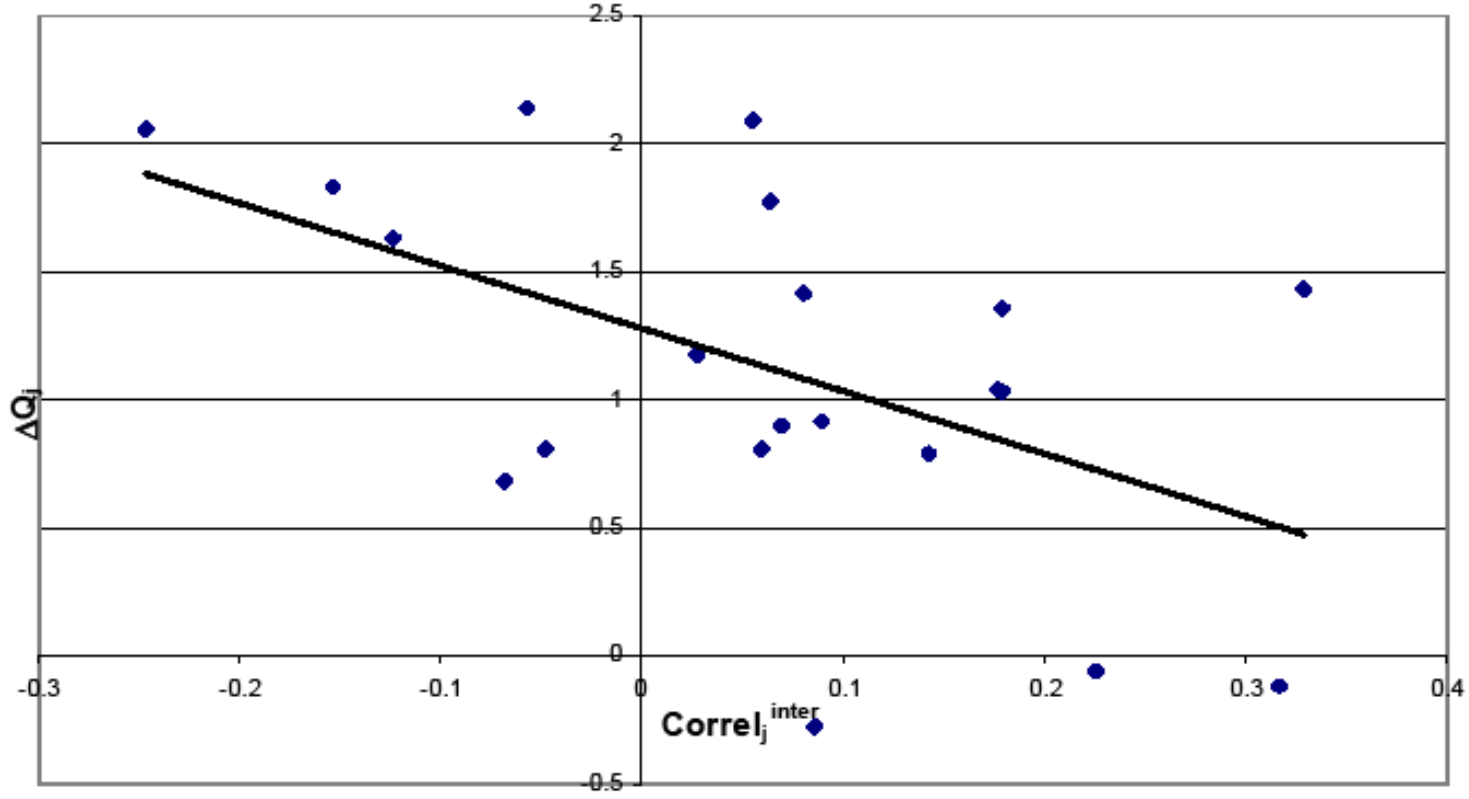
- Low r (due to high D), likely to face local competitor in each country.
  - Prices responsive to local wage in each country.
- $\Delta Q > 0$ for traded products implies $D > 1$.

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 $\text{Correl}^{\text{inter}}_{\Delta P}$.
  - More aggregate pricing-to-market, high aggregate ΔQ.
- Prediction:
  - Categories with low $\text{Correl}^{\text{inter}}_{\Delta P}$ should display high aggregate ΔQ.

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



	Coeff.	*Std. Err.*	*t Stat*
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.

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- Findings: $\text{Correl}^{\text{inter}}_{\Delta P}$ non-US exported products $<$ $\text{Correl}^{\text{inter}}_{\Delta P}$ 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:
  - θ, K_1, K_2, K_3, D, D^*, λ - trade patterns
  - σ_z, σ_a, ρ_a^{intra} - shocks
  - η - elasticity of substitution.
- ΔW_{1t}, ΔW_{2t}, and ΔW_{3t}

Parameterization: Trade

- Parameters that determine international trade shares:
  - Pick θ, K_1, K_3
  - Calibrate K_2, D, D^*, λ

$$\text{Import share in Canada from US} = 25\%$$

$$\text{Import share in US from Canada} = 2\%$$

$$\text{Average Import share in US and Canada from ROW} = 10\%$$

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

  - Only K_3 / D^* matters.
  - Results unchanged with K_1.

Parameterization: Price changes

- Parameters determining product-level price movements:
  - σ_z, σ_a, ρ_a
- Target: US exporters
  - $\text{Std}^{\Delta P} = 8\%$
  - $\text{Std}^{\Delta Q}$ intra $= 5.5\%$
  - $\rho_a^{inter} = 0$
  - Baseline: $\rho_a^{intra} = 0$
  - Also set ρ_a^{intra} to match $\text{Std}^{\Delta Q}$ 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 demand shocks**	**Correlated**
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

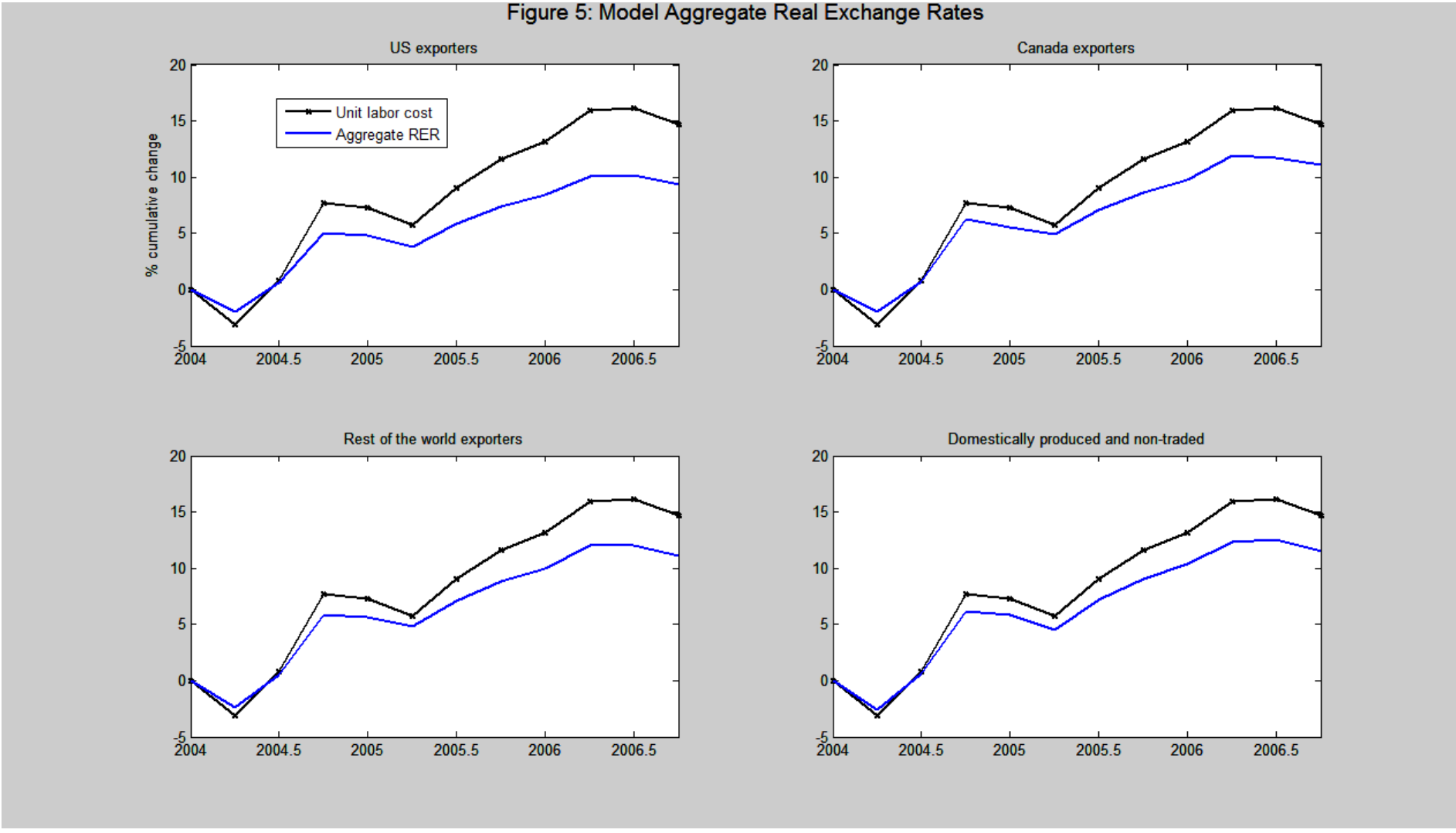
Product-level RERs: Uncorrelated demand shocks

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

Product-level RERs: Correlated demand shocks

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

Aggregate RERs



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.