Exchange Rates, Retailers, and Importing: Theory and Firm-level Evidence

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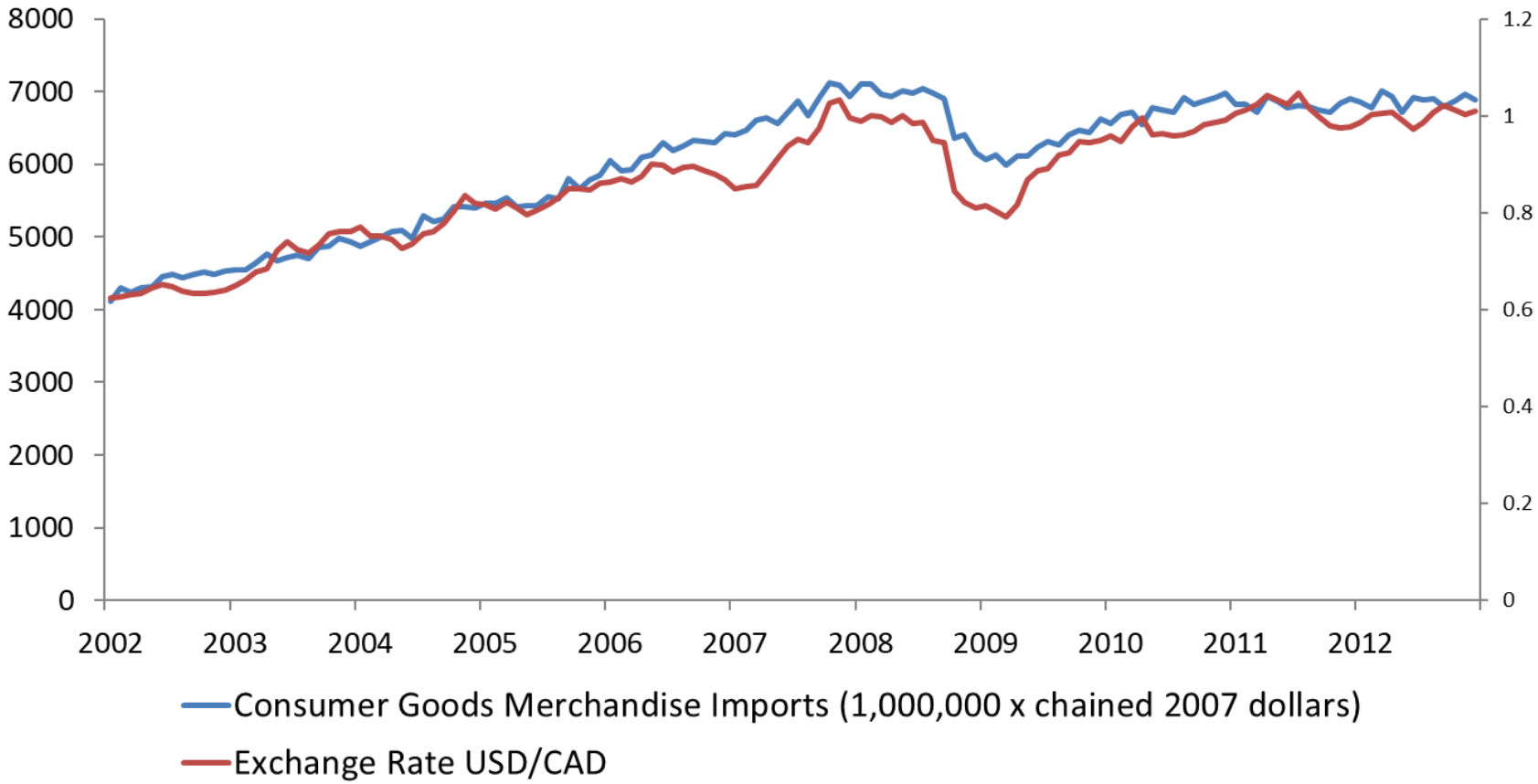
The views in this paper are those of the authors and do not necessarily reflect those of the Bank of Canada

Exchange Rates, Imports, Prices, and Output

- We focus on the role of imports in transmitting exchange-rate movements to aggregate retail prices and sales
- Using firm-level data and an adapted version of the Melitz (2003) model, we quantify the effects of the 57% appreciation of the CAD/USD exchange rate over the period 2002-2012
- Implications for monetary policy: the degree of exchange rate pass-through feeds directly into the Philips curve equation in standard DSGE models

Consumer Goods Imports and the Exchange Rate



Sources: Statistics Canada Tables 12-10-0003-01 and 10-10-0009-01

Overview of Model

- We use a standard Melitz (2003) model with the following adaptations:
  1. Direct importing by retailers in place of exporters, and indirect importing by wholesalers as in Ahn et al. (2011)
  2. The price of imports is exogenous (SOE)
  3. Cross-border shopping is modeled parsimoniously

- Our objective is to use the model to:
  - Estimate the elasticity of aggregate retail price index and sales with respect to the exchange rate

Exchange-Rate Elasticity of the Retail Price Index

$$\varepsilon_E^P = \frac{P_B Q_B}{PQ}|\varepsilon_E^{\tau_B}| - \frac{PQ + P_B Q_B}{PQ}\sum_{n=1}^{N}\left(|\varepsilon_E^{\tau_n}|\frac{P_n Q_n}{PQ}\right)$$

Quantifying ε_E^P requires for each source country n:

- Exchange-rate elasticity of importing trade cost, $\varepsilon_E^{\tau_n}$
- Import share of domestic sales, $P_n Q_n/(PQ)$

Cross-border shopping parameters required include:

- Exchange-rate elasticity of cross-border shopping costs, $\varepsilon_E^{\tau_B}$
- Ratio of cross-border to domestic retail expenditures, $P_B Q_B/(PQ)$

▸ Sales Elasticity ▸ Price Elasticity Figure

Firm-Level Predictions of the Model

Proposition 1: Consider a retailer that sells imported varieties from $N' \leq N$ countries. The exchange-rate elasticity of the retailer's sales will be higher if it imports directly, rather than indirectly, from all N' countries.

Proposition 2: A firm's sales-cost ratio only depends on its firm-level productivity and the CES mark-up, and therefore is unaffected by exchange-rate movements or its import status.

See paper for proofs

Data

Retail Firm-Level Data from Canadian Centre for Data Development and Economic Research (2002-2012):

- Annual Retail Trade Survey (ARTS)
- Import Register (IR)

Testing the Theoretical Predictions

$$y_{i,t} = \beta_0 + \beta_1 ln(RER_{j,t}) + (\beta_2 + \beta_3 ln(RER_{j,t}))\, 1(Import_{i,t})$$

$$+ (\beta_4 + \beta_5 ln(RER_{j,t}))\, ln(dist_{i,t}) + \boldsymbol{X_{j,t}\beta} + u_{i,t}$$

Two specifications of LHS variable, $y_{i,t}$:

1. $ln(sales_{i,t})$
2. $sales_{i,t}/cogs_{i,t}$

Reduced-Form Results Align with Model Predictions

	$ln(sales_{i,t})$	$sales_{i,t}/cogs_{i,t}$
$ln(RER_{j,t})$	-0.223***	0.00878
	(0.0420)	(0.0205)
$1(Imp_{i,t})$	0.0943***	-0.00238
	(0.0102)	(0.00481
$ln(RER_{j,t})1(Imp_{i,t})$	0.234***	-0.00679
	(0.0406)	(0.0210)
$ln(dist_{i,t})$	0.0650**	-0.00721
	(0.0303)	(0.0109)
$ln(RER_{j,t})ln(dist_{i,t})$	0.102***	-0.0220*
	(0.0239)	(0.0122)
Observations	89,968	89,172
R-squared	0.034	0.009
Number of firms	30,562	30,345

Standard errors are clustered at the firm-level. All regressions include a set of controls and firm-level fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Model-Based Empirical Application

$$\varepsilon_E^P = \frac{P_B Q_B}{PQ}|\varepsilon_E^{\tau_B}| - \frac{PQ + P_B Q_B}{PQ} \sum_{n=1}^{N} \left(|\varepsilon_E^{\tau_n}| \frac{P_n Q_n}{PQ} \right)$$

Variables estimated from sector-level/aggregate data:

- $P_n Q_n/(PQ)$ - Statistics Canada IO Tables
- $P_B Q_B/(PQ)$ - Corbi (2014)

▸ Source-Country Import Shares

Estimating the Importing Trade Cost Elasticity, $\varepsilon_E^{\tau_n}$

Estimating equation derived from model:

$$ln(purchases_{i,n,t}) = \zeta_0 + (1-\sigma)\varepsilon_E^{\tau_n} ln(E_{USD/CAD,t}) + \zeta_1 t + h(\tilde{\pi}_t) + u_{i,n,t}$$

- $purchases_{i,n,t}$ is the value of imports from source country n
- $\tilde{\pi}_t$ is the industry-wide average profit level in year t
- We use a benchmark value of $\sigma = 4.02$, which is the implied value from aggregate data on the sales-to-cogs ratio

Estimates of the Exchange-Rate Elasticity of Import Costs

Import Country (n)	US	China	ROW
$ln(E_{USD/CAD,t})$	0.719***	0.973***	0.606**
	(0.249)	(0.323)	(0.257)
$time_t$	-0.104***	0.0636**	-0.0363
	(0.0212)	(0.0268)	(0.0229)
Quadratic profit function	Yes	Yes	Yes
NAICS 4-digit dummy variables	Yes	Yes	Yes
Firm-level fixed effects	Yes	Yes	Yes
Observations	22,248	13,967	17,301
Number of firms	7,660	4,760	5,967
R-squared	0.009	0.099	0.012
pval: $ln(E_{USD/CAD,t})$ equal $\forall n$	0.670	0.670	0.670
$\epsilon_E^{\tau_n}$	-0.238	-0.323	-0.201

Standard errors are clustered at the firm-level. *** p<0.01, ** p<0.05, * p<0.1

Estimating the Cross-Border Cost Elasticity, $\varepsilon_E^{\tau_B}$

Estimating equation derived from model:

$$ln(P_{B,t}Q_{B,t}) = \zeta_0 + (1-\sigma)\varepsilon_E^{\tau_B} ln(E_{USD/CAD,t}) + \zeta_1 t + h(\tilde{\pi}_t) + u_t \quad (1)$$

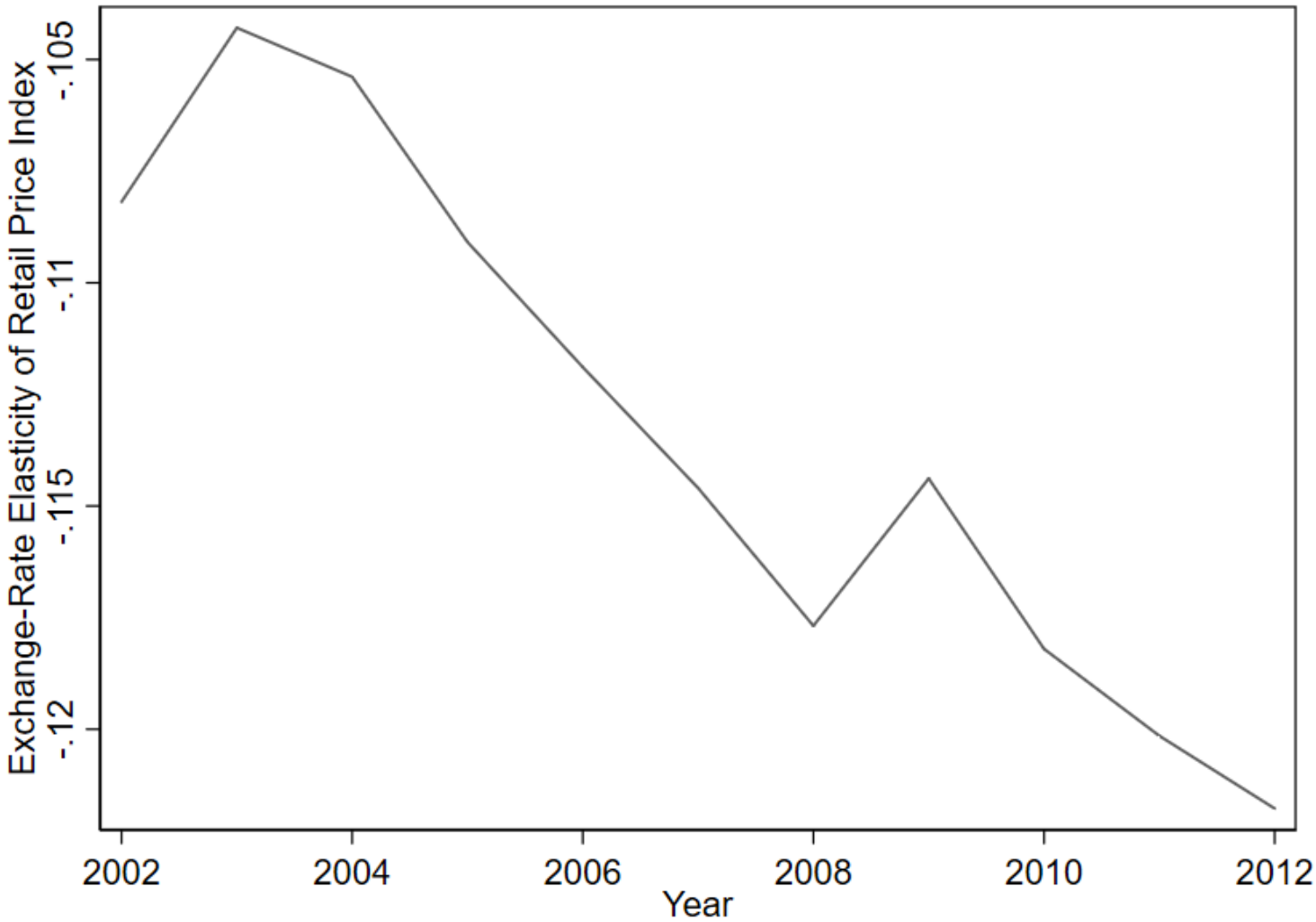
- $P_{CB}Q_{CB}$ - CANSIM quarterly data on spending in foreign countries by Canadians, 2000/Q1-2012/Q2

Exchange-Rate Elasticity of Cross-Border Costs

	(1)	(2)
$ln(E_{USD/CAD,t})$	0.294***	0.241**
	(0.0929)	(0.0945)
$time_t$	0.00252	0.00428**
	(0.00208)	(0.00204)
$9/11_t$		-0.0969***
		(0.0275)
Quadratic Profit Function	Yes	Yes
Observations	50	50
R-squared	0.942	0.951
$\epsilon_E^{\tau_B}$	-0.0975	-0.0801

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Exchange-Rate Elasticity of Retail Price Index



▸ Price Index Elasticity ▸ Price Elasticity Table

Discussion: Exchange-Rate Elasticity of Retail Price Index

Existing estimates of the exchange-rate elasticity of the CPI:

- Goldberg and Campa (2010): average of -0.15 across 21 industrialized countries
- Savoie-Chabot and Khan (2015): -0.06 for Canada using quarterly data for the period 1995 to 2013

Quantifying the effect of the 57% CAD appreciation over 2002–2012:

- According to our model, this appreciation led to a 6.5% reduction in the retail price index

Exchange-Rate Elasticity of Retail Sales

$$\varepsilon_E^{PQ} = (\sigma - 1)\frac{P_B Q_B}{PQ}\left(\sum_{n=1}^{N}\left(|\varepsilon_E^{\tau_n}|\frac{P_n Q_n}{PQ}\right) - |\varepsilon_E^{\tau_B}|\right),$$

- We estimate a positive value for ε_E^{PQ} in all years, indicating that the negative effect of increased cross-border shopping is more than offset by the positive impact of lower-cost imported inputs
- As households already spend 98% of their budget on domestic retail goods, our estimates of ε_E^{PQ} are very small
- According to our model, the 57% CAD appreciation over 2002–2012 resulted in a 0.1% increase in aggregate retail sales

▸ Sales Elasticity Table

Conclusions

- We derive and estimate exchange-rate elasticities for retail prices and sales from a model with firm heterogeneity in importing and cross-border shopping among consumers
- For the period 2002–2012, our results indicate that the 57% CAD appreciation resulted in a 6.5% reduction in the retail price index
- We find that the estimated elasticities of aggregate retail sales and prices grew over this period, driven by import growth from China

References

Ahn, JaeBin, Amit K. Khandelwal, and Shang-Jin Wei (2011) 'The role of intermediaries in facilitating trade.' *Journal of International Economics* 84, 73–85

Corbi, Patricia (2014) 'Estimates of Cross-border Shopping, 2006 to 2012.' Income and Expenditure Accounts Technical Series 76, Statistics Canada, October

Goldberg, Linda S., and José Manuel Campa (2010) 'The Sensitivity of the CPI to Exchange Rates: Distribution Margins, Imported Inputs, and Trade Exposure.' *The Review of Economics and Statistics* 92(2), 392–407

Melitz, Marc J. (2003) 'The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity.' *Econometrica* 71(6), 1695–1725

Savoie-Chabot, Laurence, and Mikael Khan (2015) 'Exchange Rate Pass-Through to Consumer Prices: Theory and Recent Evidence.' Discussion Papers 15-9, Bank of Canada

Exchange-Rate Elasticity of Retail Sales

$$\varepsilon_E^{PQ} = (\sigma - 1)\frac{P_B Q_B}{PQ}\left(\sum_{n=1}^{N}\left(|\varepsilon_E^{\tau_n}|\frac{P_n Q_n}{PQ}\right) - |\varepsilon_E^{\tau_B}|\right),$$

where σ is the CES elasticity of substitution

▸ Price Index Elasticity

Source-Country Import Shares

Year	$\frac{P_n Q_n}{PQ}$ US	$\frac{P_n Q_n}{PQ}$ China	$\frac{P_n Q_n}{PQ}$ ROW
2002	0.2583	0.0348	0.1733
2003	0.2435	0.0365	0.1691
2004	0.2386	0.0433	0.1694
2005	0.2406	0.0524	0.1704
2006	0.2382	0.0595	0.1755
2007	0.2447	0.0630	0.1754
2008	0.2419	0.0689	0.1845
2009	0.2233	0.0726	0.1844
2010	0.2328	0.0731	0.1909
2011	0.2355	0.0754	0.1936
2012	0.2463	0.0776	0.1852

▸ Model-Based Empirical Application

Exchange-Rate Elasticity of Retail Price Index

Year	ε_E^P
2002	-0.1082
2003	-0.1043
2004	-0.1054
2005	-0.1091
2006	-0.1119
2007	-0.1146
2008	-0.1177
2009	-0.1144
2010	-0.1182
2011	-0.1201
2012	-0.1218

▸ Price Elasticity Figure

Exchange-Rate Elasticity of Retail Sales

	(1)	(2)	(3)
		No Importing	
Year	$\frac{\sum_{n=1}^{N} \lvert\varepsilon_E^{\tau n}\rvert P_n Q_n}{PQ}$	ε_E^{PQ}	ε_E^{PQ}
2002	0.1076	-0.00473	0.00163
2003	0.1038	-0.00473	0.00140
2004	0.1049	-0.00473	0.00146
2005	0.1085	-0.00473	0.00168
2006	0.1113	-0.00473	0.00184
2007	0.1139	-0.00473	0.00200
2008	0.1170	-0.00473	0.00218
2009	0.1137	-0.00473	0.00199
2010	0.1175	-0.00473	0.00221
2011	0.1194	-0.00473	0.00232
2012	0.1210	-0.00473	0.00241

▸ Sales Elasticity Results