

# Asymmetries and Non-Linearities in Exchange Rate Pass-through

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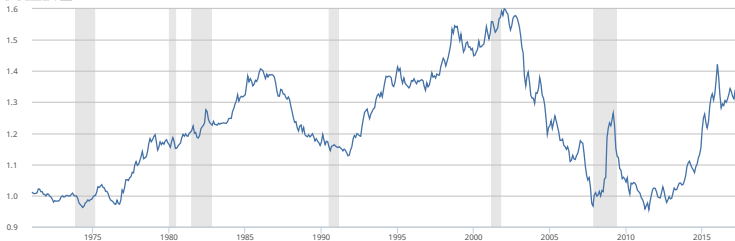
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# Motivation

- ▶ Exchange rates often go through periods of appreciations and depreciations.

## CAD/USD

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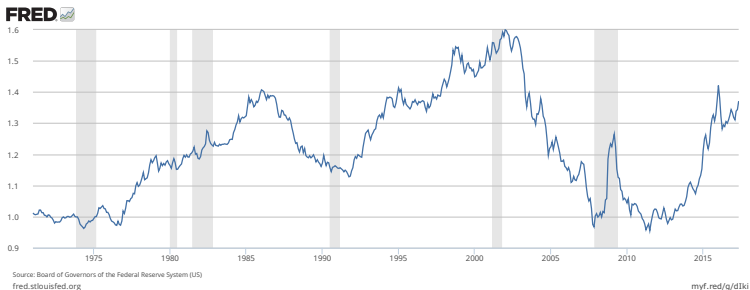
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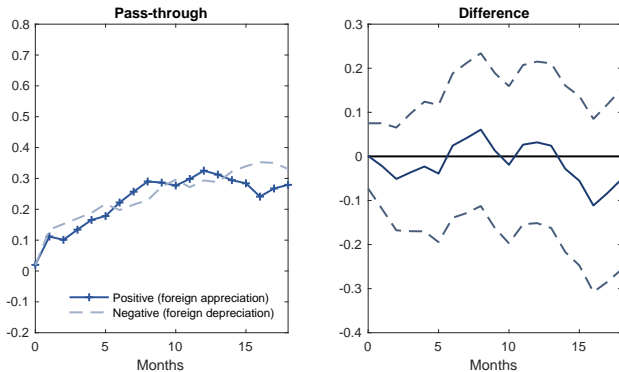
## CAD/USD



- ▶ However, the standard assumption is that exchange rate appreciations and depreciations pass through symmetrically to import prices.

## Motivation (cont.)

Aggregate pass-through for foreign currency depreciations (-) and appreciations (+) into non-fuel, non-tech products:



95% confidence bands plotted for difference.

# Questions

- ▶ Is pass-through of exchange rates into import prices asymmetric? Is it non-linear?
- ▶ If these asymmetries or non-linearities exist, do they tell us something about market structure or the nature of demand?



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- ▶ The importance of this asymmetry varies by sector, suggesting that the nature of competition and price setting plays a role.
- ▶ We find no statistically significant non-linearities.
- ▶ A theory of sticky prices with strategic complementarities and capacity constraints is generally capable of matching these facts.



## Existing literature

- ▶ The standard pass-through regression (everything in logs):

$$\Delta p_t = \alpha + \beta \Delta e_t + \delta \Delta c_t + \epsilon_t$$

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  - ▶ Pass-through of exchange rates into U.S. import prices is incomplete and fairly low.
    - ▶ Aggregate long-run pass-through elasticity around 0.4 (Campa and Goldberg 2005); product-level elasticity is similar (Gopinath and Itskhoki, 2010).
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  - ▶ Pass-through has been declining secularly since the 70s. (Marazzi, 2005)

# Data

- ▶ We use monthly product-level prices from the BLS International Price Program (IPP) for years 1994-2014.
- ▶ Other data: foreign CPI, exchange rates (IFS), commodity prices (IMF)



## BLS data

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  - ▶ Raw data includes list prices, transaction prices, estimated prices, including intrafirm prices.
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- ▶ Excluded from this study - estimated, non-usable, services, petroleum, dollar pegs.
- ▶ Analyze arms-length and intrafirm goods separately.



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$$\Delta p_{i,j,t} = \sum_{k=0}^{18} \{ \beta_k^+ \Delta e_{j,t-k}^+ + \beta_k^- \Delta e_{j,t-k}^- \} + [\dots] + \epsilon_{i,j,t}$$

$$\Delta e_{j,t}^+ \begin{cases} \Delta e & \Delta e > 0 \\ 0 & \Delta e \leq 0 \end{cases}$$

$$\Delta e_{j,t}^- \begin{cases} \Delta e & \Delta e < 0 \\ 0 & \Delta e \geq 0 \end{cases}$$

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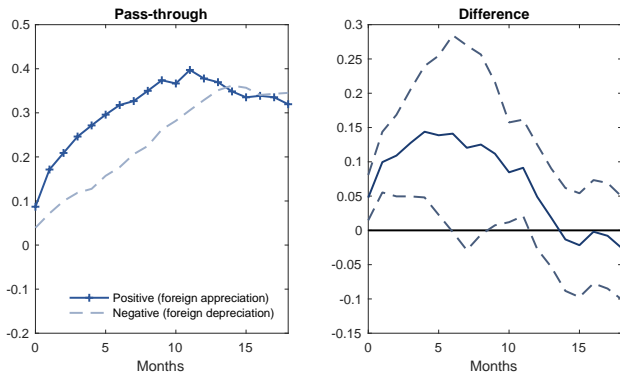
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- ▶ Country  $\times$  stratum dummies, monthly time dummies, foreign CPI are controls.
- ▶ The impulse response of a price at horizon  $h$  after an exchange rate shock is simply  $\sum_{k=0}^h \beta_k^+$  or  $\sum_{k=0}^h \beta_k^-$

## Asymmetry results

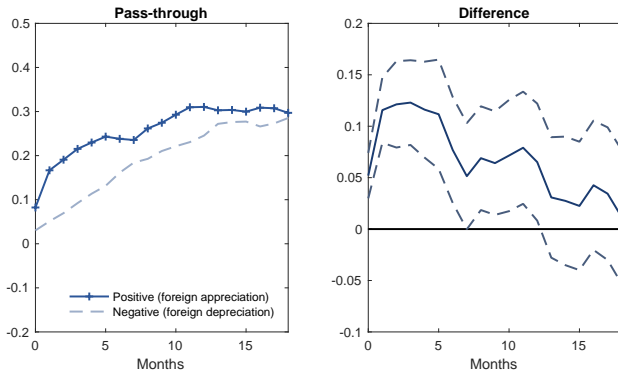
- ▶ Across all goods, pass-through for foreign appreciations (+) is faster than for foreign depreciations (-), but the pass-through at 18 months is the same:



95% confidence bands plotted for difference.

## Asymmetry results (cont.)

- ▶ Across sectors for goods that Rauch (1999) identifies as differentiated goods, asymmetries are more pronounced:



95% confidence bands plotted for difference.



## Issue 1: Nominal rigidities

- ▶ Differences in the speed of pass-through suggest that they may be caused by differences in price adjustment.
- ▶ If foreign appreciations cause foreign firms to adjust prices faster, then one might expect pass-through to be faster.



## Controlling for price stickiness: MRPT

- ▶ Following Gopinath, et al. (2010), we can eliminate the effect of nominal price rigidities on pass-through estimates by focusing on what they call medium-run pass-through (MRPT), where subscript  $c$  denotes the cumulative change between time  $t$  and the last price change  $t - k$  for good  $i$  from country  $j$ :

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- ▶ Unfortunately, this makes time dummies less natural, and so we include other explanatory variables  $\Delta Z$  like the U.S. CPI and a measure of global non-oil commodity prices. Country/strata fixed effects are still included.



## MRPT results

Table 1: Pass-through conditional on a price change

	Depr	Appr	Diff	N	R <sup>2</sup>
All goods	0.210***	0.178***	-0.032	138,877	0.08
Differentiated (strict)	0.154***	0.267***	0.113**	41,632	0.12
Differentiated (loose)	0.175***	0.214***	0.039	62,545	0.12
<i>By end-use:</i>					
0. Foods, feeds, bev.	0.130***	0.065*	-0.065	24,026	0.03
1. Industrial supplies	0.320***	0.134**	-0.186	47,994	0.08
2. Capital goods ex auto	0.249***	0.145**	-0.104	13,200	0.19
3. Automotive products	0.133	0.369***	0.237**	1,157	0.22
4. Consumer goods	0.113***	0.225***	0.112	13,172	0.16

Note: \*\*\* denotes significance at the 99% level, \*\* at the 95% level, and \* at the 90% level, with standard errors clustered at the sector (strata) level.

- ▶ Conditioning on a price change, some evidence that pass-through is still asymmetric, but only for differentiated goods.

## Issue 2: Selection

- ▶ Foreign appreciations might also induce products to exit the market, as the desired dollar price rises and the foreign firm stops selling it rather than letting the price increase through.
- ▶ This would bias the foreign appreciation pass-through towards zero, potentially understating the true asymmetry of pass-through.



# Searching for Selection

- ▶ We look for evidence of this selection effect by estimating a linear probability model of exit:

$$\text{prob}(\text{exit}_{i,j,t}) = \sum_{k=0}^{18} \{ \beta_k^+ \Delta e_{j,t-k}^+ + \beta_k^- \Delta e_{j,t-k}^- \} + [\dots] + \epsilon_{i,j,t}$$



# Searching for Selection

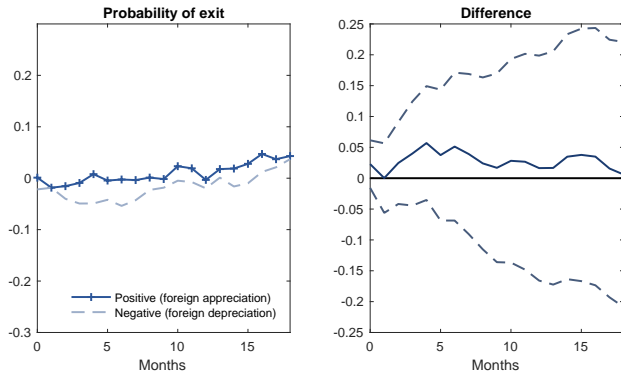
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- ▶ We take into account the reason for item exit as listed in the BLS survey.



## Selection results: Selected exits



95% confidence bands plotted for difference.

- ▶ Focusing on exits likely to be endogenous, there is no evidence of selection driving the asymmetric pass-through results.



## Non-linearities in pass-through

- ▶ Many theories of asymmetric pass-through also imply non-linear pass-through: larger shocks may have higher pass-through than smaller shocks.

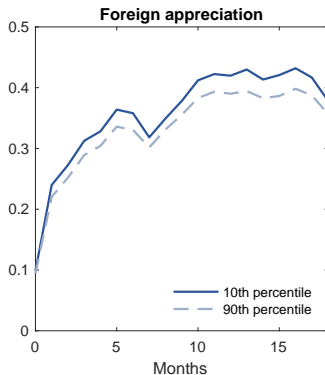


## Non-linearities in pass-through

- ▶ Many theories of asymmetric pass-through also imply non-linear pass-through: larger shocks may have higher pass-through than smaller shocks.
- ▶ Adding squared and cubed terms to our augmented pass-through regression allows for differential pass-through depending on the size of the shock:

$$\begin{aligned}\Delta p_{i,j,t} = & \sum_{k=0}^h \{ \beta_k^+ (\Delta e^+)_{j,t-k} + \gamma_k^+ (\Delta e^+)_{j,t-k}^2 + \delta_k^+ (\Delta e^+)_{j,t-k}^3 \} \\ & + \sum_{k=0}^h \{ \beta_k^- (\Delta e^-)_{j,t-k} + \gamma_k^- (\Delta e^-)_{j,t-k}^2 + \delta_k^- (\Delta e^-)_{j,t-k}^3 \} \\ & + \delta P_{j,t} + \alpha_t + s_t + \epsilon_{i,j,t}\end{aligned}$$

## Non-linearity results



- ▶ Large exchange rate changes pass through a bit slower than smaller ones, but any difference is small.

# Theory

- ▶ At the sectoral level, product entry/exit (selection) can cause asymmetries (Nakamura and Steinsson 2012)
- ▶ Product-level sources of asymmetric pass-through (Ritz 2015):
  - ▶ Demand: habit formation, demand curves with non-constant curvature
  - ▶ Supply: non-constant marginal costs, capacity constraints
- ▶ Many models used in macro and trade imply symmetric or near-symmetric pass-through.



# Theory

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- ▶ We propose a simple partial-equilibrium model of sticky prices and convex costs to raising output.
- ▶ Firms face monopolistic competition, idiosyncratic productivity shocks  $a$ , and aggregate real exchange rate shocks  $e$ . With menu cost  $\kappa$ , they are allowed to change their price, maximizing their discounted value.

$$V(p, a, e) = \max\{V^A(p, a, e), V^N(p, a, e)\},$$

$V^A$  is the value of the firm if it adjusts its price:

$$V^A(p, a, e) = \max_{p'} \Pi(p', a, e) - \kappa + \beta E[V(p', a', e')],$$

$V^N$  is the value of the firm if it does not adjust its price:

$$V^N(p, a, e) = \Pi(p, a, e) + \beta E[V(p, a', e')],$$

$\Pi(p, a, e)$  is the flow profit of the firm.



## Theory

- ▶ Flow profit has two key elements:

$$\begin{aligned}\Pi(p', a, e) = & \frac{p'q(p')}{e} - \frac{\bar{c}}{a}q(p') \\ & - \mathbb{I}[q(p') > q(p)]\phi\bar{c}(q(p') - q(p))^2\end{aligned}$$



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1.  $q(p)$  is a Klenow-Willis (2006) demand curve, inducing firms to want to price closer to the sectoral price  $\bar{P}$ , generating incomplete pass-through, even in the long run:

$$q(p) = \left(1 - \epsilon \ln \frac{p}{\bar{P}}\right)^{\frac{\theta}{\epsilon}}.$$

This generates an effective demand elasticity:

$$\tilde{\theta} = \frac{\theta}{1 - \epsilon \ln \left(\frac{p}{\bar{P}}\right)}.$$





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2. Convex adjustment costs  $\phi$  if increasing quantity produced ( $q(p') > q(p)$ ).

# Parameterization

Table 2: External Parameterization

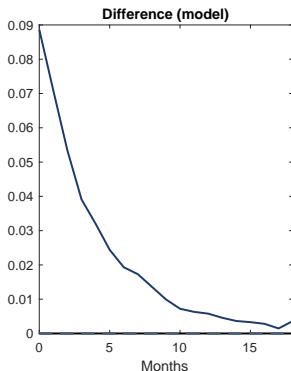
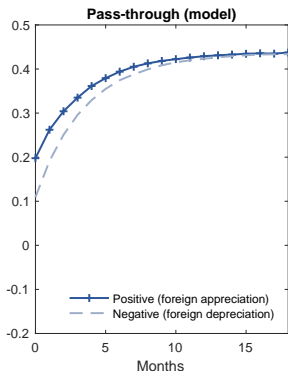
	Value	Description
$\theta$	4	Elasticity of substitution
$\beta$	$0.94^{\frac{1}{12}}$	Discount factor
$\rho_a$	0.96	AR(1) coefficient for productivity
$\rho_e$	0.99	AR(1) coefficient for exchange rates
$\sigma_e$	0.025	Standard deviation for exchange rates

Table 3: Parameterization via Indirect Inference

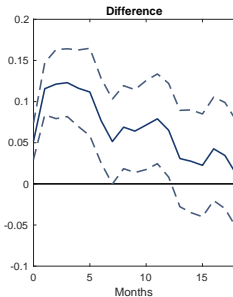
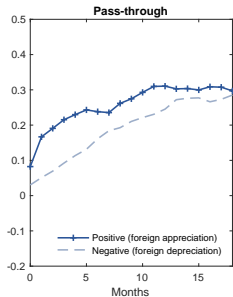
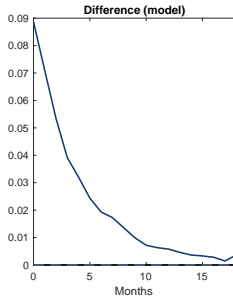
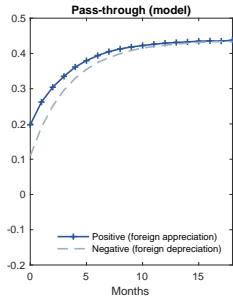
	Value	Description	Targeted Moment	Target	Model
$\epsilon$	3.63	Super-elasticity	Long-run PT	0.4	0.43
$\kappa$	0.025	Menu Cost	Frequency of $\Delta p$	0.09	0.076
$\phi$	2.80	Convex adj. cost	PT asym. (max)	0.10	0.087
$\sigma_a$	0.047	std(productivity)	Median $ \Delta p $	0.08	0.026

# Results

- ▶ Numerical exercise to see if these mechanisms can generate similar pass-through patterns:

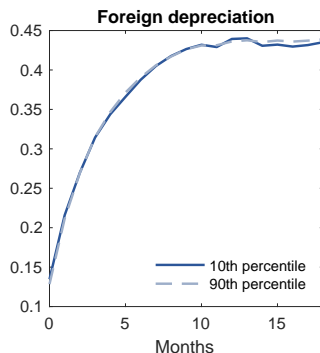
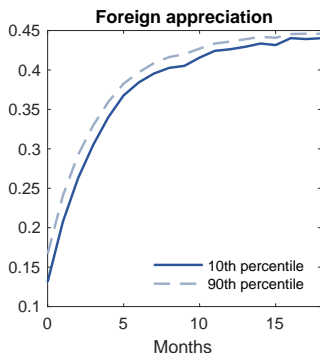


# Comparison with data

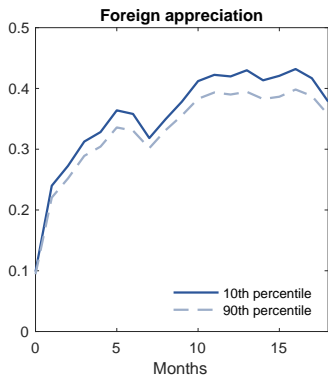
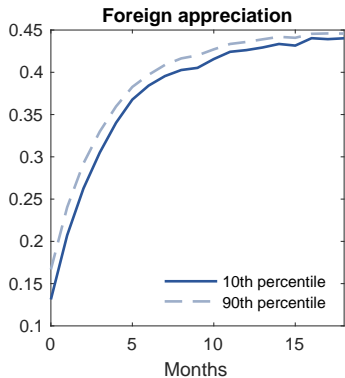


# Results

- ▶ Numerical exercise to see if these mechanisms can generate similar pass-through patterns when accounting for non-linearities:



# Comparison with data



# Conclusion

- ▶ Foreign appreciations pass through faster than depreciations.
- ▶ Asymmetries are still present conditional on a price change.
- ▶ Selection does not appear to be strongly asymmetric.
- ▶ Non-linearities are negligible.
- ▶ A theory of sticky prices with strategic complementarities and capacity constraints is generally capable of matching these facts.







# Existing literature on asymmetries and non-linearities

- ▶ Pollard and Coughlin (2004)
  - ▶ Industry-level study
  - ▶ Existence and size of asymmetry varies across industries.
  - ▶ Large movements in exchange rates are associated with higher pass-through.
- ▶ Bussiere (2013)
  - ▶ Aggregate-level study of G7 countries, including the U.S.
  - ▶ Non-linearities vary from country to country.
  - ▶ Evidence is stronger for asymmetries than for non-linearities.



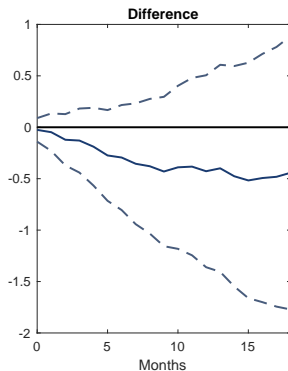
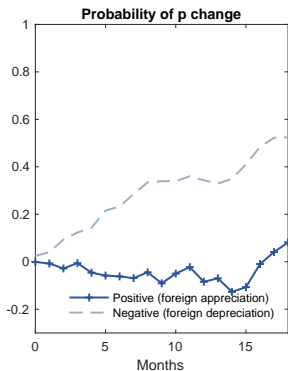
# Existing literature on asymmetries and non-linearities

- ▶ Razafindrabe (2017)
  - ▶ French firm-level data
  - ▶ Depreciations pass through faster than appreciations
  - ▶ Largely the result of price stickiness

[Back](#)



# Price changes



95% confidence bands plotted for difference.

Back