Asymmetries and Non-Linearities in Exchange Rate Pass-through

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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?

Preview of results

- We show that this pass-through is asymmetric: foreign appreciations tend to pass through faster.
  - This result is unlikely to stem from a selection effect causing product exit, but price stickiness may be important in some cases.
- 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.
- Using trade value data, implied trade quantity response is stronger for foreign depreciations after 1 year.

Existing literature

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

$$\Delta p_t = \alpha + \beta \Delta e_t + \delta \Delta c_t + \epsilon_t \tag{1}$$

  - e defined as dollar per foreign currency.
- What has been established in the literature?
  - 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).
    - Pass-through is low even conditional on a price change. (Gopinath and Itskhoki, 2010)
  - Pass-through has been declining secularly since the 70s. (Marazzi, 2005)

More literature

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

- Probability proportionate to size sampling at the reporter/item level
- Reported prices
  - Raw data includes list prices, transaction prices, estimated prices, including intrafirm prices.
- Net prices
  - Reflect dollar-denominated transaction prices, by making any necessary adjustments to reported prices.
  - Missing prices are estimated using various methods.
- Excluded from this study - estimated, non-usable, intrafirm, services, petroleum, dollar pegs.

Asymmetries in pass-through

- We augment a standard pass-through regression to separately respond to bilateral exchange rate appreciations and depreciations. For product i in country j at time t (monthly), we estimate:

$$\Delta p_{i,j,t} = \sum_{k=0}^{18} \{\beta_k^+ \Delta e_{j,t-k}^+ + \beta_k^- \Delta e_{j,t-k}^-\} + [...] + \epsilon_{i,j,t} \quad (2)$$

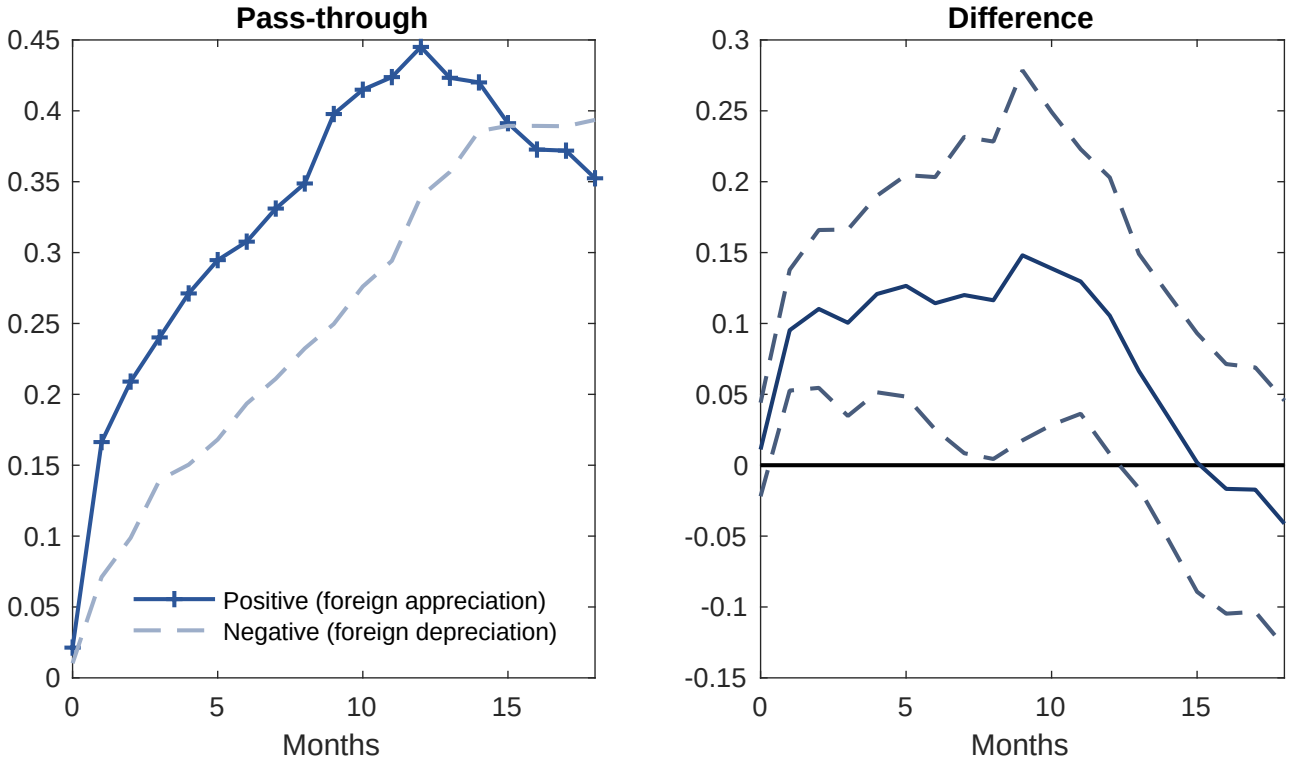
$$\Delta e_{j,t}^+ \begin{cases} \Delta e & \Delta e > 0 \\ 0 & \Delta e \leq 0 \end{cases}$$

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

- Country x 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

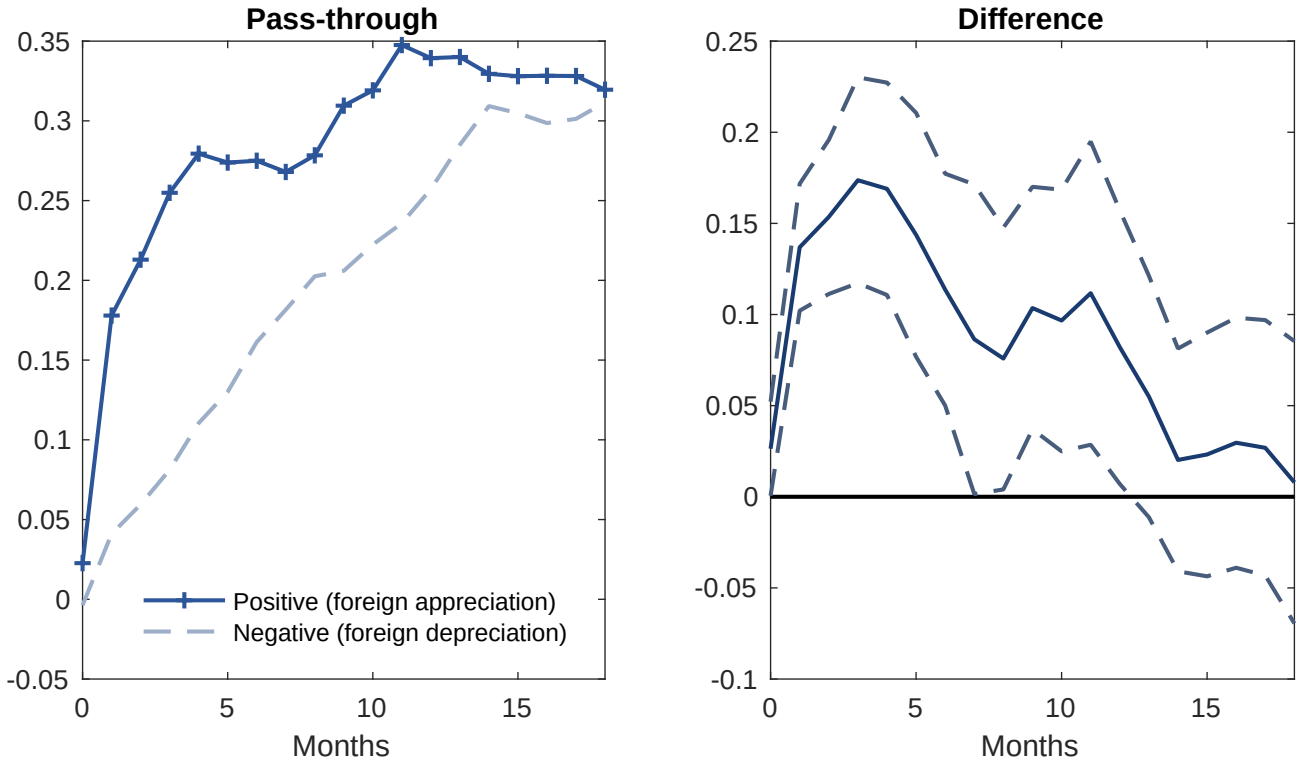
- Across all goods, pass-through for foreign appreciations (+) is faster than for foreign depreciations (−), but the pass-through at 18 months is the same:



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, the pass-through would 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:

$$\Delta p_{i,j,c} = \beta^{+}\Delta e^{+}_{j,c} + \beta^{-}\Delta e^{-}_{j,c} + \Delta Z_c + \epsilon_{i,t} \tag{3}$$

  - Unfortunately, this makes time dummies fairly unnatural, and so we include other explanatory variables ΔZ like the U.S. CPI and a measure of global non-oil commodity prices. Country/strata fixed effects are still included.

MRPT results

	Depreciation	Appreciation	Difference	N	R^2
All goods	0.228***	0.247***	0.019	133,928	0.076
Differentiated (stricter def)	0.172***	0.315***	0.143***	38,370	0.119
Differentiated (looser def)	0.183***	0.269***	0.085**	57,958	0.116
By end-use:					
0. Foods, feeds, bev.	0.128***	0.167***	0.039	23,826	0.028
1. Industrial supplies	0.370***	0.178**	-0.192***	47,256	0.072
2. Capital goods ex auto	0.265***	0.220***	-0.045	12,344	0.196
3. Automotive products	0.116	0.408***	0.292*	1,085	0.218
4. Consumer goods	0.098***	0.239**	0.141*	11,392	0.150

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

Probability of changing price

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

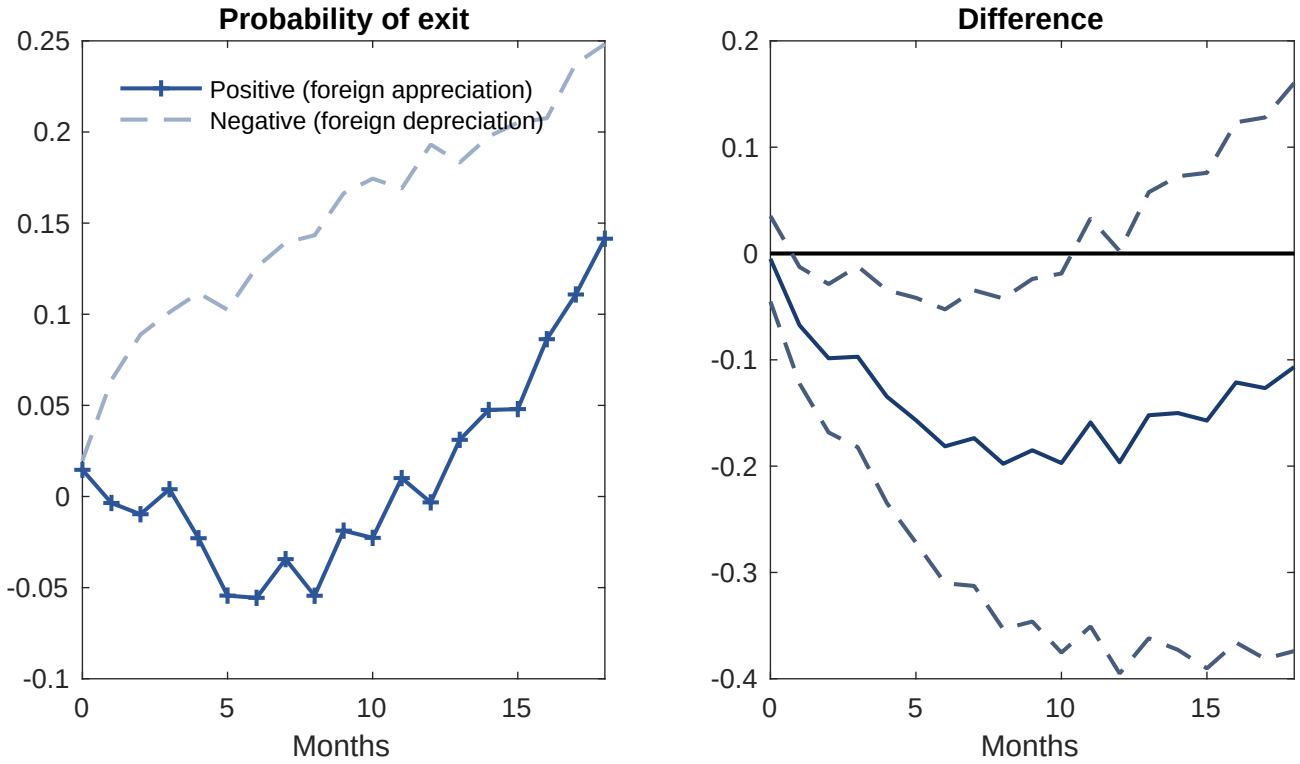
- We look for evidence of this selection effect by estimating a linear probability model of exit:

$$prob(exit_{i,j,t}) = \sum_{k=0}^{18} \{\beta_k^+ \Delta e_{j,t-k}^+ + \beta_k^- \Delta e_{j,t-k}^-\} + [...] + \epsilon_{i,j,t} \quad (4)$$

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

Selection results: Selected exits

Figure 1: 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.
- Adding square and cube terms to a standard pass-through regression allows for differential pass-through depending on the size of the shock.

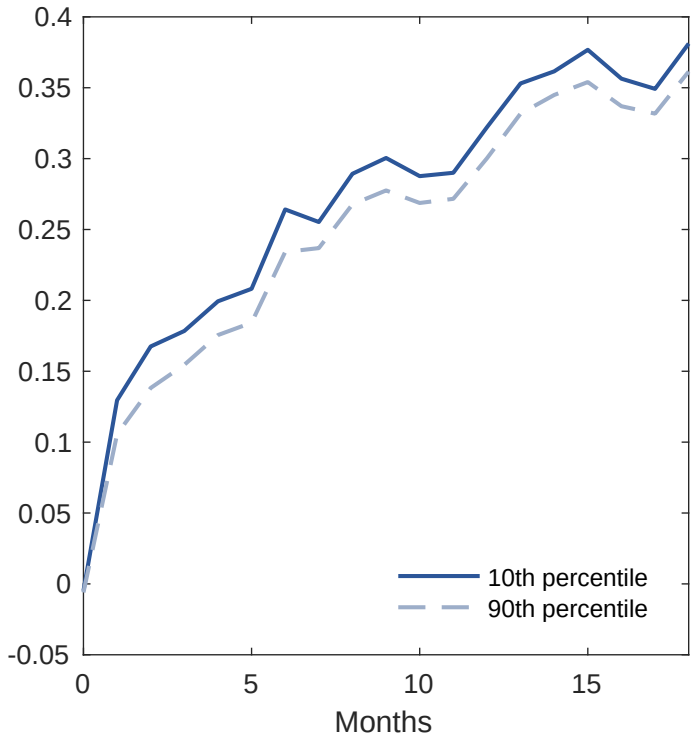
$$\Delta p_{i,j,t} = \sum_{k=0}^{h} \{\beta_k^+ (\Delta e^+)_{j,t-k} + \gamma_k^+ (\Delta e^+)_{j,t-k}^2 + \delta_k^+ (\Delta e^+)_{j,t-k}^3\} \tag{5}$$

$$+ \sum_{k=0}^{h} \{\beta_k^- (\Delta e^-)_{j,t-k} + \gamma_k^- (\Delta e^-)_{j,t-k}^2 + \delta_k^- (\Delta e^-)_{j,t-k}^3 \tag{6}$$

$$+ \delta P_{j,t} + \alpha_t + s_t + \epsilon_{i,j,t} \tag{7}$$

Non-linearity results

Figure 2: Non-linearity in pass-through



95% confidence bands plotted for difference.

- Large exchange rate changes pass through a bit faster than smaller ones, but any difference is not statistically significant.

Quantity responses

- We can take this a step further and use sectoral data on trade values to back out an implied trade quantity response.
- Start with estimating the same basic relationship but replacing prices with trade values on the LHS:

$$\Delta pq_{i,j,t} = \sum_{k=0}^{6} \{\beta_k^+ \Delta e_{j,t-k}^+ + \beta_k^- \Delta e_{j,t-k}^-\} + [...] + \epsilon_{i,j,t} \quad (8)$$

- Then, because the estimating relationship is log-linear, subtract the trade price response from the trade value response to obtain the implied trade quantity response.

Import value response

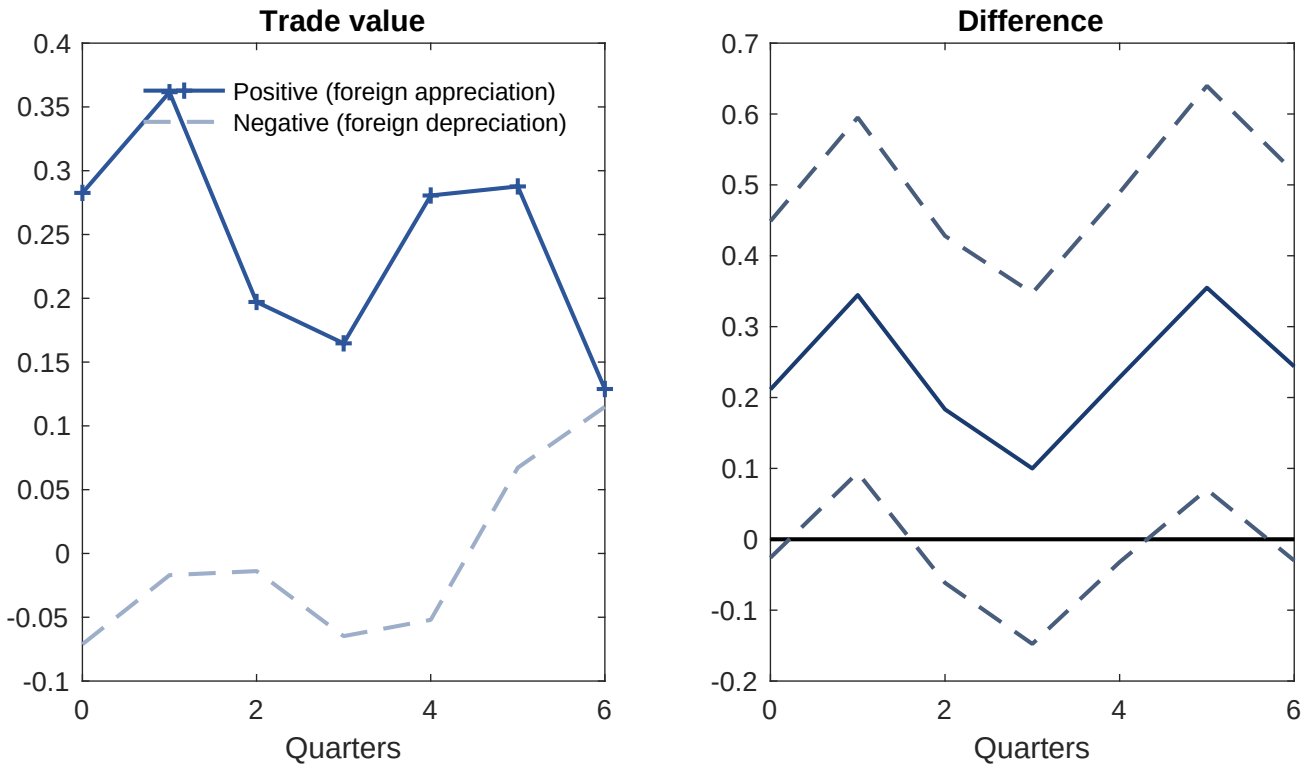


Figure 3: Import value responses for foreign currency depreciations (-) and appreciations (+) using Rauch (1999) differentiated goods

Implied quantity response

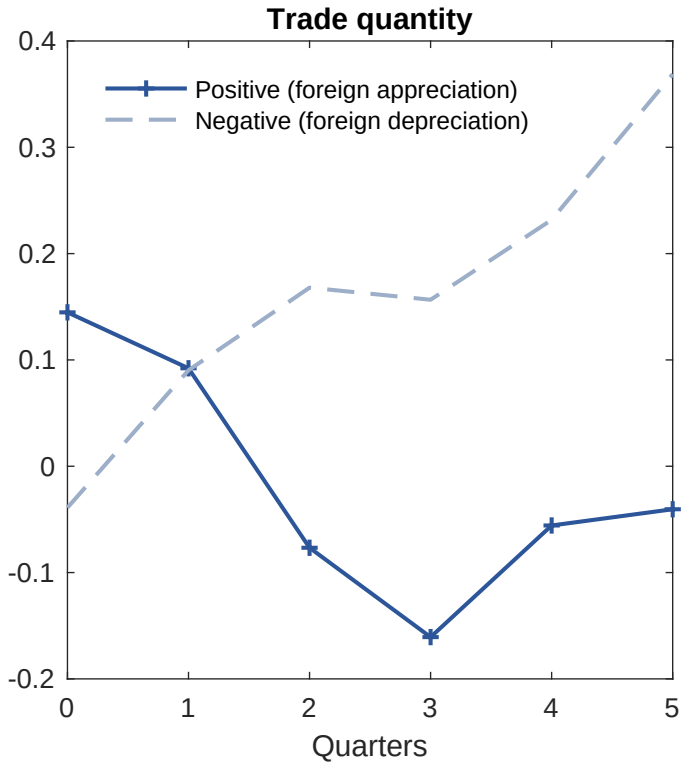


Figure 4: Implied import quantity responses for foreign currency depreciations (-) and appreciations (+) using Rauch (1999) differentiated goods

Conclusion

- Foreign appreciations pass through faster than depreciations.
- Asymmetries are still present conditional on a price change.
- Non-linearities are negligible.
- Selection does not appear to be strongly asymmetric.
- Implied trade quantity responses are symmetric and zero in the short run, but foreign depreciations have a stronger response after 1 year.

Theory

- Flow profit has two key elements:

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

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

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

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

Parameterization

Parameter	Value	Description
θ	4	Elasticity of substitution
ϵ	3	Super-elasticity
α	0.5	Probability of price change
ϕ	10	Convex adjustment cost
β	$0.94^{\frac{1}{12}}$	Discount factor
ρ_a	0.96	AR(1) coefficient for productivity
σ_a	0.001	Shut down
ρ_e	0.99	AR(1) coefficient for exchange rates
σ_e	0.03	Standard deviation for exchange rates

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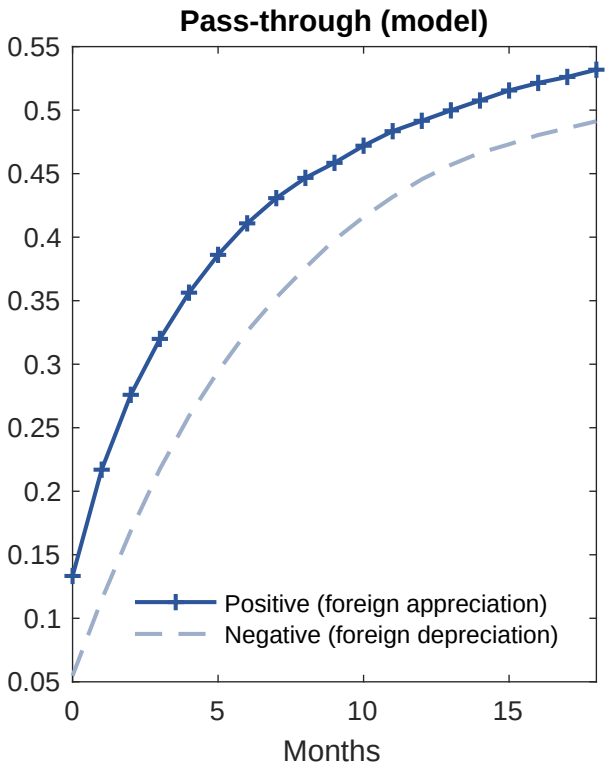
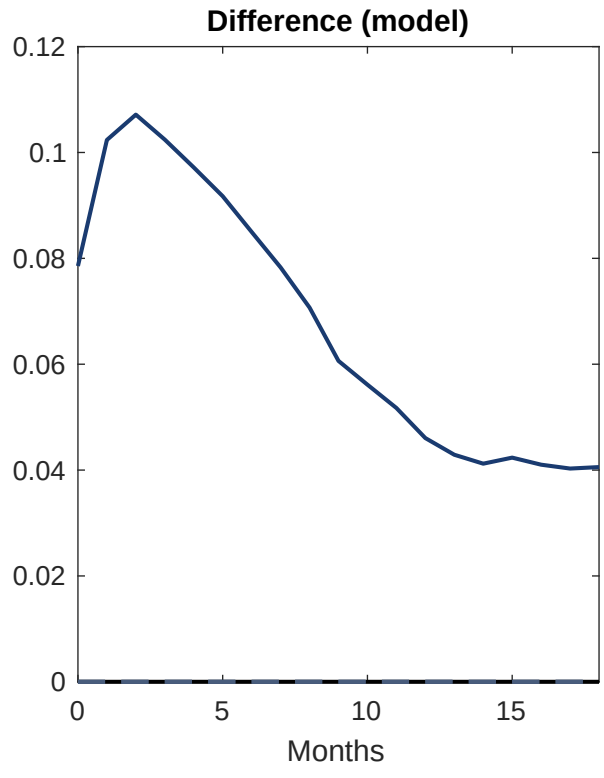
Preliminary results

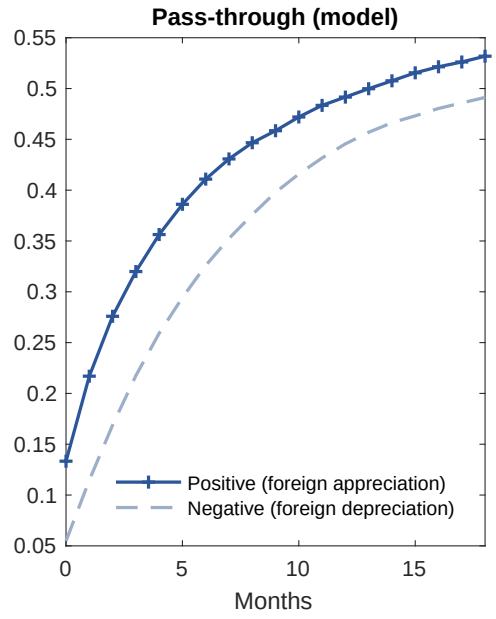
- Numerical exercise to see if these mechanisms can generate similar pass-through patterns

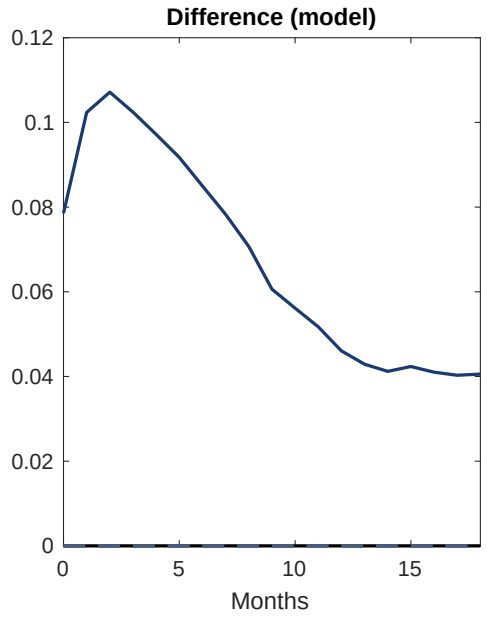


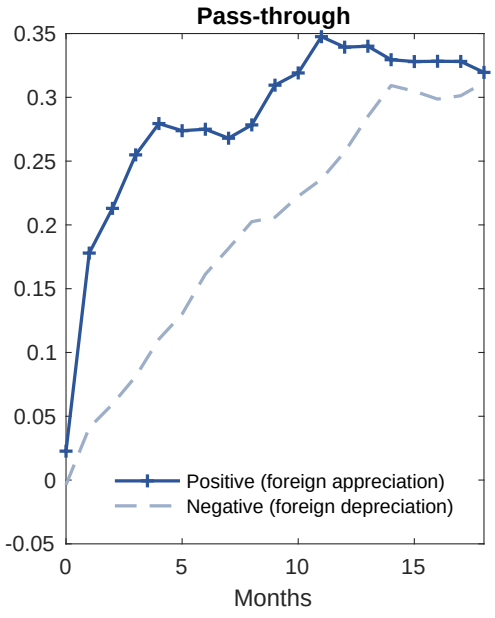


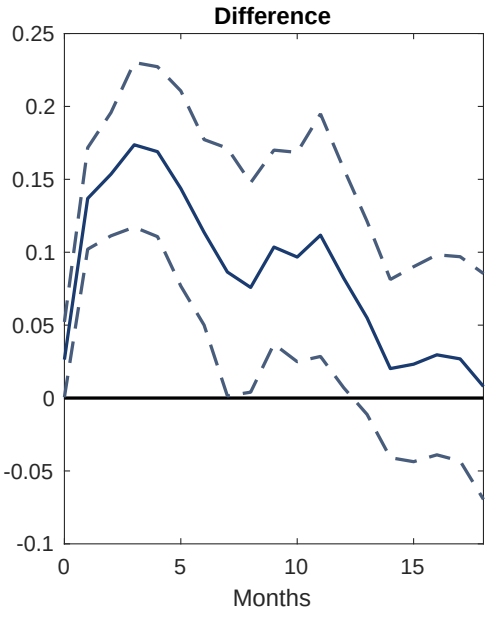
Parameters

Preliminary results









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

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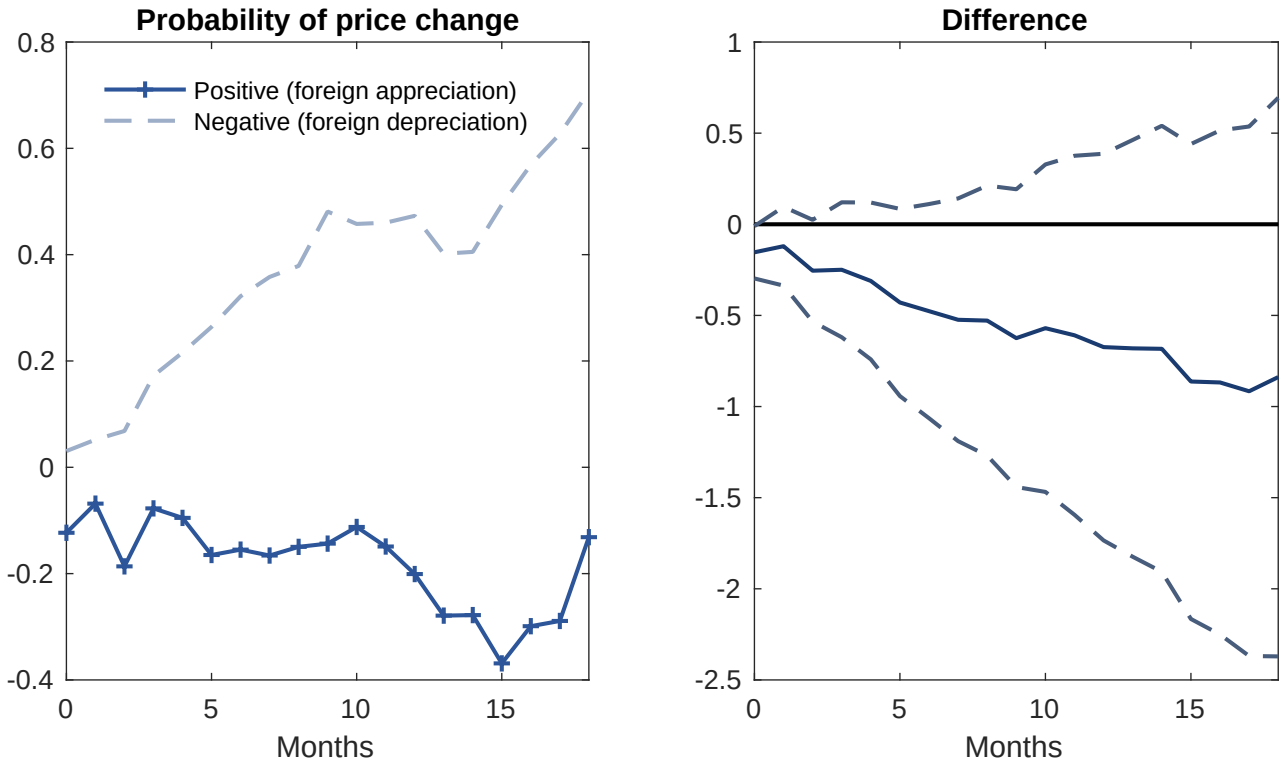
Price changes



95% confidence bands plotted for difference.

- Exchange rate appreciations significantly raise the probability of a price change, while appreciations do not affect the probability.

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