

# Exchange Rates and Prices: Evidence from the 2015 Swiss Franc Appreciation

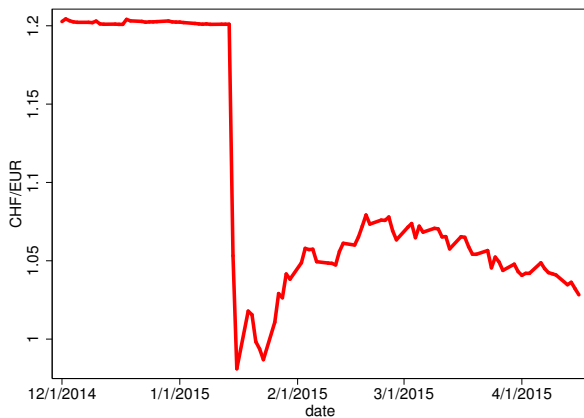
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The views expressed in this paper are those of the authors and not necessarily those of the BIS.

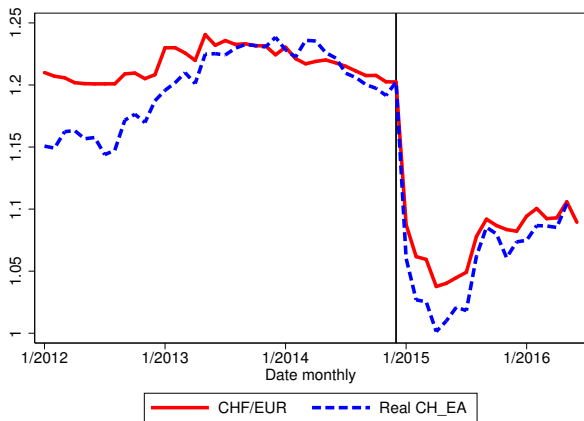
# CHF/EUR Appreciation January 15 2015



## CHF/EUR Appreciation January 2015: Unique Setting

- Follows 3-years of stable nominal and real CHF-Euro
- Aggregate economy stable before and after [▶ macrodata](#)
- SNBs abandoning of floor induced by prospects of QE in EA
  - price dynamics driven by K inflows or CHF/Euro appreciation?
  - SNB interventions did not result in  $\uparrow$  domestic credit
  - 2012-13 K inflows not followed by RER appreciation [▶ RER](#)

## CHF/EUR Appreciation: Nominal and real



## Case study of 2015 CHF/EUR appreciation

Use homescan data on retail prices and expenditures, as well as border prices by invoicing currency to study:

- Aggregate pass through and its decomposition
- Cross-sectional impact of border prices and currency of invoicing on import retail prices, Swiss-produced retail prices, and expenditure switching (allocative effects)
- Intensive and extensive margin of price adjustment along with interpretation in a Ss pricing model

## Related papers

**Large ER shocks:** Burstein et. al. (2005), Alessandria et. al. (2010), Gopinath-Neiman (2013), Cravino-Levchenko (2016), Rodnyansky (2017)

**ERPT in border prices:** Gopinath-Rigobon (2008), Goldberg-Hellerstein (2013), Nakamura-Zerom (2010)

**Border prices and retail prices:** Berger et al. (2012)

**Invoicing and ERPT:** Gopinath-Itskhoki (2010) Gopinath et. al. (2010), Gopinath (2016), Fitzgerald-Haller (2014), Cravino (2017), Devereux et. al. (2017)

**Pricing complementarities:** Auer-Schoenle (16), Amiti et al. (16)

**Evidence on price-setting behavior:** Bils-Klenow (2004), Klenow-Kryvstov (2008), Nakamura-Steinsson (2008), Midrigan (2011), Alvarez-Lippi (2014), Karadi-Reiff (2014)

**CHF floor and appreciation:** Bonadio et al. (2016), Amador et al. (2017), Jermann (2017)

Compared to other “large shock” papers: exchange rate shock in a stable economy, document PT border & retail import prices, role of invoicing beyond border prices

### Detailed data on non-durable consumer goods purchases

- 3,187 representative households scan their supermarket and drugstore purchases
- record unique barcode (EAN) of a product, purchase price, quantity purchased, retailer, product category, and purchase date
- add information on production location using [www.codecheck.info](http://www.codecheck.info) and label in retailers' websites
- focus on subsample of 3,680 continuously observed goods (around 4 mill. transactions)

## Border prices

- border prices underlying the calculation of the official IPI
- 11,638 products, but we focus on 642 matched to AC Nielsen product categories (like “apple juice”)
- mostly quarterly survey
- information on currency of invoicing (2/3 CHF, 30% EUR, 3% USD), stable over time
- match border prices and invoicing information to the retail data, at the border product category level (44 categories)



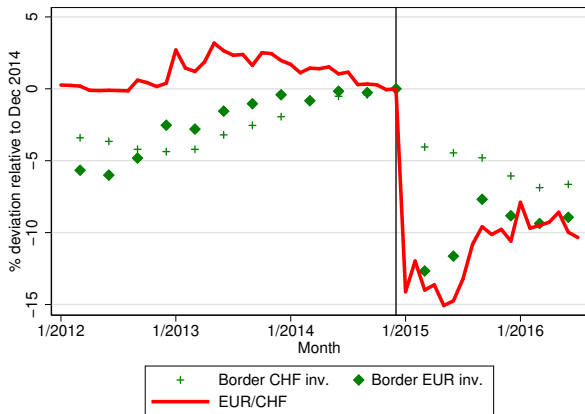
## Consumer and border price data overview

	Sample for price analysis 01/2012–05/2016			Sample for expenditure analysis 01/2013–05/2014 and 01/2015–05/2016		
	(1) Transactions	(2) Exp. Share	(3) Products	(4) Transactions	(5) Exp. Share	(6) Products
All products	4,119,241	100	3,680	2,903,082	100	7,591
Swiss-produced	3,199,428	76	2,575	997,039	73	4,195
Imports	919,813	24	1,105	344,732	27	3,396

	All products		Consumer goods		Matched products	
	(1) Observ.	(2) Products	(3) Observ.	(4) Products	(5) Observ.	(6) Products
All products	15,242	3,948	4,767	1,238	2,499	642
CHF invoiced	9,004	2,361	3,144	822	1,690	434
EUR invoiced	5,738	1,475	1,503	385	744	190
Other invoiced	500	126	120	31	65	18

- ① Aggregate prices and sources of incomplete pass-through
- ② Cross-section: border & retail prices, expenditures, invoicing
  - Pass-through of border prices into retail import prices
  - Pass-through of retail import prices to retail domestic prices
  - Expenditure switching to imports
- ③ Margins of price adjustment
  - Margins of price adjustment in retail prices
  - Margins of price adjustment in a Ss pricing model

## Change in border prices by invoicing

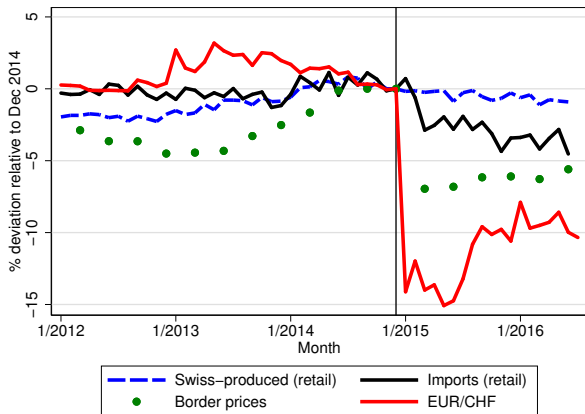


## Pass-through into border prices, cross-sectional estimates

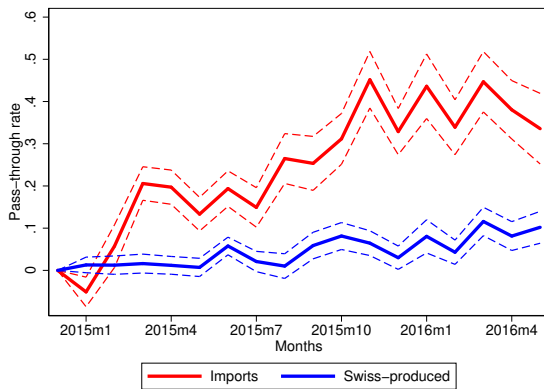
	Unconditional				Conditional			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
CHF invoiced	0.289*** [0.032]	0.302*** [0.037]	0.500*** [0.056]	0.572*** [0.072]	0.537*** [0.038]	0.742*** [0.057]	0.782*** [0.073]	0.886*** [0.073]
Observations	434	434	434	388	309	334	311	321

	Unconditional				Conditional			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
EUR invoiced	0.905*** [0.066]	0.789*** [0.089]	0.801*** [0.151]	0.789*** [0.132]	0.780*** [0.117]	0.834*** [0.187]	0.910*** [0.149]	1.034*** [0.140]
Observations	190	190	190	176	79	93	99	114

## Changes in retail prices



## Pass-through into retail prices



## Sources of incomplete pass-through

$$\Delta p_{retall} = ImpShare \times \Delta p_{retimp} + (1 - ImpShare) \times \Delta p_{retdom}$$

$$\Delta p_{retimp} = \Delta \mu_{retimp} + (1 - s_d) \times [s_{schf} \times \Delta p_{boreur} + (1 - s_{schf}) \times \Delta p_{borchf}] + s_d \times \Delta p_{ppi}$$

	Price changes		Pass-through	
	1Q	2Q	1Q	2Q
1) CHF-EUR	-14.0	-14.7		
2) Border prices, EUR invoiced	-12.7	-11.6	90.5	78.9
3) Border prices, all	-7.0	-6.8	49.7	46.2
4) Border prices + distribution	-4.2	-4.2	29.9	28.7
5) Retail prices, imports	-2.9	-2.8	20.6	19.1
6) Retail prices, all	-0.9	-1.3	6.2	9.0

- Gap between (1)-(3)  $\approx$  50% of the gap between (1)-(6)
- Gap between (3)-(5)  $\approx$  35% of the gap between (1)-(6)
- Gap between (5)-(6) small (large) in absolute (relative) terms

## Counterfactual scenarios

$$\Delta p_{retall} = ImpShare \times \Delta p_{retimp} + (1 - ImpShare) \times \Delta p_{retdom}$$

$$\Delta p_{retimp} = \Delta \mu_{retimp} + (1 - s_d) \times [s_{chf} \times \Delta p_{boreur} + (1 - s_{chf}) \times \Delta p_{borchf}] + s_d \times \Delta p_{ppi}$$

	Imports		All	
	1Q	2Q	1Q	2Q
0) Actual	-2.9	-2.8	-0.9	-1.3
1) No CHF invoiced ( $s_{CHF} = 0$ )	-5.7	-5.2	-1.5	-1.9
2) Only CHF invoiced ( $s_{CHF} = 1$ )	-1.4	-1.6	-0.5	-1.1
3) Constant retail markup, $\mu_{ret,imp}$	-4.2	-4.2	-1.2	-1.7
4) No distribution costs ( $s_d = 0$ )	-5.6	-5.4	-1.5	-1.9
5) Only imports, no distr. costs ( $s_m = 1, s_d = 0$ )	-5.6	-5.4	-5.6	-5.4



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## Pass-through of border prices to retail import prices

$$\Delta_k p_i^{retimp} = \alpha + \beta \Delta_k p_{g(i)}^{borimp} + \varepsilon_i$$

	2Q			
	(1)	(2)	(3)	(4)
	OLS	red. form	FS	2SLS
$\Delta p^{borimp}$	0.426** [0.176]			0.390*** [0.147]
<i>CHFShare</i>		0.042** [0.017]	0.107*** [0.018]	
Observations	1077	1077	1077	1077
F first stage				33.5
p-value				0.000

2SLS exclusion restriction: other drivers of retail prices after Dec. 2014 that may be correlated with changes in border prices must be uncorrelated with Dec. 2014 invoicing shares across product categories

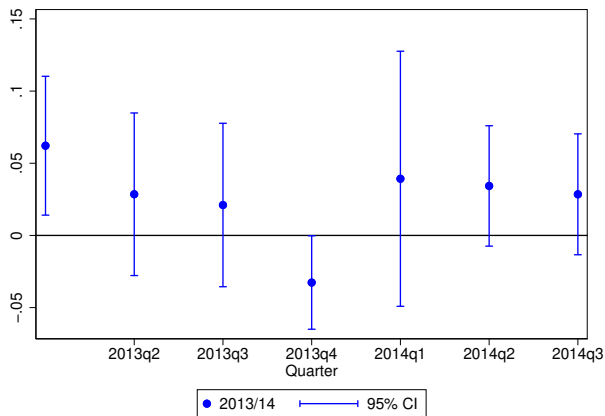
# Pass-through of border prices to retail import prices

	1Q				2Q			
	(1) OLS	(2) red. form	(3) FS	(4) 2SLS	(5) OLS	(6) red. form	(7) FS	(8) 2SLS
$\Delta p^{borimp}$	0.312** [0.146]			0.383** [0.168]	0.426** [0.176]			0.390*** [0.147]
<i>CHFShare</i>		0.038** [0.018]	0.099*** [0.020]			0.042** [0.017]	0.107*** [0.018]	
Observations	1077	1077	1077	1077	1077	1077	1077	1077
F first stage				24.9				33.5
p-value				0.000				0.000

	3Q				4Q			
	(1) OLS	(2) red. form	(3) FS	(4) 2SLS	(5) OLS	(6) red. form	(7) FS	(8) 2SLS
$\Delta p^{borimp}$	0.309 [0.283]			0.918** [0.416]	0.204* [0.110]			0.574* [0.296]
<i>CHFShare</i>		0.068** [0.025]	0.074*** [0.025]			0.038* [0.022]	0.066** [0.030]	
Observations	1077	1077	1077	1077	1077	1077	1077	1077
F first stage				8.4				4.7
p-value				0.008				0.040

## Pretrends pass-through by invoicing currency to retail import prices



## Pass-through of retail import prices to retail domestic prices

$$\Delta_k p_i^{retdom} = \alpha + \beta ImpShare_{g(i)} \times \Delta_k p_{g(i)}^{retimp} + \varepsilon_i$$

	2Q			
	(5)	(6)	(7)	(8)
	OLS	red. form	red. form	2SLS
$\Delta p^{retimp} \times ImpShare$	1.457*** [0.273]			1.360*** [0.332]
$(1 - CHFShare) \times ImpShare$		-0.129** [0.047]	-0.119** [0.046]	
$ImpShare$			-0.007 [0.015]	
Observations	2269	2269	2269	2269
F first stage				24.5
p-value				0.000

2SLS exclusion restriction: Dec. 2014 CHF-invoicing uncorrelated with changes after Dec. 2014 in costs of Swiss producers across categories.

# Pass-through of retail import prices to domestic prices

	1Q				2Q			
	(1) OLS	(2) red. form	(3) red. form	(4) 2SLS	(5) OLS	(6) red. form	(7) red. form	(8) 2SLS
$\Delta p^{retimp} \times ImpShare$	0.448*** [0.139]			0.738 [0.538]	1.457*** [0.273]			1.360*** [0.332]
$(1 - CHFShare) \times ImpShare$		-0.054 [0.051]	-0.016 [0.058]			-0.129** [0.047]	-0.119** [0.046]	
<i>ImpShare</i>			-0.025 [0.019]				-0.007 [0.015]	
Observations	2262	2262	2262	2262	2269	2269	2269	2269
F first stage				10.8				24.5
p-value				0.003				0.000

	3Q				4Q			
	(1) OLS	(2) red. form	(3) red. form	(4) 2SLS	(5) OLS	(6) red. form	(7) red. form	(8) 2SLS
$\Delta p^{retimp} \times ImpShare$	0.839*** [0.258]			1.575*** [0.398]	0.465* [0.249]			1.476*** [0.614]
$(1 - CHFShare) \times ImpShare$		-0.156*** [0.048]	-0.197*** [0.044]			-0.115** [0.045]	-0.167*** [0.040]	
<i>ImpShare</i>			0.028** [0.013]				0.035** [0.017]	
Observations	2267	2267	2267	2267	2272	2272	2272	2272
F first stage				11.4				7.1
p-value				0.002				0.014

## Interpreting RF estimates in simple model of pricing complementarities

Product  $i$  in product group  $g$ :

$$\Delta p_{ig} = \frac{1}{1 + \Gamma_{ig}} \Delta c_{ig} + \frac{\Gamma_{ig}}{1 + \Gamma_{ig}} \Delta p_g$$

Assuming all domestic firms in  $g$  have common  $\Gamma_g^{dom}$ :

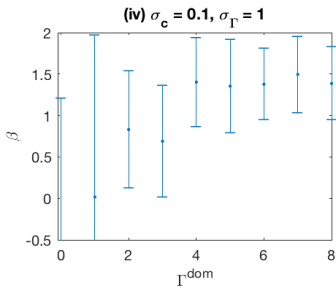
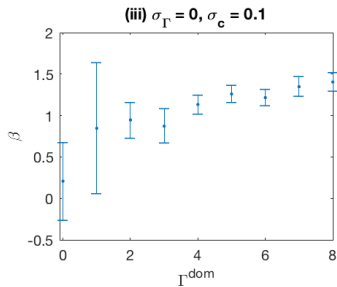
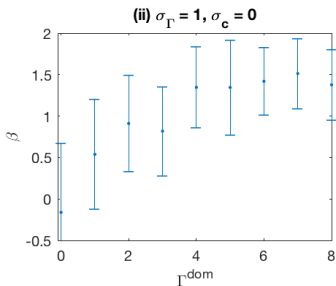
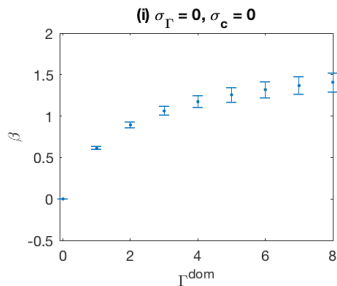
$$\Delta p_g^{dom} = \frac{1}{1 + s_g^{imp} \Gamma_g^{dom}} \Delta c_g^{dom} + \frac{\Gamma_g^{dom}}{1 + s_g^{imp} \Gamma_g^{dom}} s_g^{imp} \Delta p_g^{imp}.$$

If changes in average domestic costs  $c_g^{dom}$  (unobserved) are correlated with  $p_g^{imp}$ , then  $\beta > 0$  even if  $\Gamma^{dom} = 0$ .

Invoicing currency is good instrument for  $\Delta p_g^{imp}$  if share of imported goods in consumer expenditures and invoicing currency in Dec 14 is uncorrelated with domestic cost changes after Dec 14

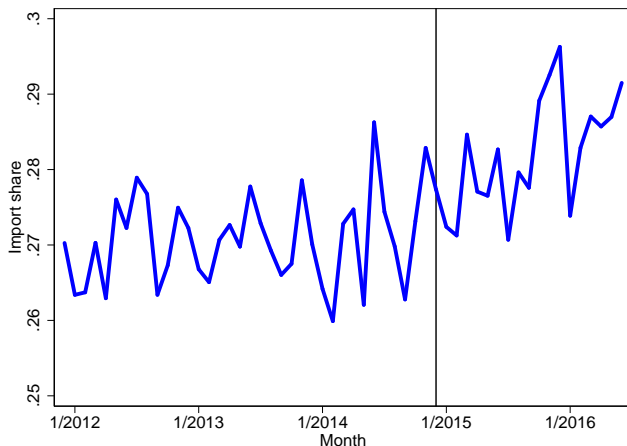
Can use  $\beta$  estimates to infer  $\Gamma^{dom}$

# Inferring pricing complementarities in simple model





## Share of imported goods in total expenditures



Rise in import share versus same period in previous year

- January 2015-December 2015: 0.76 (2.8%)
- January 2015-May 2016: 0.95 (3.6%)

## Cross-section expenditure switching, invoicing, prices: Jan15 - May16

$$\Delta_k \log(\text{expend}_i / \text{expend}_{g(i)}) = \alpha + \beta * \Delta_k (p_{g(i)}^{\text{borimp}} - p_{g(i)}^{\text{prdall}}) + \varepsilon_i.$$

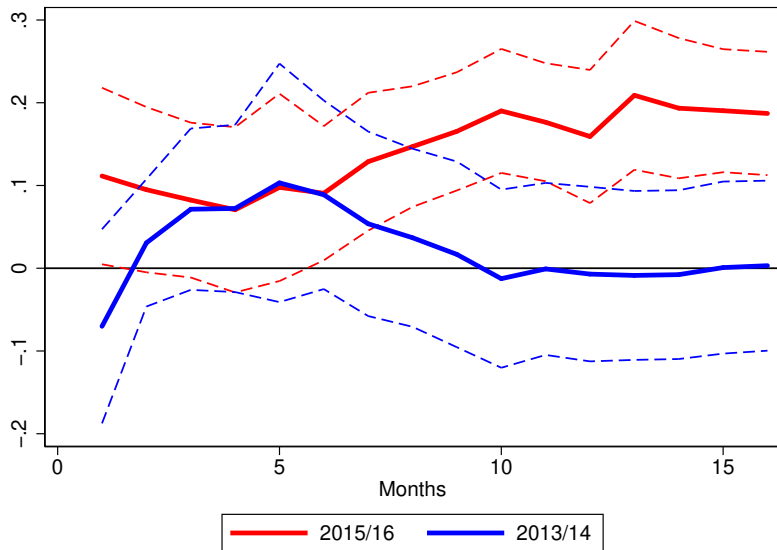
Also consider  $p_i^{\text{retimp}} - p_{g(i)}^{\text{retall}}$  instead of  $p_{g(i)}^{\text{borimp}} - p_{g(i)}^{\text{prdall}}$

	Jan 2015 – May 2016				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	Red. form	2SLS	2SLS
$\Delta$ relative border price	-1.536*** [0.419]			-1.663*** [0.366]	
$\Delta$ relative retail price		-0.121 [0.273]			-3.894** [1.618]
$(1 - \text{CHFShare}) \times (1 - \text{ImpShare})$			0.169*** [0.035]		
Observations	2346	2346	2346	2346	2346
F first stage				53.2	7.3
p-value				0.000	0.011

# Cross-section expenditure switching, invoicing, prices: Jan15 - Dec15

	Jan 2015 – Dec 2015				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	Red. form	2SLS	2SLS
$\Delta$ relative border price	-0.708** [0.305]			-1.031*** [0.248]	
$\Delta$ relative retail price		0.062 [0.134]			-2.865* [1.575]
$(1 - CHFShare) \times (1 - ImpShare)$			0.114*** [0.030]		
Observations	2447	2447	2447	2447	2447
F first stage				81.5	7.3
p-value				0.000	0.011

## Expenditure switching and instrument over time

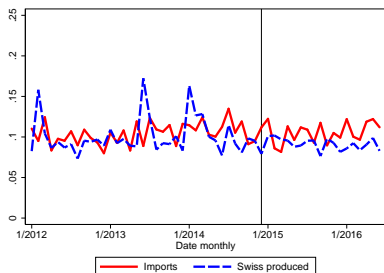


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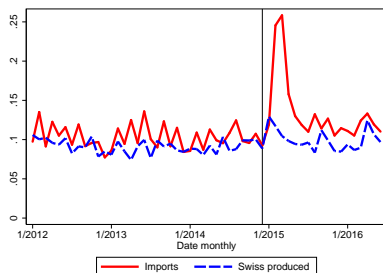
## Intensive and extensive margin of price adjustment in retail prices

$$\text{Average price change}_t = fr_t^{up} * size_t^{up} - fr_t^{down} * size_t^{down}$$

## Frequency of retail price adjustment: increases and decreases



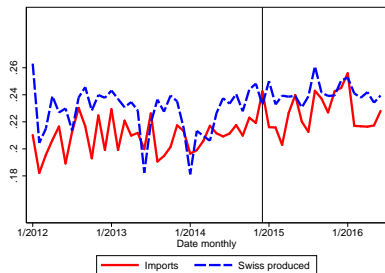
(a) Increases



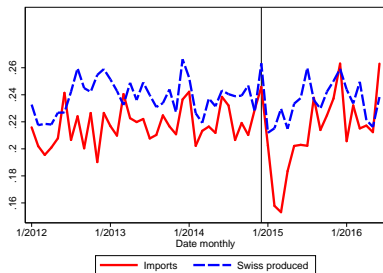
(b) Decreases

Over 30% of retail prices of imports remain unchanged 1 year after appreciation

## Size of retail price adjustment: increases and decreases



(a) Increases



(b) Decreases



## Robustness

Increase in fraction, decrease in size of price reductions robust to:

- Standardized price changes region, product-group level
- Exclude temporary price changes
- Separate more and less sticky goods
- Separate large and small market shares
- Subsample of two largest retailers
- Separating single and multi-product firms
- 2011 appreciation

Size and fraction of price changes in 2015 roughly unchanged for identical products in neighboring countries' prices

## Cross-section border prices, invoicing, and margins of price adjustment

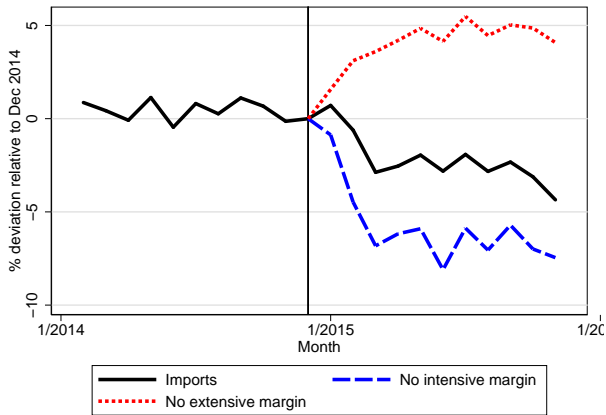
Across products, larger reductions in border prices and lower CHF invoicing of border prices result in:

- larger increase in fraction of price reductions
- larger reduction in average size of price reductions

	Frequency			Size		
	(1) OLS	(2) red. form	(3) 2SLS	(4) OLS	(5) red. form	(6) 2SLS
$\Delta p^{borimp}$	-1.941** [0.814]		-2.285** [1.052]	0.419** [0.171]		0.830*** [0.283]
CHFShare		-0.214* [0.106]			0.077** [0.034]	
Observations	1039	1039	1039	684	684	684
F first stage			27.9			28.7
p-value			0.000			0.000

## Role of adjustment margins for the aggregate price response

$$\text{Average price change}_t = fr_t^{up} * size_t^{up} - fr_t^{down} * size_t^{down}$$



## Size of price reductions in Ss pricing model

Importer  $i$  desired log price:  $p_{it}^* = w_t + z_{it}$ , appreciation  $\downarrow w_t$  by  $\Delta$

Law of motion of  $z_{it} = z_{it-1} + \varepsilon_{it}$

$$\varepsilon_{it} = \begin{cases} 0 & \text{with prob } 1 - \lambda \\ N(0, \sigma) & \text{with prob } \lambda \end{cases}$$

Simple pricing rule

$$p_{it} = \begin{cases} p_{it-1} & \text{if } |p_{it-1} - p_{it}^*| < y \\ p_{it}^* & \text{if } |p_{it-1} - p_{it}^*| \geq y \end{cases}$$

Change in average size of price reductions ▶▶ derivation

$$s' - s = \frac{f}{f'} \Delta + \left( \frac{f' - f}{f'} \right) (\tilde{s} - s)$$

- $s' < s$  requires new price changes much smaller than average price changes pre-shock ( $\tilde{s} \ll s$ )

## Extensive and intensive margins in calibrated model

	Data		Model			
	t=0	t=1	Gaussian t=0	$\lambda = 1$ t=1	Poisson t=0	$\lambda = 0.3$ t=1
Fraction down	0.08	0.21	0.11	0.18	0.11	0.18
Size down	0.22	0.16	0.22	0.23	0.22	0.20
Fraction up	0.13	0.09	0.11	0.06	0.11	0.08
Size up	0.23	0.22	0.22	0.22	0.23	0.21

New price changes relative to all changes:

Normal shocks  $\tilde{s} - s = -0.04$

Poisson shocks  $\tilde{s} - s = -0.12$

$\lambda < 1$  also implies lower aggregate pass-through (Midrigan 2010)

## Swiss Franc Appreciation in 2015: Taking stock

- Incomplete PT into border prices invoiced in domestic currency, and incomplete PT between border and retail import prices account for a significant portion of incomplete exchange-rate pass-through into consumer prices
- Invoicing matters beyond its impact on border prices: product groups invoiced in foreign currency show larger price reductions at the retail level, both for imports and domestic produced products, and more expenditure switching.
- Frequency of import price reductions rises and average size of these price reductions falls (and more so in product groups invoiced in foreign currency), contributing to low aggregate import-price pass-through. Consistent with a Ss pricing model with fat-tailed distributed price changes.

# Appendix

## Macro data

	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>
Real GDP Growth	1.1%	1.8%	2%	0.8%	1.3%
Real Consumption Growth	2.5%	2.2%	1.3%	1.2%	1.3%
Exports/GDP	66.2%	75%	69%	67%	72.2%
Imports/GDP	55.4%	61.7%	55.8%	57.7%	58.6%
Inflation	-0.7%	-0.2%	0%	-1.1%	-0.4%

Source: SECO, BFS.



## Market reaction

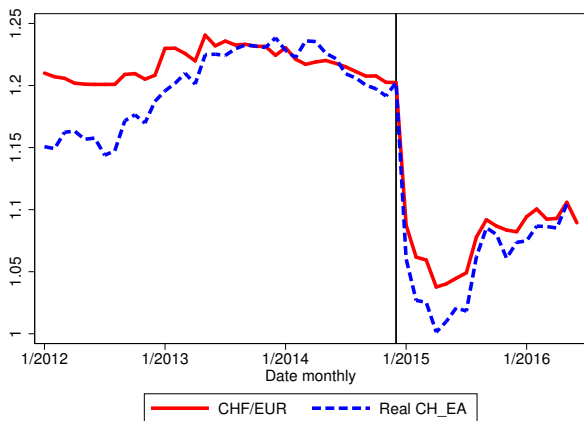
Market reactions: an example from Bloomberg 4.42 PM CET.

“The Swiss National Bank unexpectedly scrapped its three-year policy of capping the Swiss franc against the euro in a U-turn that may change the perception of a century-old institution known for reliability.[...] SNB President Thomas Jordan defended the move, saying **surprise was necessary**. [...] economists responded to the SNB announcement with comments including “surprise” and “seismic.” [...] **None of 22 economists surveyed by Bloomberg News between Jan. 9 and Jan. 14 expected the SNB to get rid of its cap in 2015.**”

The SNB stated in its previous meeting just 4 weeks before on Dec 18, 2014

“The SNB remains committed to purchasing unlimited quantities of foreign currency to enforce the minimum exchange rate with the **utmost determination**. The minimum exchange rate is **still the key instrument** to avoid an undesirable tightening of monetary conditions and to maintain price stability.”

## CHF/EUR Appreciation: Nominal and real



» Back