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

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Abstract

The removal of the lower bound on the EUR/CHF exchange rate in January 2015 provides a unique setting to study the implications of a large and sudden appreciation in an otherwise stable macroeconomic environment. Using transaction-level data on non-durable goods purchases by Swiss consumers, we measure the response of border and consumer retail prices to the CHF appreciation and how household expenditures responded to these price changes. Consumer prices of imported goods and of competing Swiss-produced goods fell by more in product categories with larger reductions in border prices and a lower share of CHF-invoiced border prices. These price changes resulted in substantial expenditure switching between imported and Swiss-produced goods. While the frequency of import retail price reductions rose in the aftermath of the appreciation, the average size of these price reductions fell (and more so in product categories with larger border price declines and a lower share of CHF-invoiced border prices), contributing to low pass-through into import prices.

JEL classification: D4, E31, E50, F31, F41, L11
Keywords: Large exchange rate shocks, exchange rate pass-through, invoicing currency, expenditure switching, price-setting, nominal and real rigidities, monetary policy.

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1 Introduction

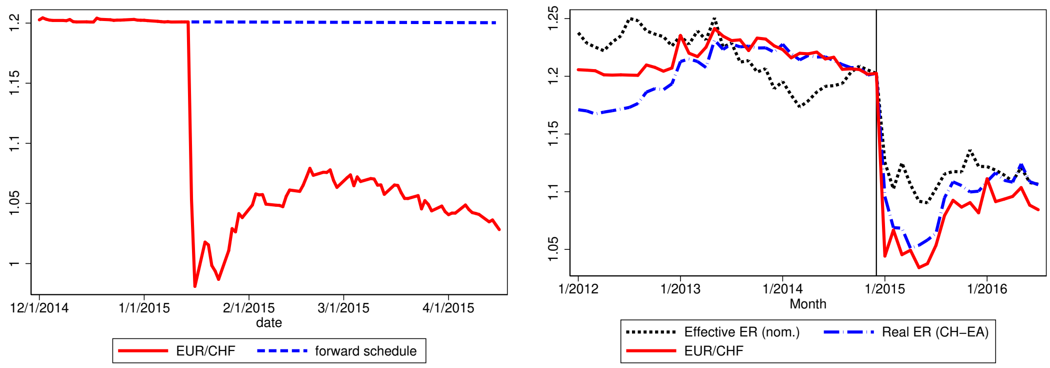
This paper studies how prices and consumer expenditures respond to exchange rate movements based on the large and sudden appreciation of the Swiss franc (CHF) on January 15, 2015. Using homescan data on non-durable consumer goods purchases by Swiss households and data on import prices at the border, we document the response of border and consumer prices, the extent of consumer expenditure switching between domestic and imported goods, and the role of the invoicing currency of border prices in these responses. We use this case study to shed some light on the sources of incomplete exchange rate pass-through, the allocative implications of invoicing currency in international trade, the role of nominal rigidities and pricing complementarities in price adjustment, and the extent of expenditure switching by households to changes in exchange rates.

The Swiss experience provides a unique setting to study the consequences of a large policy-driven change in the nominal exchange rate. On September 6, 2011, the Swiss National Bank (SNB) had put in place a minimum exchange rate of 1.20 CHF per EUR, resulting in a very stable EUR/CHF exchange rate during 2012 to 2014 (ranging between 1.2 and 1.25). At the end of 2014, foreign developments, including market participants' anticipation of a large-scale quantitative easing program in the euro area, led to a rapid surge in safe-haven capital inflows into Switzerland, in turn prompting the SNB governing board to unexpectedly abandon the minimum exchange rate on January 15, 2015.[1]

This policy change resulted in a large and sudden appreciation of the CHF. Relative to its level in December 2014, the EUR/CHF appreciated by more than 20% on January 15 2015, 14.0% three months later, 14.7% six months later, and 10.6% twelve months later (see Panel (a) in Figure 1). The EUR/CHF real exchange rate (RER), also shown in Figure 1, followed a similar path as the EUR/CHF nominal exchange rate. The real appreciation of the CHF

[1] The SNB had reiterated its commitment to the minimum exchange rate throughout late 2014. For example, on December 1st, SNB Governor Thomas Jordan (Jordan, 2014) argued that "the minimum exchange rate remains the key instrument for ensuring appropriate monetary conditions." As can be seen in Figure 1, forward rates on January 14, 2015 reveal that investors expected a flat profile of the exchange rate and thus a continuation of the SNB's policy stance. None of 22 economists surveyed by Bloomberg News (Bloomberg, 2015) between January 9 and January 14 expected the SNB to get rid of its minimum rate in 2015. Jermann (2017) argues that option prices revealed a low probability of abandoning the exchange rate floor.

Figure 1: *The 2015 CHF Appreciation*



(a) EUR/CHF and forward schedule (b) EUR/CHF and trade weighted ER

Notes: The red solid line in Panel (a) shows the nominal EUR/CHF exchange rate, daily data, from December 1, 2014 to April 30, 2015. The dashed line shows the forward schedule based on forward rates overnight, 1 week, 1, 2, and 3 months on January 14th, 2015. Panel (b) shows the EUR/CHF exchange rate as a red solid line, the nominal effective exchange rate (Switzerland's 54 main trading partners) as a black dotted line, and the real EUR/CHF exchange rate as a blue dashed line. The effective nominal exchange rate and the real exchange rate to equate the nominal EUR/CHF in December 2014. Sources: SNB, BIS, Bloomberg.

was prolonged, with the EUR/CHF RER returning to its December 2014 level only by the end of 2017.[2] These movements in the nominal exchange rate are large in magnitude relative to standard short-term exchange rate fluctuations in advanced economies, which have been a main focus of the literature.[3]

This appreciation episode is unique in a number of dimensions. It followed a period of remarkable exchange rate stability, implying that it is unlikely that price dynamics in the aftermath of January 15, 2015 reflected adjustment lags due to prior exchange rate movements. It occurred against the backdrop of a very stable macroeconomic environment, as can be seen in Table A.1 in the Appendix summarizing the main Swiss economic aggregates between 2013 and 2016. Further, the appreciation itself was not triggered by shocks that affect the domestic

[2]The CHF had also appreciated substantially versus the euro during the period 2008-2012. However, as this appreciation was gradual, it is harder to separate its effects from other contemporaneous aggregate shocks.

[3]A number of studies have resorted to large devaluations in developing countries to study the effects of sudden exchange rate changes (see e.g. Burstein et al., 2005; Alessandria et al., 2010; Cravino and Levchenko, 2017; Gopinath and Neiman, 2014). These episodes tend to be accompanied by other major macroeconomic developments (such as debt and banking crises) that can confound the effects of exchange rate movements. Moreover, most large devaluation countries have dollar invoiced import prices and hence feature little variation in currency of invoicing across product categories, which is an important ingredient of our analysis. On the 2015 CHF appreciation, Bonadio et al. (2018) document the response of unit values at the border, Efing et al. (2016) examine the effects on Swiss publicly listed firms' valuations, and Kaufmann and Renkin (2017) study the price and employment response of Swiss manufacturing firms.

economy: while the minimum rate was in place, the SNB intervened whenever market forces threatened to appreciate the CHF. The SNB, in turn, reinvested the funds abroad and the financing conditions in Switzerland were hence largely isolated from these capital flows. The potential concern that the price movements we focus on are also due to capital inflows may thus not be severe in this setting, as all capital inflows ended up on the SNB's balance sheet.[4] Last, once the minimum rate was abandoned, capital flows ceased almost instantaneously.[5]

We analyze the impact of the appreciation on prices and expenditures using detailed border and retail transaction-level data, described in Section 2. In the first six months after January 15, 2015, retail prices fell on average by only 1.3% in response to the 14.7% appreciation of the EUR/CHF. In Section 3 we perform simple accounting exercises to quantify the sources of incomplete exchange rate pass-through to retail prices. Border prices of imported goods fell by roughly 7% in the first two quarters of 2015 (and more so for the roughly 1/3 of goods invoiced in EUR), while import prices at the retail level (typically unobserved in analyses of exchange rate pass-through) fell by only 3%. Had all border prices been invoiced in EUR, the reduction of retail import prices would have been 2.4 percentage points larger, but the reduction in retail prices including imports and Swiss-produced goods would have been only 0.3 percentage points larger given the relative small share of imports in expenditures (roughly 1/4). Had all retail goods been imported and not subject to non-traded distribution costs, the decline in retail prices would have been 5.4% rather than 1.3%.

In Section 4 we look beyond the average response of prices and present a range of facts on how changes in retail prices vary across products with respect to the invoicing currency and border

[4] Detailed examinations of these capital flows (see e.g. Auer, 2015; Auer and Tille, 2016) show that foreign safe-haven demand for CHF was channelled through branches of foreign banks, which do not issue credit in Switzerland or engage in sizable positions with the Swiss financial system. The accumulation of other Swiss assets by foreign investors was not significant. Amador et al. (2017) provide a theoretical examination of the central bank's exchange rate policy and the effects on capital inflows in the context of low interest rates.

[5] While capital inflows are typically associated with an increase in economic activity, the growth rate of real GDP and real consumption fell slightly in 2015 relative to 2014, as can be seen in Table A.1 in the Appendix. Also note that in 2012-13 there was another surge of capital inflows, even more pronounced than during the December 2014-January 2015 episode. These large capital inflows, during a period in which the minimum rate was still in place, were not associated with a real appreciation of the CHF.

price change of imports in the respective product categories.[6] We first provide evidence that variation in border price changes and in invoicing currency across imported products have a sizable impact on retail prices faced by consumers. According to our estimates, in the first six months after the CHF appreciation, a 1 percentage point larger reduction in import prices at the border resulted in a 0.3–0.4 percentage point larger price reduction for imported products at the retail level. Our estimates imply that retail import prices in product categories that are (hypothetically) fully invoiced in foreign currency fell by roughly 4 percentage points more than in product categories fully invoiced in CHF. While previous evidence on the role of invoicing currency is based on import and export price changes at the border (see e.g. Gopinath et al., 2010; Fitzgerald and Haller, 2014; Gopinath, 2016; Devereux et al., 2017), our results establish that differences in border price changes associated with the currency of invoicing carry over to consumer prices.[7]

Even though retail prices of domestically produced goods fell on average by very little in the year of the CHF appreciation, we find that prices of domestically produced goods fell by more in product categories more strongly affected by declining retail prices of imported goods. This relationship between price changes of domestic and competing imported goods is stronger when we instrument retail import prices by the foreign-currency invoicing share at the border prior to the exchange rate shock. Our estimates imply that for product categories with the median import share, a 1 percentage point larger reduction in consumer prices of imported goods resulted in roughly a 0.4 percentage point larger reduction in consumer prices of Swiss-produced goods. Under the assumption that across product categories, the share of imported goods in consumer expenditures and the invoicing currency at the border prior to the exchange rate shock are uncorrelated with cost changes for domestic producers after the exchange rate shock, these estimates provide reduced-form evidence

[6]Berger et al. (2012) use the micro price data underlying the official US import and consumer price indices of the US Bureau of Labor Statistics to match individual identical items at the border and retail levels. Whereas Berger et al. (2012) estimate the evolution of good-specific distribution shares, we examine the impact of changes in border prices and invoicing currency on retail prices in response to a large shock. For related work studying pass-through at different layers of the distribution chain, see e.g. Nakamura and Zerom (2010) and Goldberg and Hellerstein (2013).

[7]The invoicing currency and response of border and consumer prices to exchange rate movements is an important ingredient of optimal exchange rate policy (see e.g. Engel, 2003; Devereux and Engel, 2007).

of pricing complementarities by which domestic producers react to changes in prices of competing imported products (complementing evidence in Amiti et al. (2016) and Auer and Schoenle (2016) by using data on retail prices of Swiss-produced and imported goods and a well-identified exchange rate shock).

In Section 5 we measure the extent of expenditure switching towards imported goods in response to the appreciation. On average, expenditure shares of imported goods rose from 26.5% to 27.4% (i.e. by 3.6% of the initial import share) during the 17-month period following the 2015 CHF appreciation. Exploiting the cross-sectional variation along the invoicing dimension, our estimates imply that expenditure shares on imported goods (within product categories) increased by less in CHF-invoiced product categories relative to product categories in which imports are invoiced in foreign currencies. That is, differences in currency of invoicing matter not only for consumer prices but also for allocations. Instrumenting border price changes across product categories using CHF-invoicing shares implies an elasticity of import retail expenditures (within product categories) to border prices between roughly 2 (at a 12-month horizon) and 3 (at a 17-month horizon). Elasticities of import expenditures with respect to retail prices are larger but less tightly estimated given the large idiosyncratic movements in consumer prices and quantities.[8]

In Section 6 we examine the response of the intensive and extensive margins of price adjustment in the months following the appreciation.[9] We document a large increase in the frequency of price reductions (on impact, from roughly 10% to 25% per month) and a small decline in the frequency of price increases. However, import prices on average did not fall substantially in spite of the large increase in the fraction of firms reducing prices because there was a marked decline in the absolute size of price reductions (relative to the pre-shock

[8]Cravino (2017) uses data on Chilean exports to estimate the differential response of exports to exchange rate shocks according to the invoicing currency of the transaction. Instead, we use information on the invoicing currency of imports to estimate pass-through of border prices to retail prices and to measure expenditure switching to imports at the consumer level in response to a large exchange rate shock. Our elasticity estimates are on the high range of elasticity estimates in the literature based on time-series variation (see e.g. Feenstra et al., 2018, and references therein).

[9]For related work on the role of the intensive and extensive margins of price adjustment for aggregate price dynamics, see e.g. Klenow and Kryvtsov (2008), Nakamura and Steinsson (2008), Gagnon (2009), Karadi and Reiff (2014), Alvarez and Lippi (2014), Alvarez et al. (2016), and Carvalho and Kryvtsov (2017).

size of price reductions).[10] In addition to this aggregate evidence, we show that the increase in the frequency of price reductions and the decline in the size of price reductions was larger for products with larger border price reductions (or larger share of foreign-currency invoicing at the border). In the Appendix, we interpret this negative co-movement between intensive and extensive margins of price adjustment through the lens of a simple Ss pricing model. In response to a decline in the cost of imported goods (when expressed in CHF), the absolute size of price reductions falls only if new price changes (i.e. those that would not have occurred in the absence of the shock) are sufficiently small relative to the size of typical price reductions. This is the case under the form of selection in Ss pricing models with idiosyncratic shocks that give rise to a fat-tailed distribution of price changes, as in Gertler and Leahy (2008) and Midrigan (2011).

2 Data

Our analysis is based on "homescan" data on Swiss retail expenditures and prices supplemented with information on product origin, retail prices in neighboring countries, prices and invoicing currency at the border.

The AC Nielsen homescan data covers a demographically and regionally representative sample of 3,187 households in Switzerland in the period January 2012 to June 2016.[11] Participating households scan the barcodes - each uniquely identifying a product - of all purchases made in supermarkets, drugstores, and department stores. The goods include food, non-food grocery items, health and beauty aids, and selected general merchandise. In what follows, we refer to the barcode as "EAN" (European Article Number, comparable to Universal Product Codes, or UPC, in the US). In addition to scanning the EAN, households enter the prices and quantities purchased for each product, and a retailer identification number.

[10] It is well understood that low exchange rate pass-through conditional on a price change can mute the change in aggregate import prices in response to exchange rate changes (see e.g. Gopinath et al., 2010; Gopinath and Itskhoki, 2010). We show that, in the presence of a spike in the fraction of price adjustments, changes in composition toward small price adjustments contribute to low aggregate pass-through.

[11] One household in the sample represents roughly 1,000 households in the total population. The selection of panelists is based upon the Swiss census conducted by the Swiss Federal Statistical Office. The Italian-speaking Canton of Ticino (accounting for 4.4% of all Swiss households) is excluded from the Nielsen panel.

In the raw data set, a single observation, which we refer to as a “transaction” below, includes the household identifier, EAN of the product purchased, quantity purchased, the price paid, the date of the shopping trip, and a retail chain code, which can be linked to the name of the retailer. All products are classified into one of 284 narrowly defined product categories such as apple juice, shampoo, and toilet paper. Much in contrast to the US, coupons do not play a prominent role in Swiss retail. The data set thus does not include information on coupon usage.[12]

We augment the homescan data with information on the country of production of each good and the price in neighboring countries. Whereas EAN codes provide information on the country in which a product has been registered, in many instances this is not the country in which the product has actually been produced. However, the latter information is included in the label of each product. We therefore collect label information from Swiss retailers' webpages and from codecheck.info.[13] For our analysis in Section 6, we complement our Swiss data with homescan data from Austria, France, and Germany (provided by the “Gesellschaft für Konsumforschung”).

In the analysis of retail prices, we construct a monthly panel of region-retailer specific prices of continuously observed individual goods.[14] To ensure that we can differentiate actual price changes from compositional effects, we first define price changes at the EAN-retailer-region tuple, and then aggregate these across retailers and regions as described below. Moreover, to ensure that our results are not driven by changes in the mix of goods over time, we focus on a balanced panel of goods for which we observe a price in at least one retailer-region in every month during the period January 2012 to June 2016. Hence, we exclude entering products, seasonal items, and products which supermarkets only sell occasionally.

[12] We clean the data for errors by adjusting wrongly entered digits and correcting the data whenever price and quantity entries have been switched. We drop expenditures on vegetables, meat, and dairy products that are not pre-packaged since for those products we cannot construct informative price series.

[13] All mentioned webpages were accessed at various occasions during October 2015 to March 2016. We drop observations for which we could not collect information on the country of origin.

[14] Major Swiss supermarket chains set prices at the “marketing region” level, which is comparable, but not identical, to the cantonal level. We do not observe the location of the retailer for each Swiss transaction but only the 2-digit postal code of the household's residence. We thus associate the retailer in a transaction to a location by assuming that, for purchases within Switzerland, households shop in the region where they live. We drop all cross-border shopping transactions from the data.

Table 1: *AC Nielsen data summary statistics*

	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

Notes: The left-hand panel shows the sample used in the analysis of price changes; the right-hand panel shows the sample used in the analysis of expenditure switching. *Transactions* are the number of purchases observed, *Exp. Share* is the share of expenditures in total expenditures (in %), and *Products* shows the number of unique products in the respective sample.

In the analysis of expenditure switching, we do not need to condition on price changes, and we thus use information on the whole set of goods for which we observe prices, origins, and expenditures at the national level (summed across all retailers and regions) in the period around January 2015 that we focus on.

Table 1 provides an overview of these two samples. For the analysis of price changes between 2012 and 2016 using the continuously observed set of goods, our sample consists of 3,680 unique products (EAN) and 4.12 million purchase transactions. Of a total of 1,105 imported goods, 885 originate from the euro area.[15] All imports (imports from the euro area) account for 24% (19%) of total expenditures. For the analysis of expenditure switching between 2013 and 2016, our sample consists of 7,591 products and 2.9 million transactions. The number of products is larger in the expenditure switching sample because we use goods that are sold in at least one month (but not necessarily in every month as in the sample for the analysis of price changes) in the 12- or 17-month period before and after the January 2015 appreciation. The number of transactions is lower in the expenditure switching sample because we use 34 months of data (17 months before and after the appreciation) versus 53 months in the price sample.

Finally, to obtain border prices and the invoicing currency, we match the homescan data by product category to the microdata underlying the calculation of the Swiss Import Price Index

[15] In our analysis below we include imports from all countries. Our cross-section results are similar if we consider only euro area imports, with somewhat larger standard errors due to a smaller number of observations.

Table 2: *Border price data summary statistics*

	All products		Consumer goods		Matched products	
	(1)	(2)	(3)	(4)	(5)	(6)
	Observ.	Products	Observ.	Products	Observ.	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

Notes: The first two columns show the number of observations and the number of products included in the 2012–2016 IPI data. The third and fourth columns show all consumer goods (excluding investment goods and commodities), the fifth and sixth all products in categories that can be matched to the retail price data. The first row shows the total number of observations/products, the second row CHF-invoiced, the third EUR-invoiced and the fourth products invoiced in other currencies. Data source: SFSO.

(IPI) from the Swiss Federal Statistical Office (SFSO). The latter data are a survey-based panel of Swiss import prices similar to the US microdata studied in Gopinath and Rigobon (2008). Prices for individual goods and information on the invoicing currency of individual transactions are obtained from importing firms via monthly or quarterly surveys. We refer to these prices as "border prices", to distinguish them from retail prices for imported products.[16].

The product identifiers used in the SFSO import price sample cannot directly be mapped to EAN codes in the retail data. We thus use the SFSO's product classification scheme and merge the border prices and invoicing information to the retail data at the border product category level. Specifically, there are 44 border product categories that can be matched to the retail data, summarized in Table B.1 in the Appendix.[17]

Since most of the consumer product categories that can be matched to our retail data are surveyed only on a quarterly basis by the SFSO, we focus on quarterly border prices. As reported in Table 2, the overall border price sample includes 3,948 products, of which 1,238 are consumer products and 642 (2,499 quarterly observations) can be matched to Nielsen's retail product categories.[18] Roughly two thirds of the included products are invoiced in CHF.

[16] In some of our calculations, we also use the data underlying the SFSO's domestic producer price index (PPI), for the same product categories as for border prices. Our proxy for changes in local distribution costs of imported goods (used in Section 3.3) is the aggregate domestic PPI published by the SFSO

[17] Accordingly, standard errors in all estimations that use this SFSO-homescan matching are clustered at the level of border product categories.

[18] The SFSO conducted a re-sampling of the IPI and PPI in December 2015. Since some products were replaced in the sample and we cannot calculate price difference versus December 2014 for newly entering products, the sample size falls in December 2015.

Of the one third foreign currency-invoiced products, 30% are invoiced in EUR, and 3% in other currencies (mainly USD).

We generate border-price indices by border product category and also generate a measure of CHF-invoicing intensity in each product category by averaging a CHF-invoicing dummy in December 2014 across IPI products within each each category.[19] We use this measure of CHF-invoicing share by product category to document the reduced-form relationship between currency of invoicing and retail prices and expenditures and, separately, as an instrument (valid only under additional assumptions that we state below) of average changes in border and retail import prices by product category after December 2014. The share of CHF-invoiced products by border category in December 2014, displayed in Table B.1 of the Appendix, ranges between 25% for the category "products for laundering, dishwashing and household cleaning" and 100% for the categories "mineral water" and "rice".

3 Exchange rate pass-through to border and consumer prices

In this section, we describe the impact of the 2015 CHF appreciation on aggregate border and retail (consumer) prices. We then perform simple accounting exercises to quantify the sources of incomplete pass-through.

3.1 Border prices

To construct aggregate border price indices, we first calculate log changes in quarterly border prices for individual goods relative to December 2014.[20] We then calculate border product category price changes as unweighted averages (since we do not observe import value per

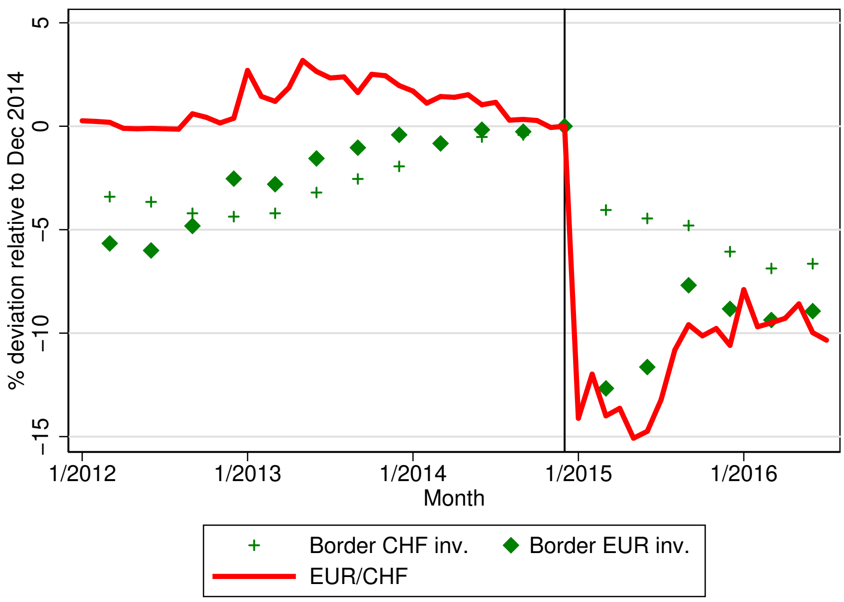
[19]The number of imported products changing invoicing currency in our data is very low, before and after December 2014. For example, the fraction of goods switching invoicing currency between CHF and non-CHF currencies in the period December 2013 - December 2014 (December 2014 - December 2015) is 0.43% (0.38%) for the full set of products in the import price index, 0.16% (0%) for the full set of consumer products, and 0.3% (0%) for the set of imported products matched to our Nielsen's product categories.

[20]Quarterly surveys for border prices are carried out by the SFSO in the first two weeks of each quarter (January, April, July, and October). Hence, prices in the January 2015 survey (which belong to our December 2014 monthly period covering December 15, 2014 - January 14, 2015) were collected before the appreciation. The first post-appreciation quarterly border price observation are in the March 2015 survey.

product) of changes in prices relative to December 2014 within the corresponding category, and aggregate price changes weighting categories by expenditures on imports by product category in the homescan data in the period 2013-2014. We consider separate aggregations for EUR- and CHF-invoiced goods.

Figure 2 displays cumulative changes in quarterly aggregate border prices, separately for EUR- and CHF-invoiced products, relative to December 2014. EUR/CHF appreciated by 14.0% in the first three months and by 14.7% in the first six months after December 2014. EUR-invoiced border prices fell by 12.7% and 11.6% in the first and second quarters, respectively, while CHF-invoiced border prices fell by 4.0% and 4.5%, respectively.[21] The divergence in the prices of CHF- and EUR-invoiced goods is unique to the post-appreciation period. CHF- and EUR-invoiced goods display similar price dynamics before January 2015, a period of stability of the EUR/CHF exchange rate.

Figure 2: *EUR/CHF and border prices*



Notes: The red solid line shows the log-difference in the exchange rate between December 2014 and a given month. The crosses and diamonds show the log difference in border prices of EUR- and CHF-invoiced products between the period in the horizontal axis and December 2014 (Dec 2014=0). Source: SNB (exchange rate), and own calculations based on SFSO data.

[21] If we aggregate all foreign currency-invoiced products (EUR and other currencies), as we do in our cross-section analysis in Sections 4 to 6, the decline in border prices is 12.6% in the first quarter and 12.2% in the second quarter (rather than 12.7% and 11.6%, respectively).

Table 3 presents coefficient estimates from a regression of the form $\Delta_k p_i^{borimp} = \beta_k \Delta_k e + \varepsilon_i$. Here, $\Delta_k p_i^{borimp}$ denotes imported product i's log change in border price $k = 1, .., 4$ quarters after December 2014, and $\Delta_k e$ is the corresponding log change in the EUR/CHF exchange rate.[22] The rate of exchange rate pass-through is around 0.9 for EUR-invoiced goods. In contrast, the rate of exchange rate pass-through rises over time from 0.28 to 0.65 for CHF-invoiced goods. Consequently, the difference in pass-through between EUR- and CHF-invoiced goods falls from roughly 0.6 in the first two quarters of 2015 to roughly 0.3 in the last two quarters.[23]

When we follow Gopinath et al. (2010) and condition on a nominal price change in the invoicing currency, we find that pass-through is lower (but far from zero) for CHF-invoiced goods relative to EUR-invoiced goods, as can be seen in the right-hand columns of Table 3 and in Figure C.1 in the Appendix. The conditional rate of exchange rate pass-through for CHF-invoiced goods ranges from 0.54 to 0.89, while that of EUR-invoiced goods ranges from 0.78 to 1.03. Our analysis in Section 4 exploits variation in CHF invoicing share across product categories in December 2014, as opposed to variation in price changes by currency of invoicing within product category.

3.2 Retail prices

We denote the log change in retail price between month $t-1$ and t of product i (EAN) in region r and retailer s by $\Delta p_{irs,t}^{ret} = p_{irs,t}^{ret} - p_{irs,t-1}^{ret}$ (where lower case variables denote logs). If we observe more than one i, r, s, t price observation in month t, we follow Eichenbaum et al. (2014) and use the mode of observed prices to obtain a value for $p_{irs,t}^{ret}$.[24] We then compute, per product and month, an unweighted average of price changes across regions and

[22] We weight individual goods i using the same weights as in the price indices described above, and therefore the pass-through coefficient β_k is equal to the price index divided by the cumulative log change in the exchange rate. Given the stability of EUR/CHF in the period 2012-2014, we do not include this period in our pass-through regressions.

[23] Border pass-through estimates in the restricted sample of consumer goods that can be matched with the AC Nielsen data are similar to estimates in the full sample of imported consumer goods (see Table C.1 in the Appendix) and to estimates in the full sample of imported goods in the import price index (see Table C.2).

[24] Eichenbaum et al. (2014) argue that using modal prices reduces measurement error. Our results are robust to using average or median (rather than mode) and to removing V-shaped movements in modal prices.

Table 3: *Pass-through into border prices, cross-sectional estimates*

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

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

Notes: Estimates of exchange rate pass-through into border prices across products 1 to 4 quarters after December 2014, $\Delta_k p_i^{borimp} = \beta_k \Delta_k e + \varepsilon_i$, for consumer goods matched with retail categories in our homescan data. The first panel titled "unconditional" shows pass-through regressions for all prices, first only for those products, that are invoiced in CHF, second for products, that are invoiced in EUR. The second panel titled "conditional" uses only price observations that have a non-zero price changes in their invoicing currency since December 2014. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

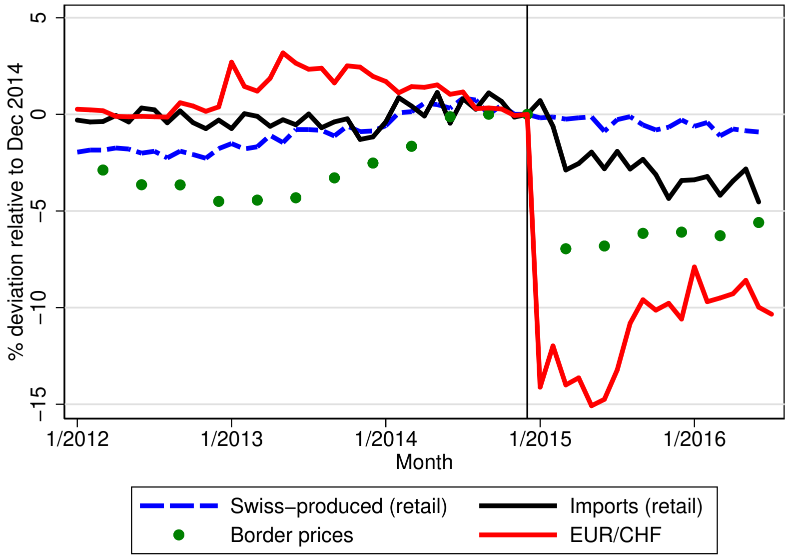
retailers, $p_{i,t}^{ret}$. We aggregate product-level price changes to the product-category level and then to the aggregate level (weighting products and categories, respectively, using 2013-2014 expenditures), separately for imports (euro and non-euro area combined) and domestic goods.

Figure 3 displays cumulative retail price changes from December 2014 for imports and Swiss-produced goods. Figure C.2 in the Appendix presents corresponding estimates of exchange rate pass-through into retail import prices (as well as for Swiss-produced goods) of the form $\Delta_k p_i^{retimp} = \beta_k \Delta_k e + \varepsilon_i$, where Δ_k now denotes monthly differences in prices relative to December 2014.

Retail prices for imported goods fell by 2.9% in the first three months and 2.8% in the first six months after December 2014 (the implied exchange rate pass-through is around 0.2). The price response of Swiss-produced goods was more muted, falling by 0.2% and 0.9% in the first three and six months, respectively (the implied exchange rate pass-through is below 0.1).[25]

[25]Weighing the response of imported and Swiss-produced goods by their expenditure shares, overall retail prices fell by 0.9% and 1.3% in the first three and six months, respectively. The official CPI combining the categories food, beverages and tobacco fell by 0.7% and 0.4% in each time period. The official CPI including all consumer goods and services fell by 0.1% and 0.4% in each time period.

Figure 3: *EUR/CHF and consumer prices*



Notes: The red solid line shows the log-difference in the exchange rate between December 2014 and a given month. The blue dashed line is the price index for retail goods produced in Switzerland, the solid black line shows retail prices of imported goods and the green dots show the border price index for the matched product categories, weighted by the same expenditure shares as retail prices (Dec 2014=0). Sources: calculations based on SNB, SFSO, and AC Nielsen data.

3.3 Summary and counterfactual scenarios

We next summarize the facts above using a simple accounting framework similar to the one in Section 3 of Burstein and Gopinath (2014), and further perform some counterfactual analysis to highlight the economic significance of the various sources of incomplete pass-through.

The log change in overall retail prices (combining imports and Swiss-produced goods in our product categories) after December 2014 is

$$\Delta p^{retall} = ImpShare \times \Delta p^{retimp} + (1 - ImpShare) \times \Delta p^{retdom}, \tag{1}$$

where $ImpShare = 0.24$ denotes the share of imported final goods in total expenditures (over the period 2013-2014). The log change in import retail prices is

$$\Delta p^{retimp} = \Delta \mu^{retimp} + (1 - s_d) \times \left[s_{chf} \times \Delta p^{boreur} + (1 - s_{chf}) \times \Delta p^{borchf} \right] + s_d \times \Delta ppi, \tag{2}$$

where $\Delta \mu_{retimp}$ denotes the change in retail markups for imported goods, s_d denotes the share of distribution costs in the pre-markup retail retail price, and $s_{chf} = 0.72$ denotes the share of CHF-invoiced goods in border prices. We assume that the log change in the price of distribution services is given by the change in the domestic producer price index, Δppi. We set $s_d = 0.5$ and infer changes in retail markups $\Delta\mu^{retimp}$ to match changes in the retail price of imports we observe in the data.[26]

Table 4 summarizes how the appreciation of the CHF translates into retail prices in 2015 as we sequentially introduce the five sources of incomplete pass-through in equations (1) and (2): incomplete pass-through to EUR-invoiced border prices and to CHF-invoiced border prices, distribution costs, changes in retail markups, and sluggish adjustment of Swiss-produced goods prices. The left-hand panel reports the log change in each price series, and the right-hand panel reports the implied exchange rate pass-through.

Table 4: *Summary of border and retail price responses by quarter*

	Price changes after Dec 2014				Pass-through			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
1) CHF-EUR	-14.0	-14.7	-9.6	-10.6				
2) Border prices, EUR invoiced	-12.7	-11.6	-7.7	-8.8	90.5	78.9	80.1	83.4
3) Border prices, all	-7.0	-6.8	-6.2	-6.1	49.7	46.2	64.2	57.5
4) Border prices + distribution	-4.2	-4.2	-4.2	-4.5	29.9	28.7	43.8	42.5
5) Retail prices, imports	-2.9	-2.8	-2.3	-3.4	20.6	19.1	24.3	32.3
6) Retail prices, all	-0.9	-1.3	-1.0	-1.0	6.2	9.0	10.1	9.7

Notes: The left-hand panel of this table summarizes the response of prices at various layers between the border and retail levels in the first four quarters after December 2014. The right-hand panel shows pass-through rates into these different layers. In row 4) we assume a distribution share of $s_d = 0.5$. A higher value of s_d would result in smaller absolute changes and smaller pass-through of "Border prices + distribution".

Incomplete pass-through of exchange rates to border prices (mainly due to the presence of CHF-invoiced imports) accounts for roughly half of the gap between changes in the exchange rate and changes in overall retail prices ("retail prices, all") in the first two quarters of 2015. The gap between changes in border prices and changes in retail prices of imported goods (due to a combination of distribution costs and changes in retail markups) is also large. In the first two quarters of 2015, this gap accounts for 30% of the absolute gap between changes in the exchange rate and "retail prices, all" ($0.3 = (6.8 - 2.8)/(14.7 - 1.3)$) and 37% of the relative

[26] The evidence in Burstein et al. (2003) based on retail census data implies distribution shares s_d of about 0.5. Using pass-through estimates of border prices to retail import prices across products similar to those presented in Section 4.1, we obtain an estimate of s_d of roughly 0.45 at a 4 quarter horizon (see Table C.3 in the Appendix).

gap ($0.37 = \ln(6.8/2.8)/\ln(14.7/1.3)$). Finally, the gap between "retail price, imports" and "retail prices, all" (due to muted price response of Swiss-produced goods) is small in absolute terms but large in relative terms, accounting for at least 30% (and up to 50%) of the gap between changes in the exchange rate and "retail prices, all".

Table 5: *Counterfactual changes in retail prices*

	Imports				All			
	(1) 1Q	(2) 2Q	(3) 3Q	(4) 4Q	(5) 1Q	(6) 2Q	(7) 3Q	(8) 4Q
0) Actual	-2.9	-2.8	-2.3	-3.4	-0.9	-1.3	-1.0	-1.0
1) No CHF invoiced ($s_{\mathrm{CHF}} = 0$)	-5.7	-5.2	-3.1	-4.8	-1.5	-1.9	-1.2	-1.4
2) Only CHF invoiced ($s_{\mathrm{CHF}} = 1$)	-1.4	-1.6	-1.6	-3.4	-0.5	-1.1	-0.8	-1.0
3) Constant retail markup, $\mu_{\mathrm{ret,imp}}$	-4.2	-4.2	-4.2	-4.5	-1.2	-1.7	-1.4	-1.3
4) No distribution costs ($s_{\mathrm{d}} = 0$)	-5.6	-5.4	-4.3	-5.0	-1.5	-1.9	-1.4	-1.4
5) Only imports, no distr. costs ($s_{\mathrm{m}} = 1, s_{\mathrm{d}} = 0$)	-5.6	-5.4	-4.3	-5.0	-5.6	-5.4	-4.3	-5.0

Notes: Row 0) shows the actual percentage change in import retail prices on the left-hand side and all retail prices (imports and Swiss-produced) on the right-hand side. Rows 1) to 5) show implied changes in these prices under the five counterfactual scenarios explained in the text.

An alternative way to quantify the sources of incomplete pass-through is to calculate counterfactual changes in retail prices under different parameterizations in equations (1) and (2).[27] We report in Table 5 the following alternative scenarios: (1) no CHF invoicing ($s_{chf} = 0$), (2) only CHF invoicing ($s_{chf} = 1$), (3) constant retail markups ($\Delta\mu_{retimp} = 0$), (4) no distribution costs ($s_d = 0$), and (5) only imports, no distribution costs ($s_m = 1, s_d = 0$). In all cases, we feed in the observed changes in border prices by currency and changes in Swiss-produced goods. Our results imply that a counterfactual shift in border price invoicing fully away from CHF invoicing would result in a 2.4 percentage point larger decline in retail import prices in the first two quarters of 2015 but only a 0.6 percentage point larger decline in overall retail prices. Abstracting from distribution costs (or from the increase in retail markups) would result in a 1.4 percentage point (2.5 percentage point) larger decline in retail import prices in the first two quarters (but a much smaller impact on overall retail prices). Finally, if all goods were imported and there were no domestic distribution costs, then the reduction in overall retail prices would be much larger (4.1 percentage points larger in the

[27] These simple accounting exercises do not take into account that these counterfactual scenarios could lead to different equilibrium responses in the price of Swiss-produced goods.

first two quarters).

4 Pass-through to retail prices: cross-section evidence

In this section we provide estimates of pass-through from border prices to retail prices at the product level, which complement the aggregate measures provided in Section 3. To do so, we leverage cross-product variation in price changes and in invoicing currencies at the border to measure how retail prices of imported goods respond to changes in border prices, and how retail prices of Swiss-produced goods respond to changes in retail prices of competing imported goods.

The first set of results provides evidence that the currency of invoicing at the border matters for changes in retail prices of imported goods. The second set of results provides reduced-form evidence (under an exclusion restriction that we discuss below) of pricing complementarities associated with domestic producers reacting to changes in prices of competing imported retail products.

4.1 Border prices and retail prices of imported goods

To estimate how much retail prices of imported product i respond to changes in border prices of the corresponding border product category $g(i)$, we consider a regression of the form

$$\Delta_k p_i^{retimp} = \alpha + \beta \Delta_k p_{g(i)}^{borimp} + \varepsilon_i, \tag{3}$$

where $\Delta_k p_i^{retimp}$ denotes the log difference in import retail prices between December 2014 and March 2015 for $k = 1$ (June 2015 for $k = 2$, September 2015 for $k = 3$, and December 2015 for $k = 4$). In all cross-section regressions in Sections 4 to 6, we weight observations by 2013-2014 expenditures, and each quarter we exclude observations with very large (top one percentile) absolute price changes since December 2014.[28] Standard errors are clustered at the border product category level.[29]

Column (1) of Table 6 reports OLS estimates for each quarter in 2015. According to our point estimates, retail import prices fall by roughly 0.3 percentage points more in product categories with a 1 percentage point larger decline in border prices one quarter after December 2014, and by 0.4 percentage points more two quarters after December 2014. In the third and fourth quarters, the estimates are around 0.2-0.3, but less tightly estimated. Note that the rate of pass-through from border prices to retail import prices based on disaggregated prices is not very different from the one implied by aggregate price indices in Section 3 (i.e., the ratio of retail to border price changes in Table 4 is roughly 0.4 in the first two quarters). The positive co-movement between border and retail import prices is a feature of our data not only after January 2015[30] and, more importantly, does not establish a causal impact of border to retail import prices.

Building on the finding from Section 3 that border prices of CHF-invoiced goods fall significantly less than goods invoiced in foreign currency after the 2015 CHF appreciation, we next examine how variation in invoicing currency matters for changes in import retail prices. Specifically, in equation (3) we replace $\Delta p_{g(i)}^{borimp}$ by $CHFShare_{g(i)}$, which denotes the share of products in border product category $g(i)$ invoiced in CHF in December 2014. Our estimates, reported in column (2) of Table 6, imply that retail prices decline by roughly 4 percentage points less for goods belonging to border product categories that

[28]Depending on the horizon (quarter), this trimming procedure removes about 8-10 observations, corresponding to price changes larger than roughly 50 percentage points. Tables D.1-D.9 of the Appendix show that our results are largely robust to removing the top five (rather than one) percentile absolute price changes, as well as the top one and bottom one percentile of (non-absolute) price changes. We also show that including all observations does not change point estimates substantially, but the increase in standard errors renders some insignificantly different from zero. Our results are very similar if we average retail prices within each quarter rather than using end of quarter retail prices.

[29]Point estimates in the cross-sectional regressions in Sections 4 to 6 are identical to those in regressions at the product category level (weighted by category level expenditures and excluding the same set of outliers) with similar standard errors compared with our baseline clustered standard errors. We choose product-level regressions as our baseline to be consistent across our cross-sectional regressions (some of which feature product-level variation in the independent variable).

[30]Estimating the OLS relationship between changes in border and retail import prices in each quarter of 2013 and 2014 (a period of EUR/CHF stability) relative to the fourth quarter of 2014 results in 3 quarters (out of a total of 7) with positive and significant coefficients, and 4 quarters with coefficients close to zero.

Table 6: *Pass-through from 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
Δp^{borimp}	0.312**			0.383**	0.426**			0.390***
	[0.146]			[0.168]	[0.176]			[0.147]
$CHFShare$		0.038**	0.099***			0.042**	0.107***	
		[0.018]	[0.020]			[0.017]	[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
Δp^{borimp}	0.309			0.918**	0.204*			0.574*
	[0.283]			[0.416]	[0.110]			[0.296]
$CHFShare$		0.068**	0.074***			0.038*	0.066**	
		[0.025]	[0.025]			[0.022]	[0.030]	
Observations	1077	1077	1077	1077	1077	1077	1077	1077
F first stage				8.4				4.7
p-value				0.008				0.040

Notes: Estimates of border prices into retail prices across individual products 1 to 4 quarters after December 2014, as in equation (3). In the 2SLS specifications, log changes in border prices are instrumented by the share of products that are CHF-invoiced in the corresponding border product category (first stage is reported under FS). Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

are (hypothetically) fully invoiced in CHF compared with goods in product categories fully invoiced in foreign currencies.[31] The estimates are significant at the 5 percent level in the first three quarters and at the 10 percent level in the fourth quarter. These estimates are not driven by pre-trends in the data.[32]

Finally, motivated by the previous regressions, we consider a two-stage least squares estimation (2SLS), where the first stage relates CHF invoicing shares in December 2014 to border price changes across product categories, and the second stage relates border price

[31]The constant in this regression (which is not reported in the table) is -0.06, quantifying the decline in retail prices for imports in product category that is (hypothetically) fully invoiced in foreign currency.

[32]Panel (a) of Figure D.1 shows that in the two years before January 2015, there is essentially no statistically significant relationship between CHF invoicing shares by product category at the border and changes in retail prices of imported goods relative to December 2014 (except for the first quarter in 2013, in which the estimated relationship has the opposite sign compared with what would be expected from a trending variable).

changes to retail import price changes. That is, in equation (3) we instrument border price changes, $\Delta p_{g(i)}^{borimp}$, by the fraction of CHF-invoiced products, $CHFShare_{g(i)}$. In order to interpret our estimates as the average causal impact of border prices on retail import prices, other drivers of retail price changes after December 2014 that may be correlated with changes in border prices (such as shocks to retail marginal costs that induce changes in border markups, or shocks to demand that induce changes in border and retail markups) must be uncorrelated with December 2014 invoicing shares across product categories.[33]

The first stage, reported in column (3), is strong especially in the first three quarters. According to this first stage, border import prices fall by roughly 1 percentage point less in product categories with a 10 percentage point higher CHF invoicing share.[34] The resulting 2SLS estimates of β, reported in column (4), are roughly 0.4 in the first two quarters of 2015. The point estimates and their standard errors are higher in the third and fourth quarters.[35]

4.2 Retail prices of imported goods and Swiss-produced goods

To estimate how strongly the retail price of Swiss-produced good i responds to changes in retail prices of imported goods in retail product category $g(i)$, we consider a regression of the form

$$\Delta_k p_i^{retdom} = \alpha + \beta ImpShare_{g(i)} \times \Delta_k p_{g(i)}^{retimp} + \varepsilon_i, \tag{4}$$

where $\Delta_k p_i^{retdom}$ and $\Delta_k p_i^{retimp}$ denote cumulative changes in Swiss-produced and import retail price, respectively, k quarters after December 2014 (using the same horizons as above, that is March 2015 for $k = 1$, June 2015 for $k = 2$, September 2015 for $k = 3$, and December 2015 for $k = 4$), and $ImpShare_{g(i)}$ denotes the import expenditure share in category $g(i)$

[33] This exclusion restriction does not require that pre-shock invoicing is uncorrelated with the sensitivity of desired retail markups to border prices or with the sensitivity of desired border markups to exchange rates, which play an important role in models of endogenous invoicing choice (see e.g. Engel, 2006).

[34] The difference in exchange rate pass-through to border prices between fully CHF-invoiced and fully foreign currency-invoiced product categories implied by our first stage estimates is only 0.1 higher in the first quarter of 2015 than the difference in border-price pass-through for CHF versus EUR products (without product category aggregation) reported in Table 3. This first stage is insignificant in the two years prior to January 2015, a period of EUR/CHF stability.

[35] As can be seen in Tables 6 and 7, 2SLS estimates can be higher or lower than OLS estimates. On the one hand, measurement error in prices and invoicing shares can lead to attenuation bias, while on the other hand the presence of common shocks to retail and domestic prices can lead to upward biases in OLS estimates.

calculated over the period 2013-2014. We include in the regression the product of import shares and import price changes, since the sensitivity of domestic prices to import prices is likely to be higher in product categories with a large participation of imported products, as in the model of variable markups we consider in Appendix E.

Table 7: *Response of retail prices of Swiss-produced goods to changes in import retail prices*

	1Q				2Q			
	(1) OLS	(2) red. form	(3) red. form	(4) 2SLS	(5) OLS	(6) red. form	(7) red. form	(8) 2SLS
$\Delta p^{retimp} \times ImpSh$	0.448***			0.738	1.457***			1.360***
	[0.139]			[0.538]	[0.273]			[0.332]
$(1 - CHFSh) \times ImpSh$		-0.054	-0.016			-0.129**	-0.119**	
		[0.051]	[0.058]			[0.047]	[0.046]	
$ImpSh$			-0.025				-0.007	
			[0.019]				[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
$\Delta p^{retimp} \times ImpSh$	0.839***			1.575***	0.465*			1.476**
	[0.258]			[0.398]	[0.249]			[0.614]
$(1 - CHFSh) \times ImpSh$		-0.156***	-0.197***			-0.115**	-0.167***	
		[0.048]	[0.044]			[0.045]	[0.040]	
$ImpSh$			0.028**				0.035**	
			[0.013]				[0.017]	
Observations	2267	2267	2267	2267	2272	2272	2272	2272
F first stage				11.4				7.1
p-value				0.002				0.014

Notes: Estimates of the change in retail prices of Swiss-produced goods to changes in import retail prices times import share ($ImpSh$) within the same product category 1 to 4 quarters after December 2014, as in equation (4). In the 2SLS specifications, log changes in import retail prices are instrumented by the share of products that are invoiced in foreign currency in the corresponding border product category $(1 - CHFSh)$. Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

According to the OLS estimates, reported in columns (1) and (5) of Table 7, retail prices of domestic goods fall relatively more in product categories with larger declines in retail import prices. Evaluated at the median import share of 0.28, the decline in domestic prices in product categories with a 1 percentage point larger decline in retail import prices is, depending on the horizon, between 0.1 and 0.4 percentage points larger.

The fact that prices of domestically produced goods are positively correlated with retail prices of imported goods within the same product category is not necessarily evidence of strategic complementarities in pricing between domestic and competing foreign products. Domestic and import prices within a product category can also co-move due to correlated production costs of domestic and foreign producers, see e.g. Amiti et al. (2014) and Amiti et al. (2016). Note that, since products in our sample consist mostly of non-durable final consumer goods such as shampoo, cheese and mineral water, it is unlikely that domestically produced goods within a product category make intensive intermediate input use of imported goods from the same product category. However, domestically produced and imported goods within a product category may employ common inputs in production that induce a correlation in cost changes.

In the absence of direct measures of domestic marginal costs that we can use as a control, we attempt to obtain an instrument for changes in retail prices of imported goods that is uncorrelated with marginal cost changes of domestic producers within the same product category. To do so, we use information on invoicing currency by border product category in December 2014, i.e. before the appreciation. Recall from Section 4.1 that retail import prices fall by less in product categories with higher CHF invoicing. Our exclusion restriction is that December 2014 CHF invoicing is uncorrelated with changes after December 2014 in marginal costs of Swiss producers across product categories.

To provide some support for this exclusion restriction in our setting, in Figure E.1 in the Appendix we show that CHF-invoicing intensity at the border is not significantly correlated across industries (either within the sample of product categories examined in this paper, or across broader but coarser industries) with a measure of Swiss firms' share of imported intermediate inputs in 2014 (which is one factor shaping marginal cost of Swiss producers after the CHF appreciation). Further, in Figure E.2 we show that there is very little Swiss value added contained in imports from the euro area, both for the aggregate of manufacturing industries and for the food, beverages and tobacco industries (which are closer related to the set of final consumption goods examined in this paper). These low shares speak against the possibility that marginal costs (and prices) of Swiss producers and foreign exporters are correlated due to local and foreign firms using identical Swiss inputs.

We then first present the reduced-form relationship between changes in retail prices of domestically produced good i and the foreign currency-invoiced share of border product category $g(i)$. In equation (4) we replace $\Delta p^{retimp}_{g(i)}$ by $1 - CHFShare_{g(i)}$.[36] The estimated coefficients, reported in column (2) of Table 7, are negative and (except for the first quarter) significant at least at the 5 percent level. The weaker effects in the first quarter may be explained by the fact that, as discussed in Section 6, nominal rigidities are likely to mute the response of retail prices in the first months after January 2015. The link between invoicing and domestic price changes remains negative and significant (except for the first quarter) if we separately control for the import share in the category, as shown in column (3). The estimates in column (2) for quarters two to four imply that, evaluated at the median import share, retail prices of domestically produced goods decline by 3-4 percentage points less for goods in border product categories that are (hypothetically) fully invoiced in CHF compared with goods in product categories fully invoiced in foreign currencies. These estimates are not driven by pre-trends in the data.[37]

Finally, we estimate equation (4) instrumenting for retail import price changes, $\Delta p^{retimp}_{g(i)}$, with the fraction of foreign-currency-invoiced products, $(1 - CHFShare_{g(i)})$. The resulting 2SLS estimates, reported in column (4), are positive, confirming that prices of domestically produced products fall by more in product categories with larger price reductions of retail prices of imported goods. The significance of these estimates varies by quarter (1% in the second and third quarters and 5% in the fourth quarter). Based on the second and third quarter estimates, the decline in domestic prices is roughly 0.4 percentage points larger in product categories with the median import share and a 1 percentage point larger decline in

[36] Since our instrument interacts the invoicing share with the import share, we must use the foreign-currency invoicing share rather than CHF-invoicing share that we use in Section 4.1.

[37] In Figure D.1 Panel (b) we show that, in the two years before January 2015, there was no statistically significant relationship between CHF invoicing at the border and retail price reductions for domestic goods.

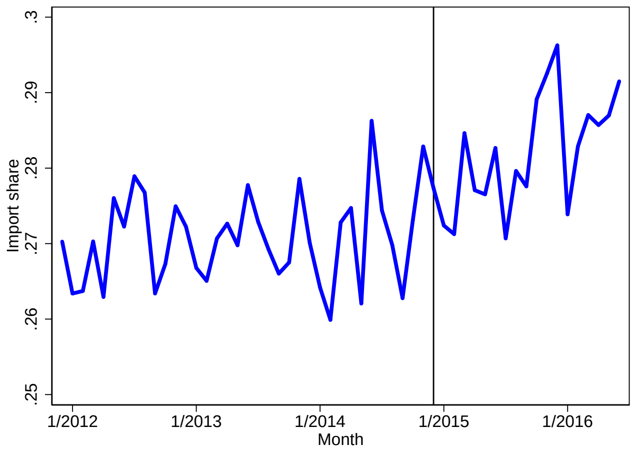
retail import prices.

In Appendix E we use a simple model of variable markups with flexible prices, following Gopinath et al. (2010) and Burstein and Gopinath (2014), to illustrate how our estimates can be used to infer the extent of strategic complementarities in the retail pricing of Swiss-produced goods with respect to imported goods.

5 Expenditure switching to imports

In this section we show that the above-documented changes of relative prices are systematically associated with changes in expenditure shares of imported goods at the retail level.

Figure 4: *Aggregate expenditure share on imports*



Notes: This figure shows the average import share, calculated as total expenditures on imported retail products over total expenditures on all retail products per month. The vertical line shows December 2014, the month just before the appreciation.

Figure 4 displays the ratio of total expenditures on imported goods relative to total expenditures in our data at a monthly frequency. Import shares are highly cyclical and volatile, since households in our data do not purchase the same goods every period. To reduce the role of these monthly fluctuations in import shares, we focus on changes in longer time horizons: the 12-month period January-December 2015 versus January-December

2014, and the 17-month period January 2015-May 2016 versus January 2013-May 2014.[38] The rise in the import share is 0.76 percentage points in the 12-month horizon and 0.95 percentage points in the 17-month horizon. These percentage point increases represent 2.8% and 3.6%, respectively, of the average import share 2 years before January 2015. Within product categories, import shares increased on average (weighting product categories by their pre-shock import expenditures) by 1.8% and 2.4% (relative to their average 2 years before January 2015) at the 12- and 17-month horizon, respectively.

To examine the cross section of expenditure switching towards imported goods, we consider an estimation of the form

$$\Delta_k ms_i = \alpha + \beta * (\Delta_k p_{g(i)}^{borimp} - \Delta_k p_{g(i)}^{prdall}) + \varepsilon_i. \quad (5)$$

For imported good i and for the $k = 12-, 17-$ month periods defined above, $\Delta_k ms_i$ denotes the change in the logarithm of the expenditure share of imported good i in its product category $g(i)$. $\Delta_k p_{g(i)}^{borimp}$ denotes the average change (over the same time period) in the logarithm of border prices in product category $g(i)$ and $\Delta p_{g(i)}^{prdall}$ denotes the average change in the logarithm of the producer price index (over Swiss-produced and imported goods) in product category $g(i)$.[39]

OLS estimates, reported in column (1) of Table 8, are negative at both time horizons and are significant at the 5 percent (1 percent) level at the 12-month (17-month) horizon. This implies that expenditures rise disproportionately for those imported goods with a falling relative border price compared with December 2014.

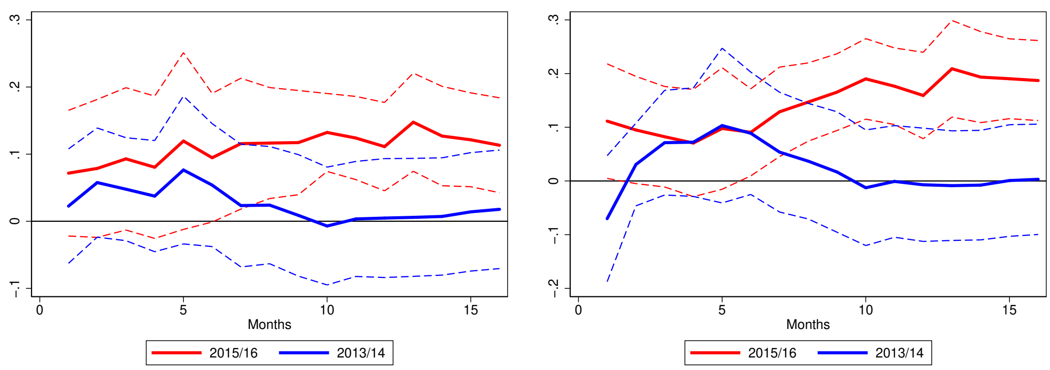
Based on the findings in Section 4.1, we next leverage heterogeneity in the pre-shock CHF-invoicing share in border product category $g(i)$ as driver of heterogenous responses to the appreciation. We first document the reduced-form relationship between changes in expenditure shares and CHF-invoicing share by estimating specification (5) where we replace the right-hand side relative price by $\left(1 - CHFShare_{g(i)}\right)$ (calculated in December

[38]When we consider a 12-month time period, results are very similar if the pre-appreciation period covers 2013 or 2014, as import shares did not display any trends in the pre-appreciation period.

[39]We construct $p_{g(i)}^{prdall}$ as an average (weighted by the import expenditure share in product category $g(i)$) of $p_{g(i)}^{borimp}$ and $p_{g(i)}^{prddom}$, where $p_{g(i)}^{prddom}$ is the PPI for domestic products in product category g.

2014). Our reduced-form estimates, reported in column (3) of Table 8, are significant at the 1 percent level and imply that 12 months (17 months) after December 2014, the expenditure share of imported goods in (hypothetical) fully foreign-invoiced categories rises by 5% (11%) more than in categories that are fully CHF-invoiced. To examine the dynamics of expenditure switching over time, we estimate this reduced-form relationship adding months sequentially between January 2015 and May 2016 (and between January 2013 and May 2014). The red line in the left panel of Figure 5 shows that β_k is increasing over time and becomes significant six months after January 2015. Again, these patterns are not explained by prior trends.[40] Because changes in the relative price of imported goods in a product category are a function of import shares,[41] we also consider the reduced-form relationship between changes in expenditure shares and import-adjusted CHF-invoicing shares, $\left(1 - CHFShare_{g(i)}\right) \times \left(1 - ImpShare_{g(i)}\right)$, both calculated in December 2014, which we use in the 2SLS that follows. Estimates are positive and significant at the 1 percent level, as reported in column (4) of Table 8 and in the right panel of Figure 5.

Figure 5: *Invoicing and expenditure switching*



(a) $(1 - CHFShare)$ (b) $(1 - CHFShare) \times (1 - ImpShare)$

Notes: This figure shows the reduced-form estimates of the relationship between $(1 - CHFShare_{g(i)})$ ($(1 - CHFShare_{g(i)}) \times (1 - ImpShare_{g(i)})$) and the changes in expenditure share within product category in Panel a) (in Panel b)). The red line shows the coefficients from adding months sequentially between January 2015 and May 2016. The blue line shows the same relationship in prior years between January 2013 and May 2014. Dashed lines show 95% confidence intervals.

[40] In the pre-trend analysis, displayed as the blue line in Figure 5, we do not observe a significant relationship between changes in import shares and CHF invoicing before 2015.

[41] Using the definition of product category price changes in footnote 39, $\left(\Delta p^{borimp}_{g(i)} - \Delta p^{prdall}_{g(i)}\right) = (1 - ImpShare_{g(i)}) \times \left(\Delta p^{borimp}_{g(i)} - \Delta p^{prddom}_{g(i)}\right)$.

Table 8: *Expenditure switching towards imports: cross-section regressions*

	Jan 15 – Dec 15					
	(1) OLS	(2) OLS	(3) Red. form	(4) Red. form	(5) 2SLS	(6) 2SLS
Δ relative border price	-0.708**				-1.031***	
	[0.305]				[0.248]	
Δ relative retail price		0.062				-2.865*
		[0.134]				[1.575]
$1 - CHFShare$			0.053***			
			[0.019]			
$(1 - CHFShare) \times (1 - ImpShare)$				0.114***		
				[0.030]		
Observations	2447	2447	2447	2447	2447	2447
F first stage					81.5	7.3
p-value					0.000	0.011

	Jan 15 – May 16					
	(1) OLS	(2) OLS	(3) Red. form	(4) Red. form	(5) 2SLS	(6) 2SLS
Δ relative border price	-1.536***				-1.663***	
	[0.419]				[0.366]	
Δ relative retail price		-0.121				-3.894**
		[0.273]				[1.618]
$1 - CHFShare$			0.105***			
			[0.030]			
$(1 - CHFShare) \times (1 - ImpShare)$				0.169***		
				[0.035]		
Observations	2346	2346	2346	2346	2346	2346
F first stage					53.2	7.3
p-value					0.000	0.011

Notes: Column 1 (column 5) reports OLS (2SLS) estimates of the change in expenditure shares within product categories for imported retail products to log changes in relative border prices, as in equation (5). Column 2 (column 6) reports OLS (2SLS) estimates of the change in expenditures within product categories for imported retail products to log changes in relative retail prices, as in equation (6). Log changes in relative prices are instrumented by the share of products that are invoiced in foreign currency in the corresponding border product category, $\left(1 - CHFShare_{g(i)}\right)$, multiplied by $\left(1 - ImpShare_{g(i)}\right)$, both calculated in December 2014. Columns 3 and 4 report the reduced form relationship between changes in market shares and $\left(1 - CHFShare_{g(i)}\right)$ and $\left(1 - CHFShare_{g(i)}\right) \times \left(1 - ImpShare_{g(i)}\right)$. Observations are weighted by product expenditures during 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Underlying these reduced-form estimates, invoicing affects expenditure switching via its impact on prices. We consider a 2SLS estimation, where the first stage relates import-adjusted CHF invoicing shares in December 2014 to border relative price change across product categories, and the second stage relates border relative price changes to changes in expenditure shares. In order to interpret our estimates as an elasticity of substitution between imported and Swiss goods within product categories, shocks after December 2014 that induce changes in import quantities other than via prices (such as demand shocks for imported goods) must be uncorrelated with December 2014 import-adjusted invoicing shares across product categories.

A 1% decline in the relative border price of imported goods is associated with an increase in import expenditure shares (within product categories) of around 1.0% (1.7%) for the 12-month (17-month) horizon, significant at the 1% level (column 5 of Table 8). The implied elasticity of substitution between Swiss-produced and imported goods is roughly 2 (2.7) for the 12-month (17-month) horizon. The fact that cross-sectional expenditure switching towards imports is larger at 17-month horizons than at 12-month horizons is consistent with the observation above that average expenditure switching is higher at longer time horizons.

Finally, we evaluate the relationship between expenditure switching towards imported goods and relative prices at the retail level (as opposed to relative prices at the border). Specifically, we consider estimates of the form

$$\Delta_k ms_i = \alpha + \beta * (\Delta_k p_i^{retimp} - \Delta_k p_{g(i)}^{retall}) + \varepsilon_i. \quad (6)$$

where $\Delta_k p_i^{retimp}$ denotes the change in the logarithm of the retail price of imported good i and $\Delta_k p_{g(i)}^{retall}$ denotes the change in the logarithm of the retail price index (over Swiss produced and imported goods) in product category $g(i)$.[42]

Column (2) in Table 8 shows that OLS estimates of β are not significantly different from zero. In column (6), we consider the same specification but instrumenting for the relative retail price of good i with the associated border product category's import-adjusted CHF-invoicing share in December 2014, $\left(1 - CHFShare_{g(i)}\right) \times \left(1 - ImpShare_{g(i)}\right)$. The estimates of β are

[42] We construct $p_{g(i)}^{retall}$ as an average (weighted by the import expenditure share in product category $g(i)$) of $p_{g(i)}^{retimp}$ and $p_{g(i)}^{prddom}$, where $p_{g(i)}^{prddom}$ was defined above.

negative but less tightly estimated than those based on relative prices at the border (they are significant at the 10 and 5 percent levels for the 12- and 17-month horizons, respectively). The elasticity of substitution implied by our point estimates is 3.9 at the 12-month horizon and 4.9 at the 17-month horizon.

6 Intensive and extensive margins of retail price adjustment

In this section we study the role of nominal rigidities in incomplete exchange rate pass-through to retail import prices that we documented in Section 3. The average change in prices in period t can be decomposed into an extensive margin defined as the fraction of non-zero price change (or frequency of price adjustment), fr_t, and an intensive margin defined as the average size of non-zero price changes, $size_t$. The extensive margin can be further decomposed into the fraction of positive and negative price changes, fr_t^{up} and fr_t^{down}, and the average size of price increases and decreases, $size_t^{up}$ and $size_t^{down}$:

$$Average\ price\ change_t = fr_t \times size_t = fr_t^{up} \times size_t^{up} - fr_t^{down} \times size_t^{down}.$$

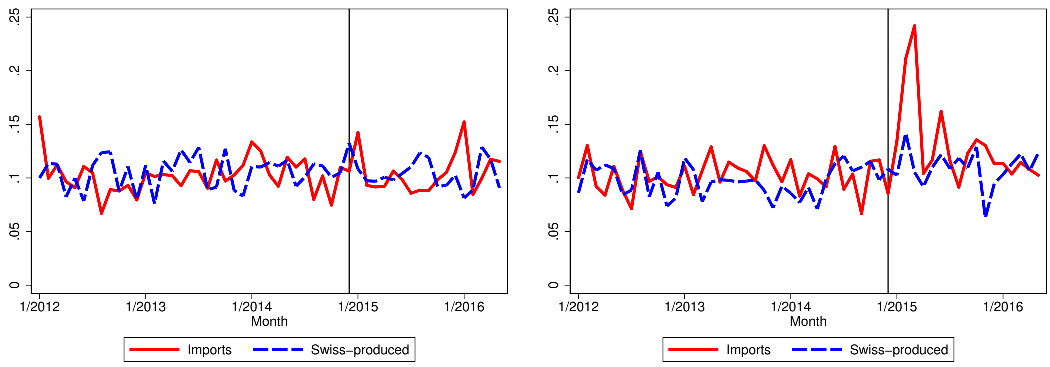
In what follows below, we thus decompose average price changes into the fraction of price adjustments and their average size, and show that the decline of import retail prices is accounted for by a large increase in the fraction of price reductions, which more than offsets a *decline* in the absolute size of price reductions. We provide various robustness checks in Appendix F.[43] We complement our aggregate evidence with cross-product information and variation in invoicing at the border.

[43] The border-price data are not as well suited to measure the degree of nominal price adjustment since for our set of goods, prices are collected at quarterly frequencies. Nonetheless, in Appendix G we document a large increase in the frequency of price reductions after the January 2015 CHF appreciation, without a sizable change in the average size of price reductions.

6.1 Extensive margin of price adjustment

In Figure 6 we document the evolution of the fraction of price changes over time between 2012 and 2016, separately for imported goods and Swiss-produced goods.[44] The average monthly frequency of price adjustment over this time period, combining increases and decreases, is roughly 0.2. If we exclude temporary price reductions (as discussed in the robustness analysis below), the average monthly frequency is 0.1.

Figure 6: *Fraction of price changes: increases and decreases*



(a) Increases (b) Decreases

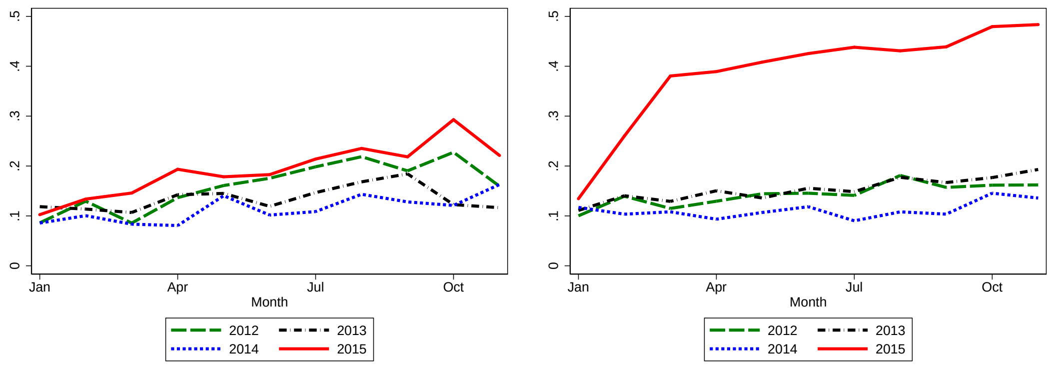
Notes: Panel (a) shows the average fraction of price increases for all imported EANs (solid line) and for all domestically produced EANs (dashed lines). The right panel (b) shows price decreases for the same sample splits. The fractions are calculated as a monthly unweighted average over all EANs: the fraction of price changes per EAN and month is the fraction of individual price changes observed for each EAN within the same month. An individual price change is defined as a non-zero log-difference of the modal price observed per EAN-retailer-region combination from one month to the next. The vertical line indicates December 2014.

Following the January 2015 CHF appreciation, there is a pronounced increase in the fraction of price changes of imported goods. This is largely accounted for by an increase in the frequency of price reductions, fr_t^{down}, which roughly doubles in February and March 2015, compared with its pre-shock level (Figure 6, Panel b). The frequency of price increases, fr_t^{up}, remains roughly constant relative to the same month in previous years (Panel a). For Swiss-produced goods, there are no noticeable changes in the fraction of price increases or decreases around the time of the CHF appreciation.

[44] We first calculate the fraction and size of price changes for individual product i across regions and retailers in a given month and then calculate unweighted averages of these statistics across all imported products and across all Swiss-produced products for each border product category. Finally, we average across all border product categories. If we weight product categories using category expenditures, we obtain similar results, as reported in Figure F.12 in the Appendix.

In Figure 7, we display, for every month, the fraction of imported products with a price that is lower than in December of the previous year. For example, a value of 0.35 in March 2015 means that 35% of prices were lower in March 2015 relative to December 2014. We can observe that in 2015 (relative to previous years) there was a significant increase in the fraction of imported products with a price reduction: more than 40% of products decreased in price by April 2015 and more than 50% by the end of the year (compared with roughly 20% in previous years). This suggests that the increase in the frequency of price reductions for imported goods after December 2014 was not due to temporary price reductions, but rather to persistent price reductions.

Figure 7: *Fraction of products with price reductions at different horizons*



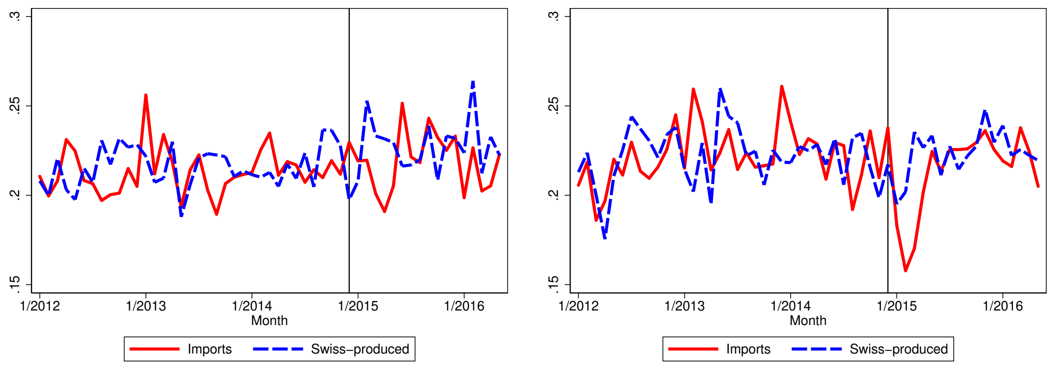
(a) Swiss-produced (b) Imports

Notes: Panel (a) shows the fraction of Swiss-produced goods with a price that is different from the price in December of the previous year as a function of the number of months since December. For example, the frequency of price changes for 2015 in March would show the average fraction of goods that changed prices between March 2015 and December 2014. Panel (b) shows the same figure for imported goods. Solid lines show the year 2015, dotted lines the year 2014, dash-dotted lines 2013, and dashed lines 2012.

6.2 Intensive margin of price adjustment

In Figure 8 we document the evolution of the average size of non-zero price changes over time between 2012 and 2016. For imported goods, there was a significant decline in the absolute size of price reductions for imported goods in early 2015 (from around 22% to 16%), while the size of price increases fell only slightly (from roughly 21% to 20%). The size of price changes did not change much for Swiss-produced goods.[45] In Figure F.1 we show that the reduction in the size of price changes in early 2015 was not driven by temporary price reductions that were quickly reverted.

Figure 8: *Average size of price changes: increases and decreases*



(a) Increases (b) Decreases

Notes: Panel (a) shows the absolute average size of price increases for imports (solid line) and domestically produced goods (dashed line). Panel (b) shows the absolute average size of price decreases (same sample split). The average of the absolute size of increases and the average of the absolute size of decreases are calculated by averaging individual price changes over all retailers and regions, and then per EAN and month. An individual price change is defined as a change in the modal price observed per EAN-retailer-region combination from one month to the next. The vertical line indicates December 2014.

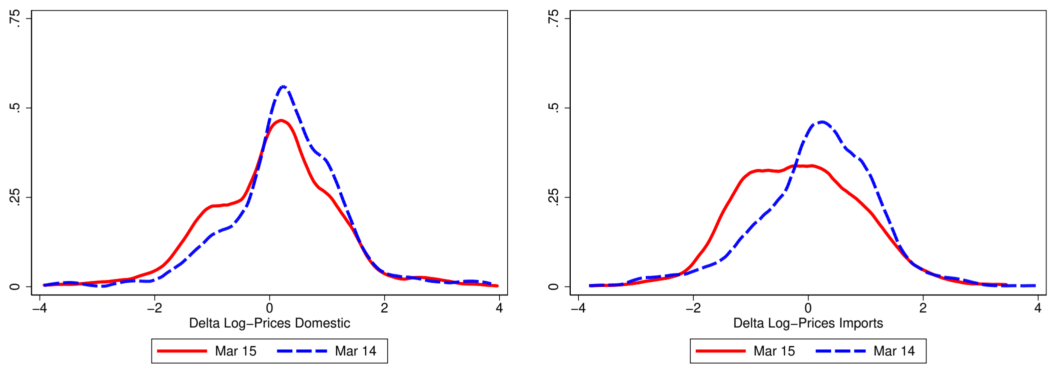
To zoom in on the decline in the average size of price changes in the first months of 2015, in Figure 9 we plot the distribution of non-zero standardized price changes across individual products between February and March 2015 (the month with the largest average price reductions) and compare it with the distribution of price changes between the same months in 2014. We standardize price changes to reduce the role of measurement error and underlying heterogeneity across goods, as discussed in Alvarez et al. (2017).[46] Figure 9 displays a kernel

[45]The average absolute size of price changes that we report is larger than the average size of price changes for unprocessed food (around 15%) and processed food (around 8%) reported for Europe in Dhyne et al. (2006) or for the US in Nakamura and Steinsson (2008). However, the average size of price changes in our data is in line with price-setting statistics in European homescan data as reported in Beck and Lein (2015), who argue that using modal prices per product, similar to Eichenbaum et al. (2014), increases the size of price changes because many small price changes are erratic and the modal price is more robust to measurement error. Eichenbaum et al. (2014) show in their scanner level data that the median size of price adjustments increases from 10% to 30% after taking measurement error into consideration.

[46] Standardized price changes for good i in a given month are defined as (log change in price of good i in a given month minus average log price change) divided by standard deviation of log price changes. Following Alvarez et al. (2017), average and standard deviation of price changes are calculated over all months (excluding the first quarter of 2015) with a non-zero price change across goods in the same product category and source (Swiss-produced or import) sold in the same region as product i.

estimate of these distributions, for Swiss-produced goods (left panel) and for imported goods (right panel). For Swiss-produced goods, there is no noticeable shift in the distribution of standardized non-zero price changes between 2014 and 2015. For imported goods, the CHF appreciation clearly shifts the distribution to the left. Given the presence of small price changes, this movement in the distribution increases the number and reduces the average size of price reductions.

Figure 9: *Distribution of import and Swiss-produced standardized price changes in March 2014 and March 2015*



(a) Swiss-produced (b) Imports

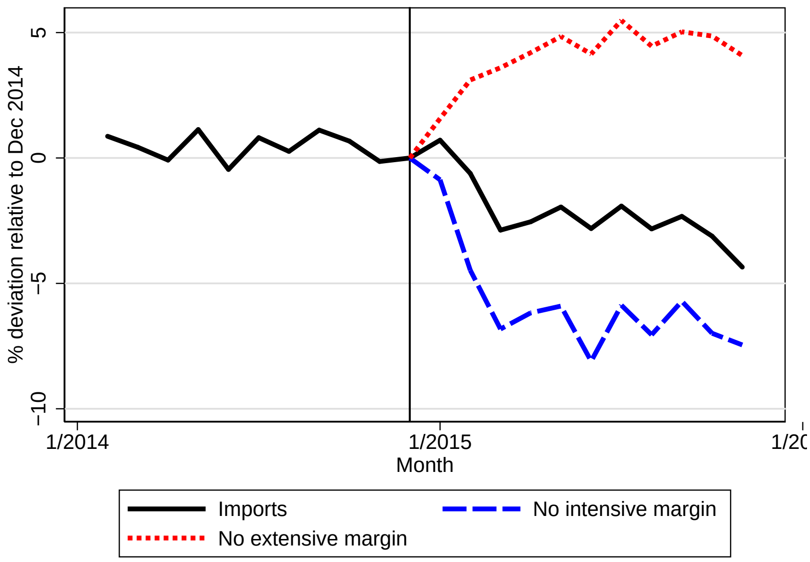
Notes: Panel (a) shows a kernel estimate of the distribution of monthly log non-zero standardized price changes (dashed line for price changes between February and March 2014, and solid line for price changes between February and March 2015) for Swiss-produced goods. Panel (b) shows the analogous distribution for imported products. Standardized price changes are calculated as described in footnote 46.

6.3 Margins of adjustment and counterfactual changes in import prices

In order to quantify the role of changes in the intensive and extensive margins on the average retail price change of imported goods, we perform simple data-based counterfactuals using the decomposition in equation (6).

We first feed the actual path of average cumulative size of price increases and decreases in the period January-December 2015 relative to December 2014, while we fix the cumulative fraction of import price increases and decreases at their levels in the respective month in 2014 (relative to December 2013). In the second counterfactual, we feed the actual path of the cumulative fraction of price increases and decreases in the period January-December 2015 relative to December 2014, while we fix the cumulative average size of price increases and decreases at their levels in the respective month in 2014 (relative to December 2013). If we combine the actual path of frequencies and average size of price changes, we recover the retail price index for imported goods displayed in Figure 3.

Figure 10: *Extensive, intensive margins and average price changes*



Notes: This figure compares actual retail import price changes to those under two counterfactual exercises quantifying the role of intensive and extensive margins. The solid black line shows the actual average change in retail import prices. The red dotted line shows the first counterfactual assuming that the frequency of price increases and decreases remained at their 2014 levels (December 2013-December 2014) after the appreciation, while the size of the price changes is that of the data. The blue dashed line instead shows the second counterfactual assuming that the size of price increases and decreases remained at their 2014 levels after the appreciation, while the frequency of price increases and decreases is that of the data.

Figure 10 displays the implied average price change under these two counterfactuals, as well as the average retail price change of imported goods in the data. Under the first counterfactual scenario, in which we fix the frequency of price adjustment at pre-appreciation levels, import prices would have risen by 3.6% (4.1%) one (two) quarters after the shock rather than having fallen by 2.9% (2.8%) as they did in the data. This is because the size of price reductions fell around that period. Conversely, under the second counterfactual scenario in which we fix the average size of price changes at pre-shock levels, import prices would have fallen by more than twice as much as they did in the data (6.8% in the first quarter, 8.1% in the second quarter). This is so as the frequency of price reductions increased substantially during this period.[47]

6.4 Border price changes, invoicing, and margins of price adjustment

In this subsection we show that these extensive and intensive margins of retail price adjustment vary systematically across imported goods with respect to the size of border price changes and invoicing currency. Specifically, we show that larger reductions in border prices (and, similarly, lower foreign-currency invoicing of border prices) result in i) larger increases in the fraction of price reductions and ii) larger reductions in the average size of price reductions.

We define Δfr_i^{down} as the frequency of retail price reductions for product i (across regions and retailers) between December 2014 and March 2015 minus the frequency of price reductions between December 2013 and March 2014.[48] Similarly, we define $\Delta size_i^{down}$ as the average size of price reductions between December 2014 and March 2015 minus the average size of price reductions between December 2013 and March 2014. We focus only on the first quarter of 2015 since we observe the largest aggregate changes in the frequency and size of price adjustment during this period.

Table 9 presents estimates of a linear regression between Δfr_i^{down} and the respective change in border price $p_{g(i)}^{borimp}$ (column 1), share of CHF invoicing of border prices $CHF_{g(i)}$ (column (2)) and border prices instrumented by CHF invoicing (column (3)). Columns (4)-(6) present estimates for similar regressions where the dependent variable is $\Delta size_i^{down}$ rather than Δfr_i^{down}.

The increase in the frequency of price reductions is more pronounced for goods with larger border price reductions. According to our OLS estimates (column (1)), the increase in the frequency of retail price reductions in the first quarter of 2015 (relative to the frequency of price reductions in the first quarter of 2014) is roughly 0.2 larger for imported goods in product

[47] Changes in these margins played a small role in accounting for the inflation dynamics of Swiss-produced goods, since neither the intensive nor the extensive margin changed substantially after the appreciation of the CHF.

[48] The measures of frequency and size of price changes for individual products that we use here are the ones we used above to construct our aggregate frequency and size measures.

categories with a 10 percentage point larger decline in border prices. Relatedly, the increase in the frequency of retail price reductions is roughly 0.2 smaller for imported products in product categories with border prices that are (hypothetically) fully CHF-invoiced compared with product categories fully invoiced in foreign currencies. 2SLS estimates (column 3) are larger than the OLS estimates. Estimates are significant at the 5, 10, and 5 percent levels, respectively.

Mirroring the above, the decline in the absolute size in retail price changes is more pronounced for goods with larger border price reductions. According to the OLS estimates (column (4)), the decline in the average size of retail price reductions in the first quarter of 2015 (relative to the average size of price reductions in the first quarter of 2014) is roughly 4.2 percentage points smaller for imported goods with a 10 percentage point smaller decline in border prices. Further, the decline in the average size of price reductions is substantially smaller for imported products in CHF-invoiced border product categories. 2SLS estimates (column (3)) are roughly double the magnitude of OLS estimates (column (2)). Estimates are significant at the 5, 5, and 1 percent levels, respectively.

Table 9: *The fraction and size of retail import price decreases and border prices/invoicing*

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

Notes: Dependent variable is the fraction of price reductions (absolute size of a price reduction, conditional on observing a reduction) between December 2014 and March 2015 (Q1), (June, Sept, Dec 2015; Q2, Q3, Q4) for product i observed over all regions and retailers where the product is observed. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

In Appendix H we use a simple Ss pricing model to understand the negative co-movement between the change in the frequency of price adjustment and the change in the absolute size of price changes of imported goods at the consumer level that we documented in response to the 2015 CHF appreciation. We show that this observation can be accounted for quite naturally in our model with a selection of price changes in response to the shock induced by a fat-tailed distribution of idiosyncratic cost shocks.

7 Conclusion

In this paper, we provided a range of facts on how prices and expenditures of consumer goods in Switzerland responded to a unique exchange rate shock: the SNB's removal of the lower bound on the EUR/CHF exchange rate on January 15, 2015, which resulted in a large and unanticipated appreciation of the CHF against all currencies. Our border and household scanner-level data allow us to link invoicing first to border prices and then to retail prices, and thus to quantify the sources of incomplete pass-through from the border to the consumer level. Differences across goods in border price changes and in pre-shock invoicing currency are strongly associated with changes in consumer prices and expenditures of imported goods, as well as to prices of Swiss-produced goods competing in the same product category. In spite of the large increase in the extent of nominal price reductions for imported goods, aggregate pass-through remains low because of an offsetting decline in the average size of price reductions. This response of the extensive and intensive margins are consistent with an Ss pricing rule with idiosyncratic shocks that give rise to a fat-tailed distribution of price changes.

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Appendix to "Exchange Rates and Prices: Evidence from the 2015 Swiss Franc Appreciation"

A Macroeconomic indicators

Table A.1: *Main macroeconomic indicators for Switzerland 2013–2016*

	2012	2013	2014	2015	2016
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%

Sources: State Secretariat of Economic Affairs (SECO), SFSO.

B Product category matching, expenditure shares and invoicing

Table B.1: *Product categories in the retail and border price data*

Retail category	Expend. Share (%)	Border category	CHF inv. share (%)	Expend. Share (%)
Gellant	0.27	Amylum and amylum products	71.43	0.67
Amylum products	0.40	Amylum and amylum products	71.43	0.67
Cat food	0.07	Animal feed for pets	100.00	0.79
Other animal food	0.23	Animal feed for pets	100.00	0.79
Animal food	0.11	Animal feed for pets	100.00	0.79
Other pet food	0.38	Animal feed for pets	100.00	0.79
Other pastries	0.36	Bakery products	50.00	7.05
Flans	0.56	Bakery products	50.00	7.05
Torts/Pies/Cake	0.51	Bakery products	50.00	7.05
Big bread	0.20	Bakery products	50.00	7.05
Small bread	0.23	Bakery products	50.00	7.05
Bread products	0.93	Bakery products	50.00	7.05
Piece items	0.94	Bakery products	50.00	7.05
Cookies	0.35	Bakery products	50.00	7.05
HB/pastries	0.42	Bakery products	50.00	7.05
Crispbread	0.25	Bakery products	50.00	7.05
Long durable	0.25	Bakery products	50.00	7.05
Tortillas/Tacos	0.84	Bakery products	50.00	7.05
Sweden bread	0.08	Bakery products	50.00	7.05
Whole-grain cracker	0.17	Bakery products	50.00	7.05
Rusk	0.30	Bakery products	50.00	7.05
Apero pastry	0.28	Bakery products	50.00	7.05
Durable bakery products	0.39	Bakery products	50.00	7.05
Coal zinc	0.02	Batteries and accumulators	61.54	0.45
Battery	0.25	Batteries and accumulators	61.54	0.45

Continued: Product categories in the retail and border price data

Retail category	Expend. Share (%)	Border category	CHF inv. share (%)	Expend. Share (%)
Lithium	0.01	Batteries and accumulators	61.54	0.45
Alkali	0.17	Batteries and accumulators	61.54	0.45
Beer o/Alc	0.31	Beer	33.33	1.31
Beer variegated	0.41	Beer	33.33	1.31
Beer m/Alc	0.59	Beer	33.33	1.31
Intimate	0.21	Body care products and perfumes	37.50	1.92
Make-up body	0.03	Body care products and perfumes	37.50	1.92
Masks	0.00	Body care products and perfumes	37.50	1.92
Lipstick	0.00	Body care products and perfumes	37.50	1.92
Cosmetics	0.21	Body care products and perfumes	37.50	1.92
Shower	0.01	Body care products and perfumes	37.50	1.92
Eyes	0.00	Body care products and perfumes	37.50	1.92
Sun	0.03	Body care products and perfumes	37.50	1.92
Treatment	0.29	Body care products and perfumes	37.50	1.92
Women	0.01	Body care products and perfumes	37.50	1.92
Manicure	0.08	Body care products and perfumes	37.50	1.92
Razor accessories	0.19	Body care products and perfumes	37.50	1.92
Care	0.01	Body care products and perfumes	37.50	1.92
Accessories	0.01	Body care products and perfumes	37.50	1.92
Toothbrushes	0.01	Body care products and perfumes	37.50	1.92
Oral hygiene	0.00	Body care products and perfumes	37.50	1.92
Hair removal	0.08	Body care products and perfumes	37.50	1.92
Coloration	0.20	Body care products and perfumes	37.50	1.92
Make-up face	0.01	Body care products and perfumes	37.50	1.92
Styling	0.01	Body care products and perfumes	37.50	1.92
Nail polish	0.19	Body care products and perfumes	37.50	1.92
Toothpaste	0.08	Body care products and perfumes	37.50	1.92
Deodorant	0.00	Body care products and perfumes	37.50	1.92
Shampoo	0.01	Body care products and perfumes	37.50	1.92
Cleaning	0.02	Body care products and perfumes	37.50	1.92
Head/Hair care	0.03	Body care products and perfumes	37.50	1.92
Men hair care	0.01	Body care products and perfumes	37.50	1.92
Jewellery	0.18	Body care products and perfumes	37.50	1.92
Semi hard	0.53	Cheese	52.63	3.00
Cream cheese	0.92	Cheese	52.63	3.00
Soft	0.68	Cheese	52.63	3.00
Hard	0.49	Cheese	52.63	3.00
Melted	0.38	Cheese	52.63	3.00
Coffee beans	0.18	Coffee	88.24	1.67
Coffee dissolvable	0.80	Coffee	88.24	1.67
Coffee complements	0.68	Coffee	88.24	1.67
Chocolate neapolitans	0.60	Coffee and chocolate products	96.00	2.53
Chocolate/Cocoa powder	0.16	Coffee and chocolate products	96.00	2.53
Chocolate bars	0.31	Coffee and chocolate products	96.00	2.53
Chocolate seasonal articles	0.22	Coffee and chocolate products	96.00	2.53
Chocolate branches	0.31	Coffee and chocolate products	96.00	2.53
Chocolate dragees	0.15	Coffee and chocolate products	96.00	2.53
Chocolate tablets	0.23	Coffee and chocolate products	96.00	2.53
Chocolate rest	0.12	Coffee and chocolate products	96.00	2.53
Chocolate marshmallow	0.13	Coffee and chocolate products	96.00	2.53
Chocolate pralines	0.30	Coffee and chocolate products	96.00	2.53
Chewing gum	0.18	Confectioneries	100.00	1.33
Fruit gum	0.34	Confectioneries	100.00	1.33
Breath freshener	0.11	Confectioneries	100.00	1.33

Continued: Product categories in the retail and border price data

Retail category	**Expend. Share (%)**	**Border category**	**CHF inv. share (%)**	**Expend. Share (%)**
Bubble gum	0.23	Confectioneries	100.00	1.33
Sugar Confectionery	0.11	Confectioneries	100.00	1.33
Sweetened	0.25	Confectioneries	100.00	1.33
Specialities	0.02	Confectioneries	100.00	1.33
Candy	0.08	Confectioneries	100.00	1.33
Dessert products	0.02	Confectioneries	100.00	1.33
DF Vegetabl./Mushr.	0.48	Convenience food	66.67	8.89
DF Bakery products	0.35	Convenience food	66.67	8.89
Mashed potatoes	0.15	Convenience food	66.67	8.89
DF Ice cream	0.14	Convenience food	66.67	8.89
DF Poultry	0.28	Convenience food	66.67	8.89
Cook set/Meal kits	0.35	Convenience food	66.67	8.89
DF Rest	0.36	Convenience food	66.67	8.89
DF Desserts	0.46	Convenience food	66.67	8.89
DF Pasta	1.38	Convenience food	66.67	8.89
Convenience food	1.05	Convenience food	66.67	8.89
DF Fish	0.23	Convenience food	66.67	8.89
DF Convenience food	0.84	Convenience food	66.67	8.89
DF potatoes	0.48	Convenience food	66.67	8.89
Conven. food at home	0.36	Convenience food	66.67	8.89
DF Pizza	0.41	Convenience food	66.67	8.89
Instant salad	0.02	Convenience food	66.67	8.89
DF Meat	0.00	Convenience food	66.67	8.89
Pizza	0.36	Convenience food	66.67	8.89
DF Fruits	0.55	Convenience food	66.67	8.89
DF Seafood	0.65	Convenience food	66.67	8.89
Razor blades	0.19	Cutlery	20.00	0.19
Chicken eggs	1.65	Eggs	50.00	1.65
Accessories eyeglass	0.02	Eyeglasses, lenses, related items	50.00	0.03
Lens cleaning	0.00	Eyeglasses, lenses, related items	50.00	0.03
Fish	0.15	Fish and fish products	60.00	2.58
Seafood	1.51	Fish and fish products	60.00	2.58
Salmon	0.45	Fish and fish products	60.00	2.58
Canned fish	0.47	Fish and fish products	60.00	2.58
Apple juice	0.40	Fruit and vegetable juices	75.00	1.83
Vegetable juice	0.40	Fruit and vegetable juices	75.00	1.83
Nectar	0.17	Fruit and vegetable juices	75.00	1.83
Lemon juice/contentr.	0.18	Fruit and vegetable juices	75.00	1.83
Pippin juice	0.39	Fruit and vegetable juices	75.00	1.83
Fruit juice	0.29	Fruit and vegetable juices	75.00	1.83
Power food	0.25	Homogenized and dietetic food	100.00	2.81
Treacles	0.14	Homogenized and dietetic food	100.00	2.81
Face care dragees	0.23	Homogenized and dietetic food	100.00	2.81
Dietetic meals/drinks	0.00	Homogenized and dietetic food	100.00	2.81
Sweetenings	0.38	Homogenized and dietetic food	100.00	2.81
Unsweetened	0.29	Homogenized and dietetic food	100.00	2.81
Nuts	0.16	Homogenized and dietetic food	100.00	2.81
Vitamins	0.21	Homogenized and dietetic food	100.00	2.81
Baby food	0.40	Homogenized and dietetic food	100.00	2.81
Food complements	0.58	Homogenized and dietetic food	100.00	2.81
Powder	0.18	Homogenized and dietetic food	100.00	2.81
Sticks	0.08	Household&hygiene prod. pulp and paper	33.33	7.20
Gloves	0.26	Household&hygiene prod. pulp and paper	33.33	7.20
Wool	2.50	Household&hygiene prod. pulp and paper	33.33	7.20

Continued: Product categories in the retail and border price data

Retail category	Expend. Share (%)	Border category	CHF inv. share (%)	Expend. Share (%)
Coffee filter	0.18	Househ.&hygiene prod. pulp and paper	33.33	7.20
Tampons	0.16	Househ.&hygiene prod. pulp and paper	33.33	7.20
Toilet paper	0.17	Househ.&hygiene prod. pulp and paper	33.33	7.20
Panty liners	0.02	Househ.&hygiene prod. pulp and paper	33.33	7.20
Bags	0.07	Househ.&hygiene prod. pulp and paper	33.33	7.20
Condoms	0.11	Househ.&hygiene prod. pulp and paper	33.33	7.20
Wet wipes	0.05	Househ.&hygiene prod. pulp and paper	33.33	7.20
Humid	0.18	Househ.&hygiene prod. pulp and paper	33.33	7.20
Bandages	0.18	Househ.&hygiene prod. pulp and paper	33.33	7.20
Baking paper	0.10	Househ.&hygiene prod. pulp and paper	33.33	7.20
One-way nappies	0.78	Househ.&hygiene prod. pulp and paper	33.33	7.20
Cleansing tissue	0.19	Househ.&hygiene prod. pulp and paper	33.33	7.20
Films	0.15	Househ.&hygiene prod. pulp and paper	33.33	7.20
Patches	0.37	Househ.&hygiene prod. pulp and paper	33.33	7.20
Table deco	0.44	Househ.&hygiene prod. pulp and paper	33.33	7.20
Vacuum cleaner bag	0.21	Househ.&hygiene prod. pulp and paper	33.33	7.20
Dry cleaning	0.21	Househ.&hygiene prod. pulp and paper	33.33	7.20
Household paper	0.18	Househ.&hygiene prod. pulp and paper	33.33	7.20
Circular flower beds	0.04	Househ.&hygiene prod. pulp and paper	33.33	7.20
Shopping help	0.21	Househ.&hygiene prod. pulp and paper	33.33	7.20
Disposable bags	0.37	Househ.&hygiene prod. pulp and paper	33.33	7.20
Pork sausage	0.01	Meat products	55.56	5.02
Other sausage products	1.33	Meat products	55.56	5.02
Beef sausage	1.18	Meat products	55.56	5.02
Canned meat/poultry	0.82	Meat products	55.56	5.02
Other charcuterie	0.81	Meat products	55.56	5.02
Chicken sausage	0.56	Meat products	55.56	5.02
Beef charcuterie	0.09	Meat products	55.56	5.02
Veal sausage	0.22	Meat products	55.56	5.02
M/CO2	0.51	Mineral water	100.00	0.83
O/CO2	0.32	Mineral water	100.00	0.83
Cooking oil	1.76	Oils and fats (without margarine)	88.46	3.12
Cooking fat	0.64	Oils and fats (without margarine)	88.46	3.12
Butter	0.72	Oils and fats (without margarine)	88.46	3.12
Tofu/Soja	0.19	Other foods	28.57	0.95
Honey	0.28	Other foods	28.57	0.95
Apero nuts/Nut mix	0.26	Other foods	28.57	0.95
Snacks other	0.22	Other foods	28.57	0.95
Meat, veal	0.82	Other meat	79.66	2.33
Meat, beef	0.68	Other meat	79.66	2.33
Other meat	0.83	Other meat	79.66	2.33
Desserts	0.49	Other dairy products	36.84	5.13
Cream	0.37	Other dairy products	36.84	5.13
Yoghurt	1.11	Other dairy products	36.84	5.13
Milk concentrate	0.27	Other dairy products	36.84	5.13
Milk drinks	1.20	Other dairy products	36.84	5.13
Curd	0.52	Other dairy products	36.84	5.13
Milk fresh	0.39	Other dairy products	36.84	5.13
Margarine	0.78	Other dairy products	36.84	5.13
Cereal	0.49	Other milling products	69.23	6.99
Rtec	0.33	Other milling products	69.23	6.99
Accessories drink prep.	0.22	Other milling products	69.23	6.99
Flour	5.26	Other milling products	69.23	6.99
Grain/works	0.38	Other milling products	69.23	6.99
Baking ingredient	0.29	Other milling products	69.23	6.99

Continued: Product categories in the retail and border price data

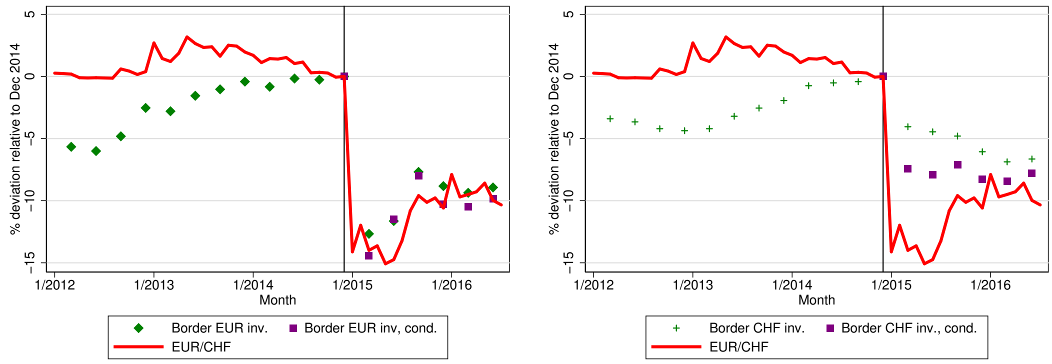
Retail category	Expend. Share (%)	Border category	CHF inv. share (%)	Expend. Share (%)
Fruit/Nut mix	0.26	Other proc. fruits and vegetables	83.02	3.52
Fruits dried	0.33	Other proc. fruits and vegetables	83.02	3.52
Appetizers	0.25	Other proc. fruits and vegetables	83.02	3.52
Mustard fruits	0.17	Other proc. fruits and vegetables	83.02	3.52
Vinegar tins	0.32	Other proc. fruits and vegetables	83.02	3.52
Jam	0.08	Other proc. fruits and vegetables	83.02	3.52
Vegetable tins	0.32	Other proc. fruits and vegetables	83.02	3.52
Olives	0.23	Other proc. fruits and vegetables	83.02	3.52
Chips	0.30	Other proc. fruits and vegetables	83.02	3.52
Fruit tins	0.27	Other proc. fruits and vegetables	83.02	3.52
Vegetables dried	0.18	Other proc. fruits and vegetables	83.02	3.52
Vegetables/Apperizers	0.84	Other proc. fruits and vegetables	83.02	3.52
Paste products	0.25	Pasta	100.00	1.42
Pasta tins	0.52	Pasta	100.00	1.42
Dry Pasta	0.33	Pasta	100.00	1.42
Pasta	0.32	Pasta	100.00	1.42
Insecticides	0.11	Pesticides, plant protection&germicides	33.33	0.11
Face medicine	0.30	Pharmaceutical products	46.67	0.30
Pork charcuterie	0.78	Pork meat	55.56	1.52
Pork meat	0.75	Pork meat	55.56	1.52
Chicken meat	0.71	Poultry meat	90.91	1.90
Other poultry	0.97	Poultry meat	90.91	1.90
Chicken charcuterie	0.21	Poultry meat	90.91	1.90
Soap	0.21	Prod. for laundering&cleaning	25.00	2.35
Cleaning additive	0.13	Prod. for laundering&cleaning	25.00	2.35
Hand	0.98	Prod. for laundering&cleaning	25.00	2.35
Textile refiner	0.13	Prod. for laundering&cleaning	25.00	2.35
Cleaning cleaning agent	0.11	Prod. for laundering&cleaning	25.00	2.35
Air refresher	0.18	Prod. for laundering&cleaning	25.00	2.35
Machine	0.06	Prod. for laundering&cleaning	25.00	2.35
Toilet stones	0.10	Prod. for laundering&cleaning	25.00	2.35
Special products	0.21	Prod. for laundering&cleaning	25.00	2.35
Detergent	0.20	Prod. for laundering&cleaning	25.00	2.35
Addition	0.04	Prod. for laundering&cleaning	25.00	2.35
Ordinary table wine red	0.31	Red wine	67.02	1.22
Foreign wine	0.22	Red wine	67.02	1.22
Foreign wine rose	0.54	Red wine	67.02	1.22
Ordinary table wine rose	0.16	Red wine	67.02	1.22
Rice	0.39	Rice	100.00	0.39
Spice tea	0.27	Seasoning and sauces	51.72	4.63
Cold uncooked	0.38	Seasoning and sauces	51.72	4.63
Mayonnaise	0.20	Seasoning and sauces	51.72	4.63
Salad dressing uncooked	0.30	Seasoning and sauces	51.72	4.63
Wet soups uncooked	0.10	Seasoning and sauces	51.72	4.63
Aspic	0.15	Seasoning and sauces	51.72	4.63
Mustard	0.29	Seasoning and sauces	51.72	4.63
Horseradish	0.07	Seasoning and sauces	51.72	4.63
Marinade	0.23	Seasoning and sauces	51.72	4.63
Hot uncooked	0.31	Seasoning and sauces	51.72	4.63
Ketchup	0.18	Seasoning and sauces	51.72	4.63
Dried soups	0.45	Seasoning and sauces	51.72	4.63

Continued: Product categories in the retail and border price data

Retail category	**Expend. Share (%)**	**Border category**	**CHF inv. share (%)**	**Expend. Share (%)**
Tomato puree	0.33	Seasoning and sauces	51.72	4.63
Salt	0.95	Seasoning and sauces	51.72	4.63
Table vinegar	0.41	Seasoning and sauces	51.72	4.63
Soda machines	0.00	Small devices	42.86	0.22
Razors	0.22	Small devices	42.86	0.22
Soda concentrate	0.69	Soft drinks	100.00	1.77
Sweet water	0.24	Soft drinks	100.00	1.77
Sport/Energy drinks	0.20	Soft drinks	100.00	1.77
Ice-Tea	0.21	Soft drinks	100.00	1.77
Sirup	0.43	Soft drinks	100.00	1.77
Cooked convenience sauces	0.64	Soups and broths	100.00	1.08
Bouillon uncooked	0.44	Soups and broths	100.00	1.08
Sparkling wine pure	0.34	Sparkling wine	46.15	1.60
Cider	0.42	Sparkling wine	46.15	1.60
Wine/Sparkling wine mix	0.18	Sparkling wine	46.15	1.60
Champagne	0.66	Sparkling wine	46.15	1.60
Sweet wines	0.01	Sparkling wine	46.15	1.60
Fruit spirits	0.53	Spirits	76.92	3.81
White spirits	0.02	Spirits	76.92	3.81
Alcopops	0.01	Spirits	76.92	3.81
Hot wine/Punch	0.01	Spirits	76.92	3.81
Brandy	0.20	Spirits	76.92	3.81
Port wine/Sherry	0.43	Spirits	76.92	3.81
Whisky	1.38	Spirits	76.92	3.81
Aperitif	0.45	Spirits	76.92	3.81
Liqueur	0.78	Spirits	76.92	3.81
Sugar	0.40	Sugar	91.67	0.40
Portions	0.00	Tea	87.50	2.73
Black tea	2.31	Tea	87.50	2.73
Herbage/Fruit Tea	0.18	Tea	87.50	2.73
White tea	0.13	Tea	87.50	2.73
Assorted	0.12	Tea	87.50	2.73
Tinfoil	0.21	Tinfoil	33.33	0.21
Ordinary table wine white	0.25	White wine	60.00	0.55
Foreign wine white	0.30	White wine	60.00	0.55

C Pass-through into border prices: additional results

Figure C.1: *EUR/CHF and border prices conditional on a price change in the invoicing currency*



(a) EUR invoiced

(b) CHF invoiced

Notes: The red solid line shows the log-difference in the exchange rate between December 2014 and a given month. Panel (a) shows the log difference in border prices of EUR invoiced products between the period in the horizontal axis and December 2014. Green diamonds show unconditional prices converted to CHF, purple squares show prices conditional on observing a non-zero price change (in EUR) compared with December 2014. Panel (b) shows the same indices for CHF invoiced products, purple squares are border prices conditional on a price change in CHF, green crosses are all prices in CHF, including zero price changes. Source: SNB, and own calculations based on SFSO data.

Table C.1: *Pass-through into border prices on full sample of consumer goods*

	Unconditional				Conditional			
	(1) 1Q	(2) 2Q	(3) 3Q	(4) 4Q	(5) 1Q	(6) 2Q	(7) 3Q	(8) 4Q
CHF invoiced	0.262***	0.313***	0.458***	0.533***	0.436***	0.480***	0.642***	0.710***
	[0.020]	[0.025]	[0.036]	[0.043]	[0.031]	[0.036]	[0.049]	[0.062]
Observations	822	822	822	650	494	537	587	507

	Unconditional				Conditional			
	(1) 1Q	(2) 2Q	(3) 3Q	(4) 4Q	(5) 1Q	(6) 2Q	(7) 3Q	(8) 4Q
EUR invoiced	0.807***	0.931***	0.960***	0.977***	0.808***	0.848***	0.874***	0.879***
	[0.022]	[0.029]	[0.041]	[0.046]	[0.056]	[0.072]	[0.094]	[0.106]
Observations	385	385	385	319	107	135	155	166

Notes: Estimates of exchange rate pass-through into border prices across all imported consumer products, including those that cannot be matched to AC Nielsen retail categories, 1,...,4 quarters after December 2014, $\Delta_k p_i^{borimp} = \beta_k \Delta_k e + \varepsilon_i$. The first panel titled "unconditional" shows pass-through regressions for all prices, first only for those products, that are invoiced in CHF, second for products, that are invoiced in EUR. The second panel titled "conditional" uses only price observations, which have a non-zero price changes in their invoicing currency since December 2014. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

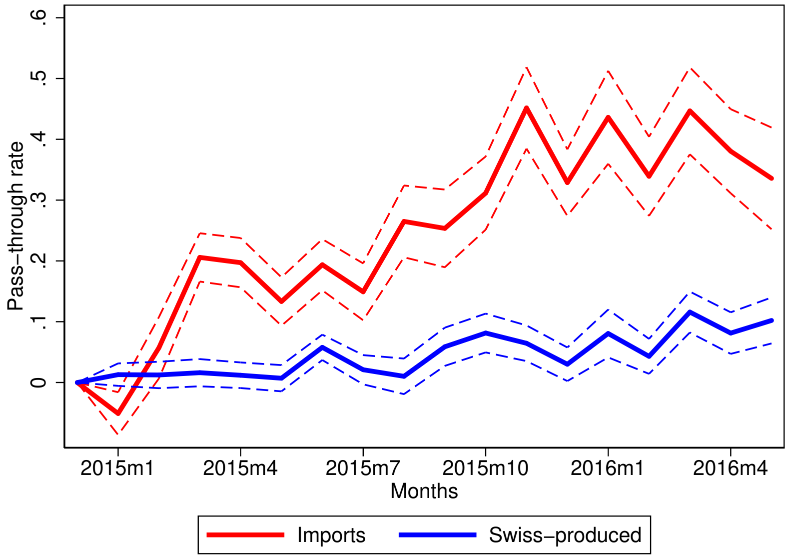
Table C.2: *Pass-through into border prices on full sample of goods*

	Unconditional				Conditional			
	(1) 1Q	(2) 2Q	(3) 3Q	(4) 4Q	(5) 1Q	(6) 2Q	(7) 3Q	(8) 4Q
CHF invoiced	0.276***	0.384***	0.655***	0.943***	0.402***	0.510***	0.827***	1.165***
	[0.013]	[0.019]	[0.025]	[0.032]	[0.019]	[0.024]	[0.030]	[0.041]
Observations	2346	2347	2347	1875	1612	1765	1856	1598

	Unconditional				Conditional			
	(1) 1Q	(2) 2Q	(3) 3Q	(4) 4Q	(5) 1Q	(6) 2Q	(7) 3Q	(8) 4Q
EUR invoiced	0.877***	1.056***	1.171***	1.175***	1.056***	1.165***	1.283***	1.260***
	[0.015]	[0.016]	[0.026]	[0.031]	[0.035]	[0.035]	[0.048]	[0.071]
Observations	1462	1462	1462	1228	531	621	742	740

Notes: Estimates of exchange rate pass-through into border prices across all imported goods with available border price data (i.e. not only consumer goods), 1,...,4 quarters after December 2014, $\Delta_k p_i^{borimp} = \beta_k \Delta_k e + \varepsilon_i$. The first panel titled "unconditional" shows pass-through regressions for all prices, first only for those products, that are invoiced in CHF, second for products, that are invoiced in EUR. The second panel titled "conditional" uses only price observations, which have a non-zero price changes in their invoicing currency since December 2014. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Figure C.2: *Pass-through into retail prices*



Notes: The solid lines show the point estimate of the regression $\Delta_k p_i = \beta_k \Delta_k e + \varepsilon_i$ where Δ_k denotes monthly differences in prices relative to December 2014, p_i denotes unique products' retail prices, and e is the EUR/CHF exchange rate. The horizontal axis displays k. The blue line shows β_k based on the regression for domestic products, the red line for imports. Regressions are weighted using 2013-2014 expenditure weights. Dashed lines show 95% confidence intervals.

Table C.3: *Estimates of distribution share*

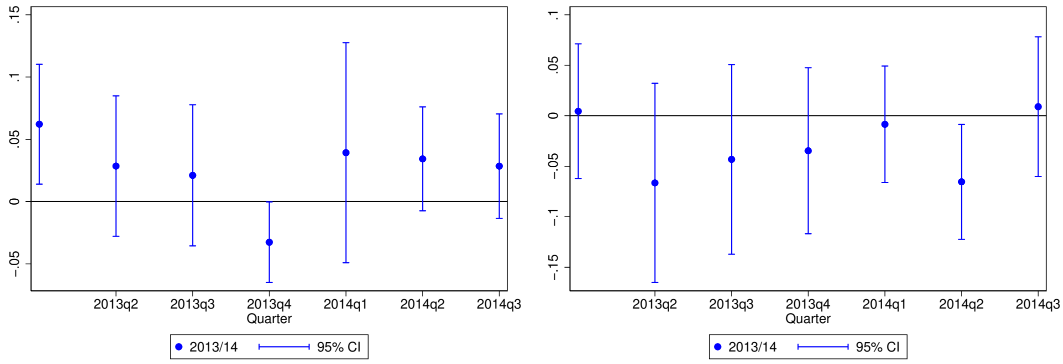
	1Q				2Q			
	(1) OLS	(2) red. form	(3) FS	(4) 2SLS	(5) OLS	(6) red. form	(7) FS	(8) 2SLS
$\Delta p^{borimp} - \Delta ppi$	0.312**			0.382**	0.426**			0.390***
	[0.146]			[0.170]	[0.176]			[0.147]
$CHFShare$		0.038**	0.099***			0.042**	0.107***	
		[0.018]	[0.020]			[0.017]	[0.018]	
Observations	1077	1077	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
$\Delta p^{borimp} - \Delta ppi$	0.310			0.903**	0.210**			0.563**
	[0.284]			[0.416]	[0.101]			[0.277]
$CHFShare$		0.066**	0.074***			0.037*	0.066**	
		[0.025]	[0.025]			[0.020]	[0.031]	
Observations	1077	1077	1077	1077	1077	1077	1077	1077
F first stage				8.4				4.6
p-value				0.008				0.041

Notes: This table presents estimates of the distribution share in Swiss retail. We assume that log changes in the cost of supplying imported good i at the retail level are given by $(1 - s_d) \times \Delta_k p^{borimp}_{g(i)} + s_d \times \Delta_k ppi$, where ppi denote the log of the overall producer price index. Point estimates for s_d are obtained from a regression of the form $(\Delta_k p^{retimp}_i - \Delta_k ppi) = \alpha + \beta(\Delta_k p^{borimp}_{g(i)} - \Delta_k ppi) + \varepsilon_i$, where β is the estimate for $1 - s_d$ if retail markup changes (in the residual) are uncorrelated with border price changes across product categories (which is more likely to be satisfied at longer horizons when retail price stickiness is less prevalent). Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

D Cross-sectional regressions: additional results and robustness

Figure D.1: *Tests for pre-trends in reduced form*



(a) Retail import prices

(b) Retail Swiss-produced prices

Notes: Panel (a) tests for pre-existing tends in the relation between invoicing and retail prices of imported goods. It shows the results of the reduced-form relation between CHF-invoicing share and the log-difference in prices of imported goods compared with December 2014 the estimated equation is thus identical to the one in Columns (2) and (6) in Table 6. Panel (a) shows the results for the last months of Q1 2013, Q2 2013, Q3 2013, Q4 2013, Q1 2014, Q2 2014 and Q3 2014. All variables are constructed as in the main text. Panel (b) tests for pre-existing trends in the relation between invoicing and the retail prices of Swiss-produced goods. It shows the results of the reduced-form relation between on the one side the interaction of CHF-invoicing share with the import share and on the other side the log-differences in prices of domestic goods compared with December 2014. The estimated equation is thus identical to the one in Columns (2) and (6) in Table 7

Table D.1: *Pass-through from border prices to retail import prices: one percent trimming*

	1Q				2Q			
	(1) OLS	(2) red. form	(3) FS	(4) 2SLS	(5) OLS	(6) red. form	(7) FS	(8) 2SLS
Δp^{borimp}	0.309**			0.374**	0.393**			0.386**
	[0.141]			[0.167]	[0.167]			[0.151]
$CHFShare$		0.037*	0.100***			0.041**	0.107***	
		[0.019]	[0.020]			[0.017]	[0.019]	
Observations	1065	1065	1065	1065	1065	1065	1065	1065
F first stage				24.9				33.2
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
Δp^{borimp}	0.325			0.948**	0.203*			0.615**
	[0.286]			[0.420]	[0.109]			[0.294]
$CHFShare$		0.070***	0.074***			0.041*	0.066**	
		[0.025]	[0.026]			[0.021]	[0.031]	
Observations	1065	1065	1065	1065	1065	1065	1065	1065
F first stage				8.3				4.6
p-value				0.008				0.041

Notes: Estimates of border prices into retail prices across individual products 1 to 4 quarters after December 2014, as in equation (3). Log changes in border prices are instrumented by the share of products that are CHF-invoiced in the corresponding border product category (first stage is reported under FS). Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table D.2: *Response of retail price of Swiss-produced to changes in retail price of imports weighted by importshare: one percent trimming*

	1Q				2Q			
	(1) OLS	(2) red. form	(3) red. form	(4) 2SLS	(5) OLS	(6) red. form	(7) red. form	(8) 2SLS
$\Delta p^{retimp} \times ImpSh$	0.415***			0.857*	1.003***			1.360***
	[0.143]			[0.439]	[0.157]			[0.308]
$(1 - CHFSh) \times ImpSh$		-0.063	-0.034			-0.132***	-0.138***	
		[0.044]	[0.048]			[0.041]	[0.040]	
$ImpSh$			-0.018				0.004	
			[0.017]				[0.015]	
Observations	2243	2243	2243	2243	2248	2248	2248	2248
F first stage				10.3				29.0
p-value				0.004				0.000

	3Q				4Q			
	(1) OLS	(2) red. form	(3) red. form	(4) 2SLS	(5) OLS	(6) red. form	(7) red. form	(8) 2SLS
$\Delta p^{retimp} \times ImpSh$	0.781***			1.538***	0.349			1.238**
	[0.213]			[0.386]	[0.239]			[0.564]
$(1 - CHFSh) \times ImpSh$		-0.152***	-0.190***			-0.095**	-0.141***	
		[0.043]	[0.039]			[0.042]	[0.039]	
$ImpSh$			0.026*				0.030*	
			[0.014]				[0.017]	
Observations	2255	2255	2255	2255	2254	2254	2254	2254
F first stage				11.3				6.8
p-value				0.003				0.015

Notes: Estimates of the change in retail prices of Swiss-produced goods to changes in import retail prices times import share ($ImpSh$) within the same product category 1 to 4 quarters after December 2014, as in equation (4). Log changes in import retail prices are instrumented by the share of products that are invoiced in foreign currency in the corresponding border product category ($1 - CHFSh$). Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table D.3: *Expenditure switching towards imports: expenditure shares and relative prices within product categories: one percent trimming*

	Jan 15 – May 16					
	(1) OLS	(2) OLS	(3) Red. form I	(4) Red. form	(5) 2SLS	(6) 2SLS
Δ relative border price	-1.413***				-1.625***	
	[0.422]				[0.397]	
Δ relative retail price		-0.151				-3.802**
		[0.277]				[1.659]
$1 - CHFShare$			0.120***			
			[0.025]			
$(1 - CHFShare) \times (1 - ImpShare)$				0.165***		
				[0.037]		
Observations	2332	2332	2332	2332	2332	2332
F first stage					53.3	7.3
p-value					0.000	0.011

Notes: Column 1 (column 4) reports OLS (IV) estimates of the change in market shares (MS) for imported retail products to log changes in relative border prices, as in equation (5). Column 2 (column 5) reports OLS (IV) estimates of the change in expenditures for imported retail products to log changes in relative retail prices, as in equation (6). Log changes in relative prices are instrumented by the share of products that are CHF-invoiced in the corresponding border product category. Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table D.4: *Pass-through from border prices to retail import prices: drop five percent largest absolute price changes*

	1Q				2Q			
	(1) OLS	(2) red. form	(3) FS	(4) 2SLS	(5) OLS	(6) red. form	(7) FS	(8) 2SLS
Δp^{borimp}	0.303**			0.365**	0.406**			0.451***
	[0.130]			[0.151]	[0.150]			[0.166]
$CHFShare$		0.036**	0.099***			0.049**	0.108***	
		[0.017]	[0.020]			[0.020]	[0.019]	
Observations	1033	1033	1033	1033	1033	1033	1033	1033
F first stage				24.3				33.3
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
Δp^{borimp}	0.367			0.735**	0.196			0.562**
	[0.217]			[0.357]	[0.128]			[0.282]
$CHFShare$		0.055**	0.075***			0.037	0.065**	
		[0.024]	[0.025]			[0.022]	[0.031]	
Observations	1033	1033	1033	1033	1034	1034	1034	1034
F first stage				8.8				4.4
p-value				0.006				0.045

Notes: Estimates of border prices into retail prices across individual products 1 to 4 quarters after December 2014, as in equation (3). Log changes in border prices are instrumented by the share of products that are CHF-invoiced in the corresponding border product category (first stage is reported under FS). Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table D.5: *Response of retail price of Swiss-produced to changes in retail price of imports weighted by importshare: drop five percent largest absolute price changes*

	1Q				2Q			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	red. form	red. form	2SLS	OLS	red. form	red. form	2SLS
$\Delta p^{retimp} \times ImpSh$	0.302***			0.539	0.464***			0.905***
	[0.102]			[0.398]	[0.139]			[0.282]
$(1 - CHFSh) \times ImpSh$		-0.039	-0.027			-0.087***	-0.094***	
		[0.033]	[0.034]			[0.027]	[0.024]	
$ImpSh$			-0.008				0.005	
			[0.014]				[0.016]	
Observations	2185	2185	2185	2185	2187	2187	2187	2187
F first stage				10.2				30.0
p-value				0.004				0.000

	3Q				4Q			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	red. form	red. form	2SLS	OLS	red. form	red. form	2SLS
$\Delta p^{retimp} \times ImpSh$	0.437*			1.070***	0.173			0.768*
	[0.225]			[0.339]	[0.242]			[0.452]
$(1 - CHFSh) \times ImpSh$		-0.103***	-0.115***			-0.058*	-0.099***	
		[0.027]	[0.023]			[0.031]	[0.025]	
$ImpSh$			0.008				0.027*	
			[0.014]				[0.015]	
Observations	2190	2190	2190	2190	2200	2200	2200	2200
F first stage				11.0				6.4
p-value				0.003				0.018

Notes: Estimates of the change in retail prices of Swiss-produced goods to changes in import retail prices times import share ($ImpSh$) within the same product category 1 to 4 quarters after December 2014, as in equation (4). Log changes in import retail prices are instrumented by the share of products that are invoiced in foreign currency in the corresponding border product category $(1 - CHFSh)$. Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table D.6: *Expenditure switching towards imports: expenditure shares and relative prices within product categories: drop five percent largest absolute price changes*

	Jan 15 – May 16					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	Red. form I	Red. form	2SLS	2SLS
Δ relative border price	-0.933**				-1.071***	
	[0.350]				[0.376]	
Δ relative retail price		0.027				-2.603*
		[0.118]				[1.364]
$1 - CHFShare$			0.073**			
			[0.027]			
$(1 - CHFShare) \times (1 - ImpShare)$				0.109***		
				[0.036]		
Observations	2272	2272	2272	2272	2272	2272
F first stage					53.2	7.5
p-value					0.000	0.011

Notes: Column 1 (column 4) reports OLS (IV) estimates of the change in market shares (MS) for imported retail products to log changes in relative border prices, as in equation (5). Column 2 (column 5) reports OLS (IV) estimates of the change in expenditures for imported retail products to log changes in relative retail prices, as in equation (6). Log changes in relative prices are instrumented by the share of products that are CHF-invoiced in the corresponding border product category. Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table D.7: *Pass-through from border prices to retail import prices: no outlier adjustment*

	1Q				2Q			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	red. form	FS	2SLS	OLS	red. form	FS	2SLS
Δp^{borimp}	0.286*			0.164	0.352*			0.356**
	[0.150]			[0.201]	[0.191]			[0.179]
$CHFShare$		0.016	0.098***			0.038*	0.106***	
		[0.020]	[0.019]			[0.019]	[0.018]	
Observations	1088	1088	1088	1088	1088	1088	1088	1088
F first stage				25.8				33.1
p-value				0.000				0.000
	3Q				4Q			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	red. form	FS	2SLS	OLS	red. form	FS	2SLS
Δp^{borimp}	0.293			0.932**	0.163			0.373
	[0.289]			[0.454]	[0.099]			[0.325]
$CHFShare$		0.068**	0.073***			0.024	0.066**	
		[0.027]	[0.025]			[0.024]	[0.030]	
Observations	1088	1088	1088	1088	1088	1088	1088	1088
F first stage				8.4				4.7
p-value				0.007				0.040

Notes: Estimates of border prices into retail prices across individual products 1 to 4 quarters after December 2014, as in equation (3). Log changes in border prices are instrumented by the share of products that are CHF-invoiced in the corresponding border product category (first stage is reported under FS). Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table D.8: *Response of retail price of Swiss-produced to changes in retail price of imports weighted by importshare: no outlier adjustment*

	1Q				2Q			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	red. form	red. form	2SLS	OLS	red. form	red. form	2SLS
$\Delta p^{retimp} \times ImpSh$	0.616***			0.903*	1.888***			1.169**
	[0.148]			[0.476]	[0.529]			[0.470]
$(1 - CHFSh) \times ImpSh$		-0.067	0.002			-0.106*	-0.060	
		[0.047]	[0.053]			[0.061]	[0.064]	
$ImpSh$			-0.046*				-0.031*	
			[0.024]				[0.017]	
Observations	2287	2287	2287	2287	2287	2287	2287	2287
F first stage				11.3				19.1
p-value				0.003				0.000

	3Q				4Q			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	red. form	red. form	2SLS	OLS	red. form	red. form	2SLS
$\Delta p^{retimp} \times ImpSh$	0.815***			1.683***	0.503*			1.698**
	[0.245]			[0.410]	[0.252]			[0.788]
$(1 - CHFSh) \times ImpSh$		-0.166***	-0.194***			-0.132**	-0.190***	
		[0.047]	[0.044]			[0.051]	[0.045]	
$ImpSh$			0.019				0.038**	
			[0.018]				[0.017]	
Observations	2287	2287	2287	2287	2287	2287	2287	2287
F first stage				11.5				7.1
p-value				0.002				0.014

Notes: Estimates of the change in retail prices of Swiss-produced goods to changes in import retail prices times import share ($ImpSh$) within the same product category 1 to 4 quarters after December 2014, as in equation (4). Log changes in import retail prices are instrumented by the share of products that are invoiced in foreign currency in the corresponding border product category ($1 - CHFSh$). Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table D.9: *Expenditure switching towards imports: expenditure shares and relative prices within product categories: no outlier adjustment*

	Jan 15 – May 16					
	(1) OLS	(2) OLS	(3) Red. form I	(4) Red. form	(5) 2SLS	(6) 2SLS
Δ relative border price	-1.840***				-2.108***	
	[0.645]				[0.623]	
Δ relative retail price		-0.358				-4.719**
		[0.224]				[2.039]
$1 - CHFShare$			0.148***			
			[0.041]			
$(1 - CHFShare) \times (1 - ImpShare)$				0.215***		
				[0.053]		
Observations	2366	2366	2366	2366	2366	2366
F first stage					53.7	8.4
p-value					0.000	0.007

Notes: Column 1 (column 4) reports OLS (IV) estimates of the change in market shares (MS) for imported retail products to log changes in relative border prices, as in equation (5). Column 2 (column 5) reports OLS (IV) estimates of the change in expenditures for imported retail products to log changes in relative retail prices, as in equation (6). Log changes in relative prices are instrumented by the share of products that are CHF-invoiced in the corresponding border product category. Observations are weighted by product expenditures summed over 2013-2014. Clustered standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

E Simple model of pricing complementarities

Here we consider a simple flexible price model with variable markups, following Gopinath et al. (2010) and Burstein and Gopinath (2014), to motivate and illustrate the use of the reduced-form regressions of Section 4.2.

Consider product i in product category g. Suppose that the log price change Δp_{ig} can be expressed, up to a first-order approximation, as

$$\Delta p_{ig} = \frac{1}{1+\Gamma_{ig}}\Delta c_{ig} + \frac{\Gamma_{ig}}{1+\Gamma_{ig}}\Delta p_g, \tag{7}$$

where Δc_{ig} denotes the log change in marginal cost, Γ_{ig} denotes the markup elasticity, and Δp_g denotes the log change in the aggregate price index in product category g, which we assume is given by $\Delta p_g = \sum_i s_{ig}\Delta p_{ig}$ where s_{ig} denotes expenditure share of product i in g.

We now assume that all domestic firms in g have a common markup elasticity Γ_g^{dom}.[49] Aggregating equation (7) across all domestic products, the expenditure-weighted average of domestic prices in g, denoted by Δp_g^{dom}, is

$$\Delta p_g^{dom} = \frac{1}{1+s_g^{imp}\Gamma_g^{dom}}\Delta c_g^{dom} + \frac{\Gamma_g^{dom}s_g^{imp}}{1+s_g^{imp}\Gamma_g^{dom}}\Delta p_g^{imp}. \tag{8}$$

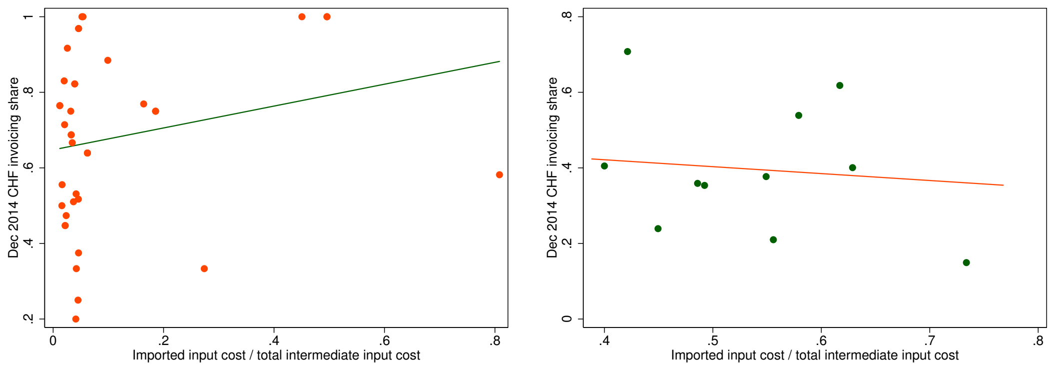
Here, Δc_g^{dom} denotes the expenditure-weighted average of domestic marginal cost changes in g, Δp_g^{imp} denotes the expenditure-weighted average of import price changes in g, and s_g^{imp} denotes the expenditure share on imported products in g.

While equation (8) and regression equation (4) both contain the term $s_g^{imp}\Delta p_g^{imp}$ in the right-hand side, these two specifications are different so the estimated coefficients cannot be directly interpreted in terms of model structural parameters. Moreover, since changes in domestic marginal costs Δc_g^{dom} are unobservable to us, the error term in equation (4) could be correlated with Δp_g^{imp} if changes in import prices are correlated with changes in domestic costs. This concern can be somewhat alleviated by instrumenting changes in retail import prices using the share of non-CHF invoiced border prices in each product category, under the assumption that pre-January 2015 invoicing currency share is uncorrelated across product categories with post-January 2015 changes in domestic marginal costs. Figure E.1 shows that CHF-invoicing intensity at the border is not significantly correlated across

[49] Due to its partial coverage of consumer expenditures, our homescan data is not well suited to estimate the dependance of Γ_{ig}^{dom} on product characteristics such as market share.

industries (either within the sample of product categories examined in this paper, or across broader but coarser industries) with a measure of Swiss firms' share of imported intermediate inputs in 2014 (which is one determinant of post-January 2015 changes in marginal costs of Swiss producers). In addition, Figure E.2 shows that there is very little Swiss value added contained in imports from the euro area, both for the aggregate of manufacturing industries and for the food, beverages and tobacco industries (which are closer related to the set of final consumption goods examined in this paper). These low shares speak against the possibility that marginal costs (and prices) of Swiss producers and foreign exporters are correlated due to local and foreign firms using identical Swiss inputs.

Figure E.1: *Invoicing at the border and reliance on intermediate inputs by domestic firms*

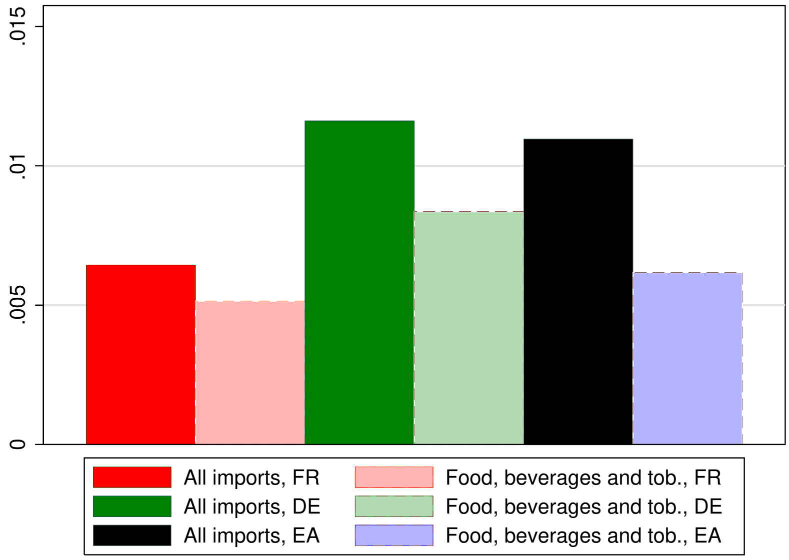


(a) NOGA sectors matched to Nielsen data (b) Tradeable economic categories

Notes: Left-hand panel (a) shows the relation between CHF-invoicing share of imports at the border and the ratio imported inputs costs/all input costs of domestic firms in the same 4-digit NACE/NOGA sector (2008 classification). The sample includes 39 4-digit sectors that can be matched to the Nielsen homescan sample. The slope of the displayed simple unweighted regression line is 0.29 (p-value 0.178). Right-hand panel (b) shows the same relation for the sample of 11 tradable economic categories (slightly coarser than NACE/NOGA 2-digit sectors) covered by the Swiss Value Added Statistics for which information on CHF invoicing at the border is available (without restricting the sample to goods included in homescan data). The slope of the displayed unweighted simple regression line is -0.16 (p-value 0.40). Information on invoicing is from the SFSO and information on intermediate inputs and domestic intensity is from Auer et al. (2018), who in turn use the micro trade data provided by the Swiss customs authority for information on imported input use, ORBIS Switzerland for information on firm revenue, and the SFSO for information on input use, all for 2014.

We estimate equation (4) using simulated data from equation (8). We use observed values of s_g^{imp} and Δp_g^{imp} (in the second quarter of 2015 relative to December 2014). We assume that the markup elasticity of domestic producers in group g is $\Gamma_g^{dom} = \Gamma^{dom} + e_{\Gamma g}$ where $e_{\Gamma g}$ is normally distributed with mean 0 and variance σ_Γ, and that the average change in domestic marginal cost in g is $\Delta c_g^{dom} = \Delta w^{dom} + e_{cg}$, where e_{cg} is normally distributed with mean 0 and variance σ_c. We choose Δw^{dom} so that the expenditure-weighted average decline in domestic prices is -0.01, and consider a range of values of Γ^{dom} between 0 and 8. We consider four specifications for σ_Γ and σ_c: i) $\sigma_\Gamma = \sigma_c = 0$, ii) $\sigma_\Gamma = 1$,

Figure E.2: *Swiss value added share in imports from France, Germany, and the euro area*

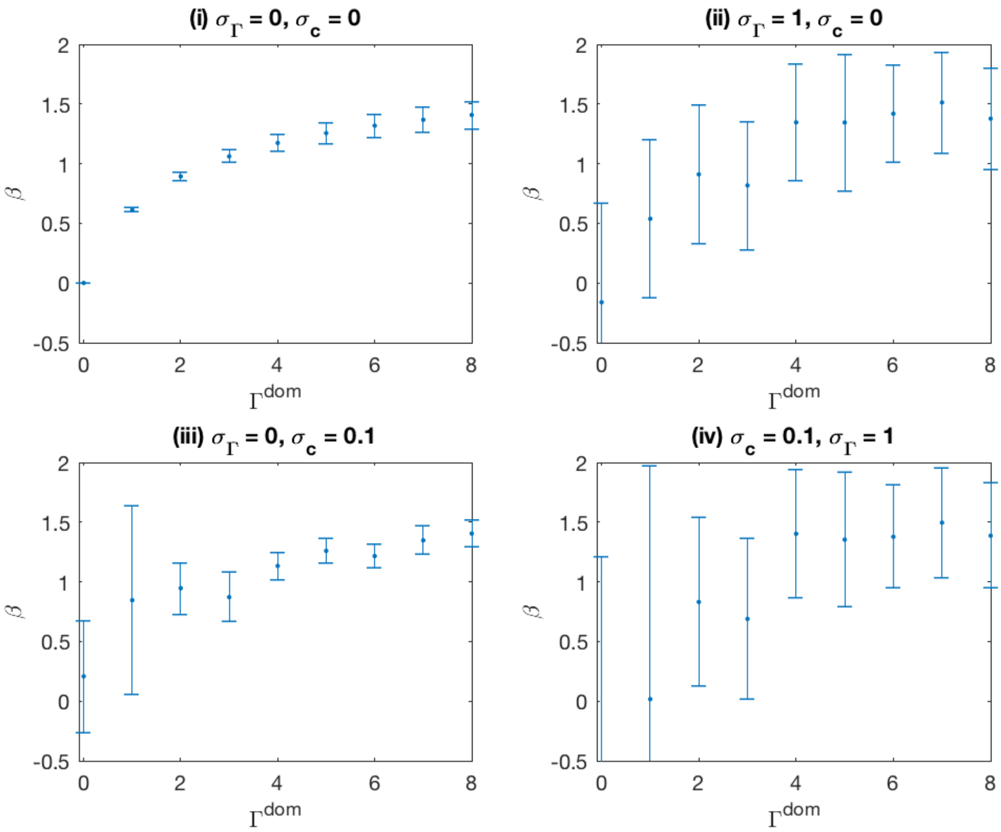


Notes: This figure displays the 2011 fraction of value added originating from Switzerland for French (red), German (green), or Euro area (blue) exports to Switzerland. This statistic is shown for either total exports (dark color bars, solid outline) or the food, beverage, and tobacco sector only (light color bars, dashed outline). For example, the number 0.006 in the left-most bar means that for every 100 CHF worth of French exports to Switzerland, 0.6 CHF worth of Swiss labor and other Swiss factors of production were ultimately used. Data is from the OECDs Trade in Value Added (TiVA) statistic, which only covers data until 2011 (origin of value added in gross imports; https://stats.oecd.org, accessed on 23.08.2018).

$\sigma_c = 0$, iii) $\sigma_\Gamma = 0$, $\sigma_c = 0.1$, and iv) $\sigma_\Gamma = 1$, $\sigma_c = 0.1$.

Figure E.3 reports estimates of β in equation (4) (together with 95 percent confidence intervals) for different values of Γ and for each of the four specifications of σ_Γ, σ_c. In all four specifications, when $\Gamma^{dom} = 0$, we cannot reject that $\beta = 0$. In order to target our estimates of $\beta \approx 1.5$, we need to set Γ^{dom} at least as high as 3. In the presence of large variation in cost changes across product category ($\sigma_c = 0.1$), the estimates of β have wide confidence intervals, but we can reject that $\beta = 0$ for moderate and high values of Γ^{dom}.

Figure E.3: *Simple model of pricing complementarities*



Notes: Simulation results, see discussion in the text.

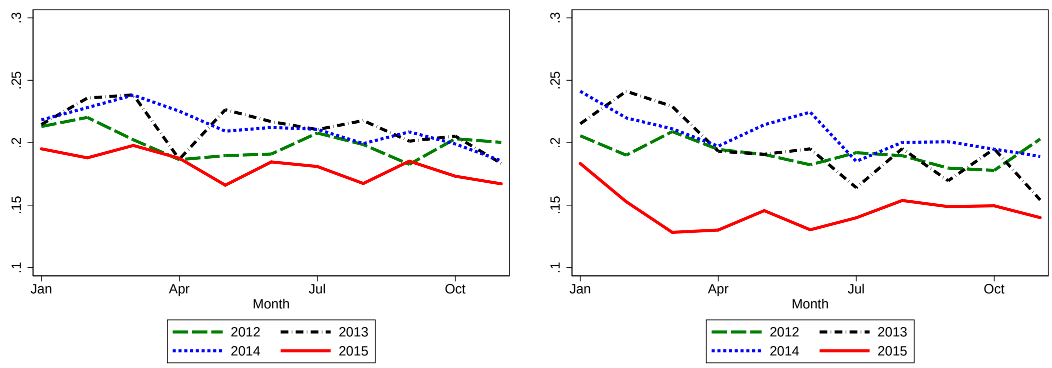
F Margins of price adjustment: robustness checks

In this section we perform a number of robustness checks on the margins of price adjustment facts presented in Section 6. First, we exclude temporary price changes due to temporary price reductions based on a simple v-shaped sales filter (i.e. price changes in month t that are exactly offset in month $t+1$). Results are reported in Figure F.2.[50].

Second, we standardize price changes at the region and product-level as described in footnote 46) (see Figure F.3). Third, we split goods into those with sticky prices prior to 2015 and those that changed prices frequently prior to 2015 (see Figures F.4 and F.5). Specifically, we group products into those

[50]The frequency of temporary price reductions dropped slightly after January 2015 while the frequency of regular price reductions rose. This is consistent with evidence in Anderson et al. (2017) for the US, who show that in response to a positive cost shock, regular prices rise and sales (or temporary price changes) fall. In the episode studied here, the frequency of sales falls after a *decline* in marginal costs while the frequency of changes of regular price changes increases

Figure F.1: *Average size of price reductions at different horizons*



(a) Swiss-produced (b) Imports

Notes: Panel (a) shows the a size of price changes of Swiss products with a price that is different from the price in December of the previous year as a function of the number of months since December. For example, the size of price changes for March 2015 shows the average absolute size of the price difference between March 2015 and December 2014 for products that changed prices. Panel (b) shows the same figure for imported products from the euro area. Solid lines show the year 2015, dotted lines the year 2014, dash-dotted lines 2013, and dashed lines 2012.

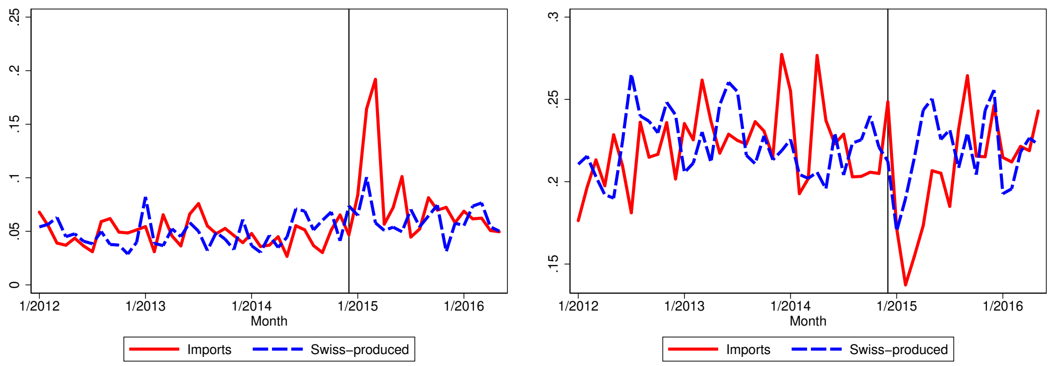
whose price changed more than twice (less sticky) or less than twice (more sticky) per year during the period 2012-2014 (two is the median number of price adjustments per good per year in this period).

Fourth, we separate firms with one or two goods from firms with more than two goods (see Figures F.6 and F.7). Fifth, we split goods into those with high or low market share prior to 2015 within their respective product category (see Figures F.8 and F.9). For this, we allocate producers by market share within each product group into two bins, one with market share below median within the product category, and one for above-median market share. Sixth, we show that these patterns hold within the two largest retailers (Coop and Migros), as well as in the remainder of the sample (see Figures F.10 and F.11). Seventh, we show that the result also holds when both frequency and size of price changes are weighted by expenditures (see Figure F.12).

In addition, we investigate whether these patterns are specific to the January 2015 appreciation. To do so, we focus on the appreciation of the CHF in 2011. Between January and August 2011, the CHF appreciated by roughly 25% against the EUR. During this time period, we observe an increase in the fraction of price declines and a reduction in their size, consistent with the findings in our baseline period (see Figure F.13).

Finally, we augment our analysis by adding homescan data from GfK Germany, Austria, and France which are constructed in a similar manner as the Swiss data.[51] We restrict the set of goods to products that are imported in Switzerland and also purchased in either Germany, France, or Austria. Panel (a) in Figure F.14 in the Appendix reveals that the increase in the frequency of price decreases can be observed in Switzerland for this subset of the data, but not in Germany, France and Austria during the same time period. Similarly, the decline in the average size of price decreases can be observed on the Swiss market only, and it cannot be observed in the exact same sets of goods sold in Germany, Austria and France (Panel (b) in Figure F.14).

Figure F.2: *Fraction and size of price decreases excluding sales*

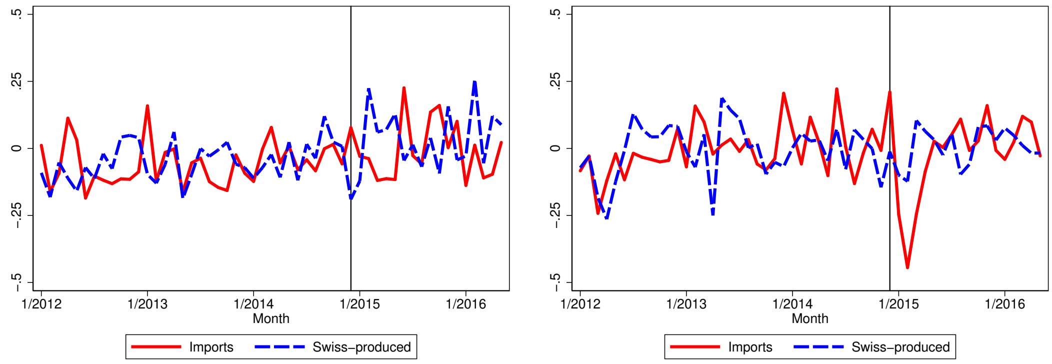


(a) Fraction (b) Size

Notes: Panel (a) shows the fraction of price decreases excluding sales and Panel (b) shows the absolute average size of price decreases excluding sales for imports (solid line) and domestically produced goods (dashed line). The average size of price decreases is calculated over all individual price changes and averaged over all retailers and regions per EAN and month. An individual price change is defined as the absolute value of the non-zero log-difference of the modal price observed per EAN, retailer, region and month, from one month to the next. To calculate the frequency (and conditional size) of price changes excluding sales, all price changes in month t that are exactly offset in month $t+1$ are excluded.

[51] To compare the price in Switzerland with the prices in the neighboring countries, we match the prices for all EAN codes observed in Switzerland to the prices paid in the regions bordering Switzerland for France and Germany, where such regional information is available. We only consider prices in geographical areas close to Switzerland. For Germany, we use the data for the German Bundesland Baden-Württemberg and for France the zip-codes starting with 1, 25, 39, 68, 70, 74, and 90. For Austria, no such regional information is available, and we thus use the entire data set, which is small compared with the one of France or Germany. See Beck and Lein (2015) for a description of the collection procedures and sample statistics of the European homescan data collected by GFK.

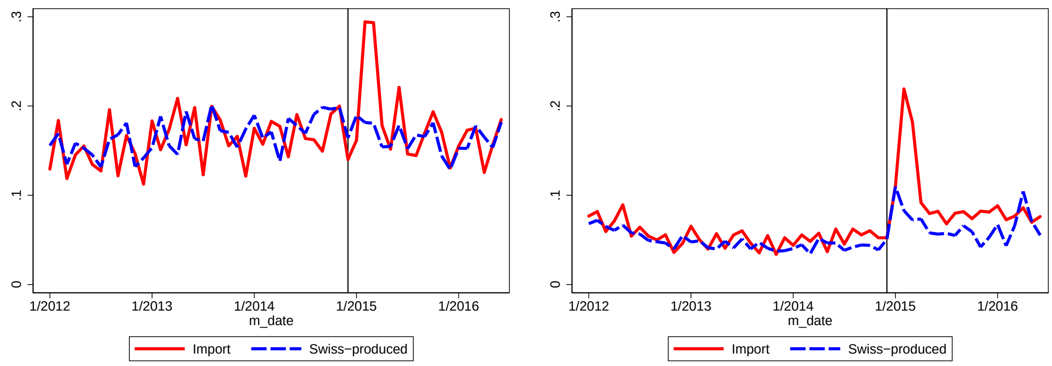
Figure F.3: *Size of price changes: increases and decreases (standardized)*



(a) Increases (b) Decreases

Notes: Panel (a) shows the absolute average size of standardized price increases for imports (solid line) and domestically produced goods (dashed line). Panel (b) shows the absolute average size of standardized price decreases (same sample split). An individual price change is defined as a change in the modal price observed per EAN-retailer-region combination from one month to the next. Standardized price changes are calculated as described in footnote 46.

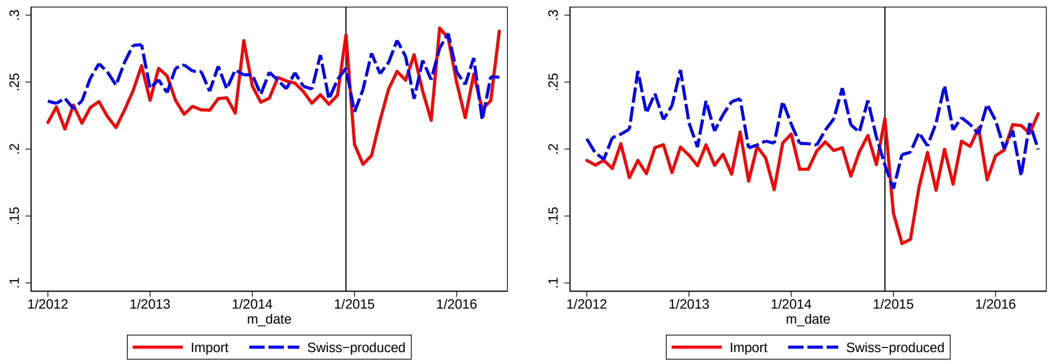
Figure F.4: *Fraction of price decreases by degree of stickiness*



(a) Less sticky (b) More sticky

Notes: Both panels show the average fraction of price decreases for all imported EANs (solid line) and for domestically produced EANs (dashed lines). Panel (a) documents this for the subsample of goods with comparatively flexible prices before 2015 and Panel (b) for the subsample of goods with comparatively sticky prices before 2015. Less sticky respectively more sticky refers to a good having more than two or fewer than three price changes per year during the period 2012-2014 (two is the median number of price adjustments per good per year in this period). The fraction of price changes per EAN and month is the fraction of individual price changes observed for each EAN within the same month. An individual price change is defined as a non-zero log-difference of the modal price observed per EAN-retailer-region combination from one month to the next.

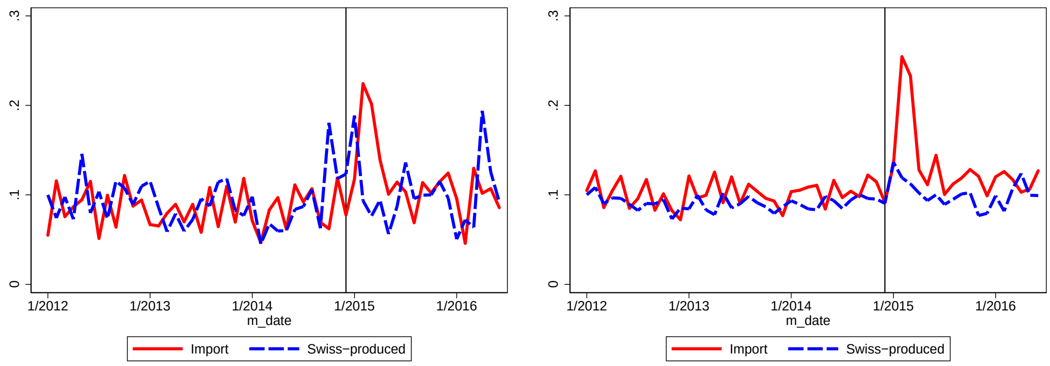
Figure F.5: *Size of price decreases by degree of stickiness*



(a) Less sticky (b) More sticky

Notes: Both panels show the absolute average size of price decreases for all imported EANs (solid line) and for all domestically produced EANs (dashed line). Panel (a) documents this for the subsample of goods with comparatively flexible prices before 2015 and Panel (b) for the subsample of goods with comparatively sticky prices before 2015. Less sticky respectively more sticky refers to a good having more than two or fewer than three price changes per year during the period 2012-2014 (two is the median number of price adjustments per good per year in this period). The average of the absolute size of price decreases is calculated by averaging individual price decreases over all retailers and regions, and then per EAN and month. An individual price decrease is defined as a decrease in the modal price observed per EAN-retailer-region combination from one month to the next.

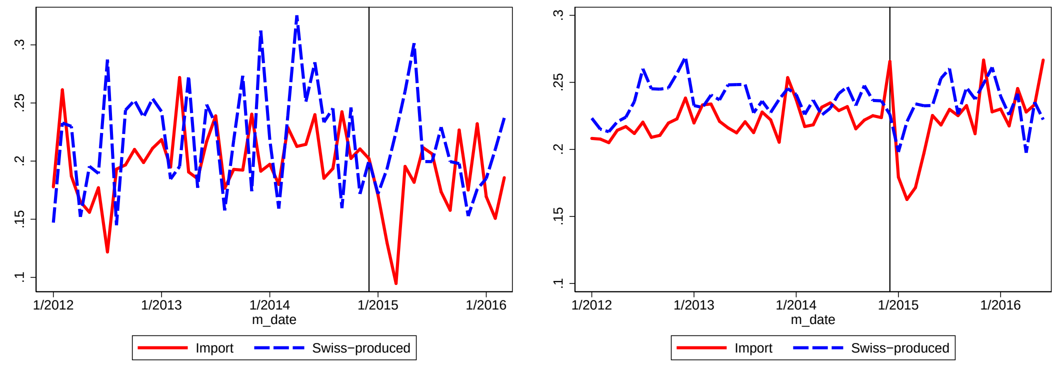
Figure F.6: *Fraction of price decreases by number of products*



(a) Less than 3 products (b) 3 products and more

Notes: Both panels show the average fraction of price decreases for all imported EANs (solid line) and for domestically produced EANs (dashed lines). Panel (a) shows this for the subsample of goods produced by firms selling at most two goods in Switzerland and Panel (b) shows this for the subsample of goods produced by firms selling three or more goods in Switzerland (two is the median number of goods per firm). The fraction of price changes per EAN and month is the fraction of individual price changes observed for each EAN within the same month. An individual price change is defined as a non-zero log-difference of the modal price observed per EAN-retailer-region combination from one month to the next.

Figure F.7: *Size of price decreases by number of products*

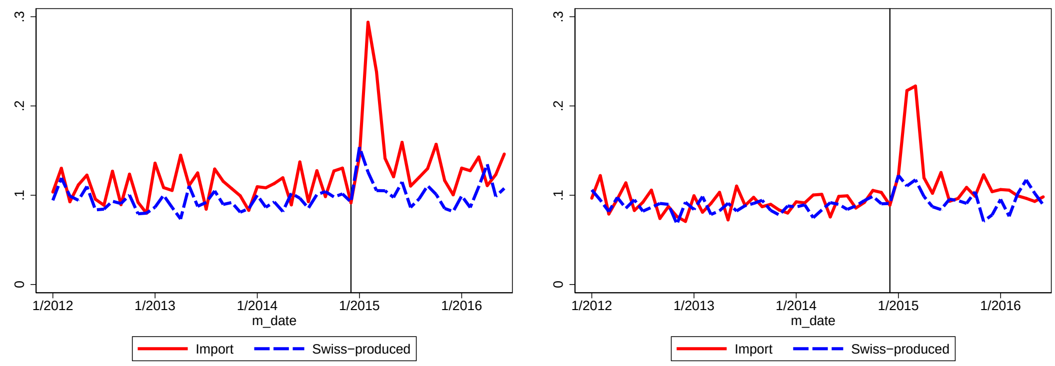


(a) Less than 3 products

(b) 3 products and more

Notes: Both panels show the absolute average size of price decreases for all imported EANs (solid line) and for all domestically produced EANs (dashed line). Panel (a) shows this for the subsample of goods produced by firms selling at most two goods in Switzerland and Panel (b) shows this for the subsample of goods produced by firms selling three or more goods in Switzerland (two is the median number of goods per firm). The average of the absolute size of price decreases is calculated by averaging individual price decreases over all retailers and regions, and then per EAN and month. An individual price decrease is defined as a decrease in the modal price observed per EAN-retailer-region combination from one month to the next.

Figure F.8: *Fraction of price decreases by product marketshare*

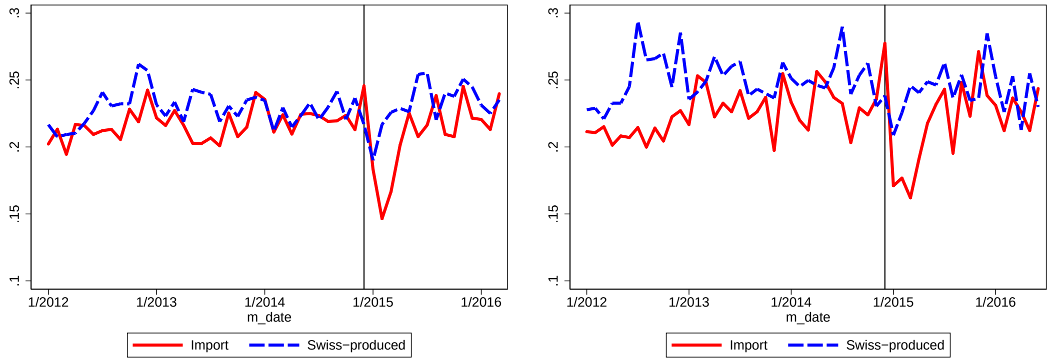


(a) High

(b) Low

Notes: Both panels show the average fraction of price decreases for all imported EANs (solid line) and for domestically produced EANs (dashed lines). Panel (a) documents this for the subsample of goods produced by firms with below-median market share (compared with average in the product category) in the period before 2015 and Panel (b) documents this for the remainder of the sample. The fraction of price changes per EAN and month is the fraction of individual price changes observed for each EAN within the same month. An individual price change is defined as a non-zero log-difference of the modal price observed per EAN-retailer-region combination from one month to the next.

Figure F.9: *Size of price decreases by product marketshare*

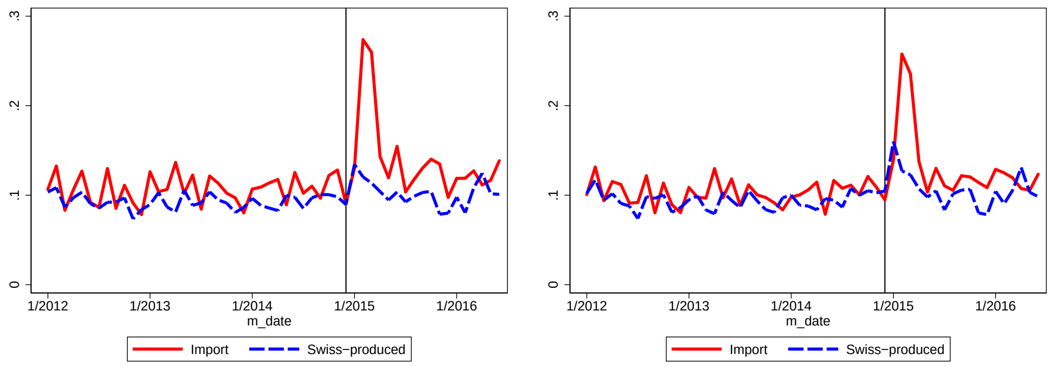


(a) High

(b) Low

Notes: Both panels show the absolute average size of price decreases for all imported EANs (solid line) and for all domestically produced EANs (dashed line). Panel (a) documents this for the subsample of goods produced by firms with below-median market share (compared with average in the product category) in the period before 2015 and Panel (b) documents this for the remainder of the sample. The average of the absolute size of price decreases is calculated by averaging individual price decreases over all retailers and regions, and then per EAN and month. An individual price decrease is defined as a decrease in the modal price observed per EAN-retailer-region combination from one month to the next.

Figure F.10: *Fraction of price decreases by retailer*

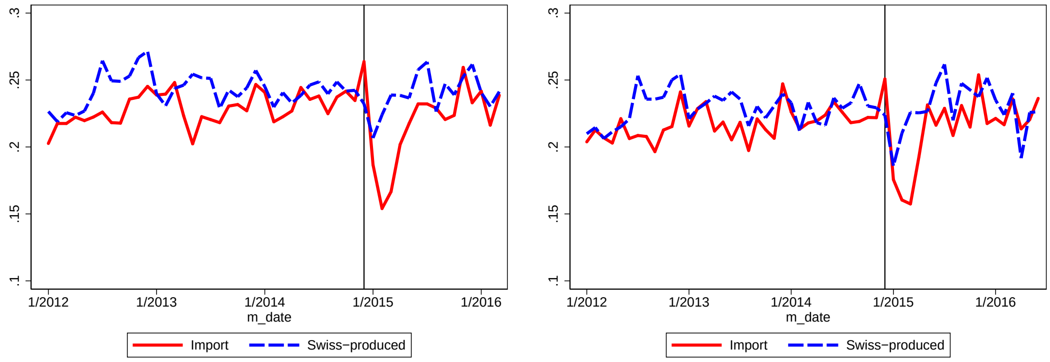


(a) Two largest

(b) Other

Notes: Both panels show the average fraction of price decreases for all imported EANs (solid line) and for domestically produced EANs (dashed lines). Panel (a) documents this for the subsample of goods sold by the two largest retailers and Panel (b) documents this for the remainder of the sample. The fraction of price changes per EAN and month is the fraction of individual price changes observed for each EAN within the same month. An individual price change is defined as a non-zero log-difference of the modal price observed per EAN-retailer-region combination from one month to the next.

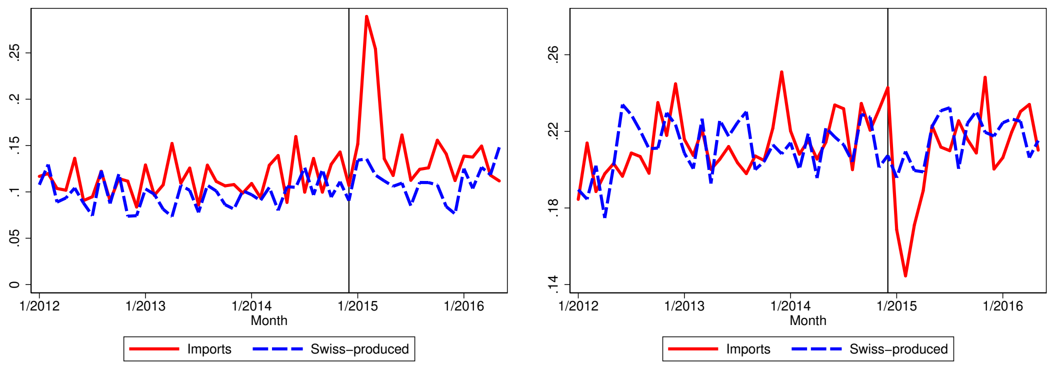
Figure F.11: *Size of price decreases by retailer*



(a) Two largest (b) Other

Notes: Both panels show the absolute average size of price decreases for all imported EANs (solid line) and for all domestically produced EANs (dashed line). Panel (a) documents this for the subsample of goods sold by the two largest retailers and Panel (b) documents this for the remainder of the sample. The average of the absolute size of price decreases is calculated by averaging individual price decreases over all retailers and regions, and then per EAN and month. An individual price decrease is defined as a decrease in the modal price observed per EAN-retailer-region combination from one month to the next.

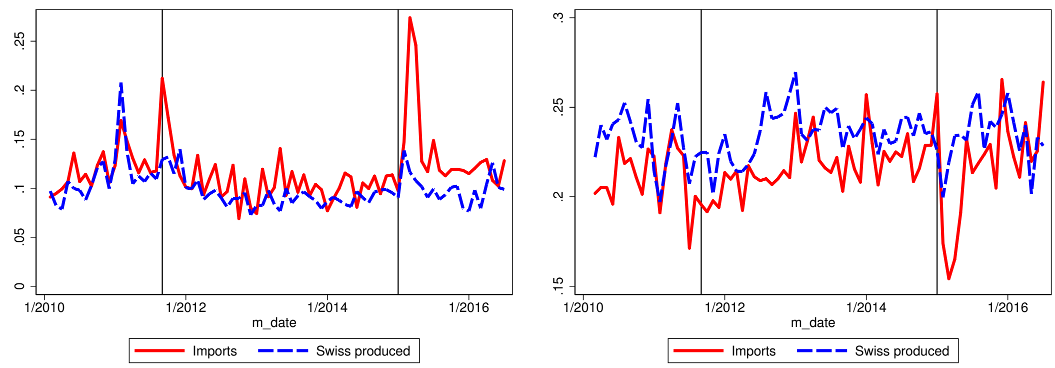
Figure F.12: *Fraction and size of price decreases weighted by expenditure shares*



(a) Fraction (b) Size

Notes: Panel (a) shows the expenditure-weighted fraction of price decreases and Panel (b) shows the expenditure-weighted absolute average size of price decreases for imports (solid line) and domestically produced goods (dashed line). An individual price change is defined as the absolute value of the non-zero log-difference of the modal price observed per EAN, retailer, region and month, from one month to the next. The average size of price decreases is calculated over all individual price changes and averaged over all retailers and regions per EAN and month. The average in the entire sample is then calculated over all EANs using 2014 expenditure weights.

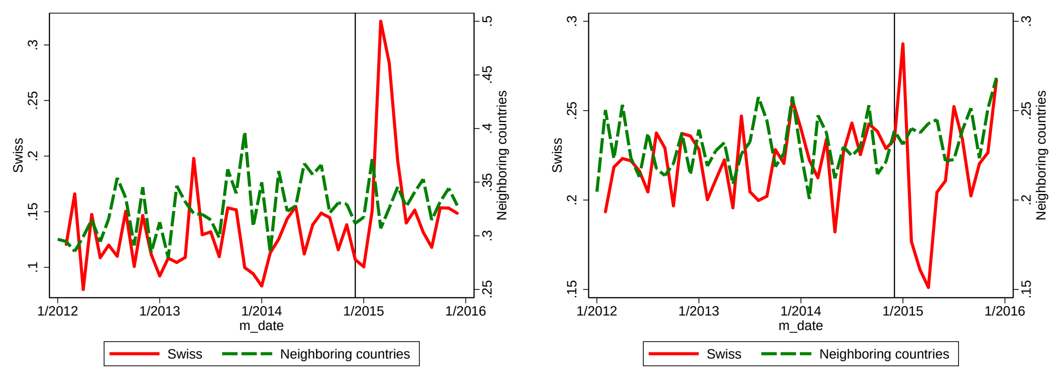
Figure F.13: *Fraction and size of price decreases since 2010*



(a) Fraction (b) Size

Notes: This figure shows, for a time horizon starting in January 2010, the fraction of price decreases (Panel (a)) and the absolute average size of price decreases (Panel (b)) for imports (solid line) and domestically produced goods (dashed line). The average size of price decreases is calculated over all individual price changes and averaged over all retailers and regions per EAN and month. An individual price change is defined as the absolute value of the non-zero log-difference of the modal price observed per EAN, retailer, region and month, from one month to the next. The vertical lines indicate August 2011 and December 2014.

Figure F.14: *Fraction and size of price decreases in neighboring countries and Switzerland*

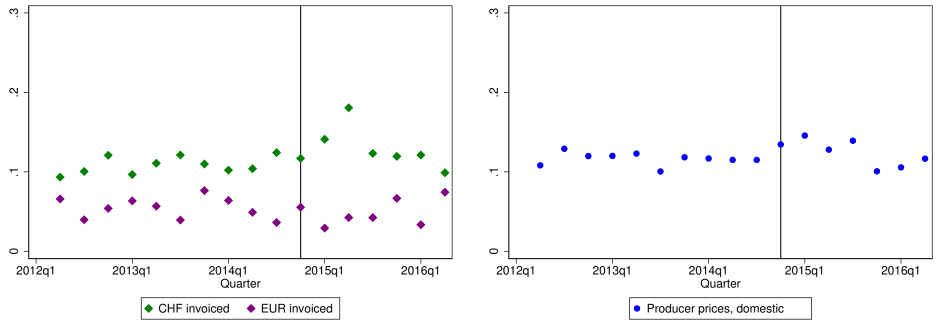


(a) Fraction (b) Size

Notes: Panel (a) shows the fraction of price decreases in Switzerland (solid line) and in the three neighboring countries Austria, Germany, and France (dashed lines). It is based on a sample of 540 EANs, which are observed in both Switzerland and Germany, France and/or Austria. Panel (b) shows the average absolute size for price decreases. The data for neighboring countries is available up to 2015. Sources: own calculations based on homescan data provided by AC Nielsen Switzerland, GfK Germany, GfK France, GfK Austria.

G Frequency and size of border price changes

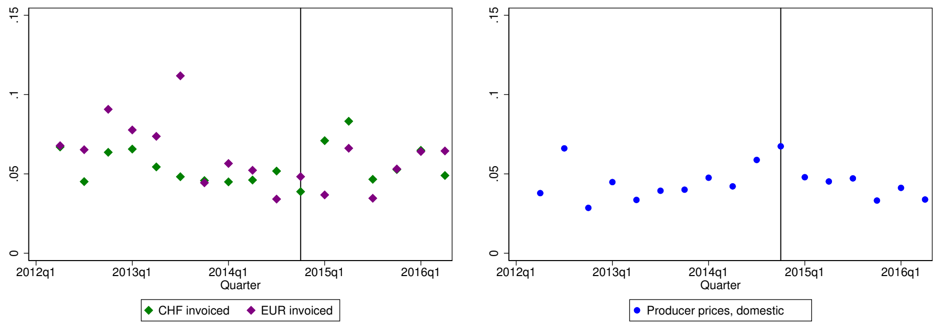
Figure G.1: *Frequency of border price and producer price decreases*



(a) Border prices (b) Producer prices

Notes: Panel (a) shows the average frequency of border price decreases (in their invoicing currency) for CHF-invoiced goods and EUR-invoiced goods. Panel (b) shows the average frequency of Swiss domestic producer price decreases. An individual price change is defined as a non-zero difference of the price of an individual good, from one quarter to the next (the survey frequency is quarterly).

Figure G.2: *Size of border price and producer price decreases*



(a) Border prices (b) Producer prices

Notes: Panel (a) shows the average absolute size of border price decreases (in their invoicing currency) for CHF-invoiced goods and EUR-invoiced goods. Panel (b) shows the average absolute size of Swiss domestic producer price decreases. An individual price change is defined as a non-zero difference of the price of an individual good, from one quarter to the next (the survey frequency is quarterly).

H Understanding the decline in the size of price reductions in a Ss pricing model

Consider the following pricing rule for goods produced abroad and imported into Switzerland. Firm i's desired or reset price denominated in CHF is denoted (in logs) by p_{it}^*. We assume that $p_{it}^* = c + w_t + z_{it}$, where c is a constant, w_t is the aggregate component of marginal costs (production and local costs) measured in CHF, and z_{it} is the idiosyncratic component of marginal costs. An appreciation of the CHF reduces w_t for imported goods.

Following Gertler and Leahy (2008) and Midrigan (2011), we allow for the possibility that changes in the idiosyncratic component of marginal costs arrive infrequently according to a Poisson process. Specifically, $z_{it} - z_{it-1} = \varepsilon_{it}$ where

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

We assume that single-product firms change their price to p^*_{it} if the price gap (i.e. the difference between the actual log price, p_{it}, and the desired log price, p^*_{it}) exceeds y.[52]

This implies that the actual log price evolves according to

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

This policy function allows us to provide a simple characterization of how the average absolute size of price changes responds to an aggregate cost shock. Consider first the pre-shock steady-state, in which the aggregate component of costs w_t is constant over time. Every period a fraction f of firms reduce their price by an average size of $s \geq y$, a fraction f raise their price by the same average size s, while the remaining fraction of firms $1-2f$ leave their price unchanged.

Consider now the response of prices after a one-time permanent decline in w_t of size $\Delta > 0$. The fraction of firms reducing their prices increases from f to f'. Of these f' firms reducing their price after the shock, f would have reduced their price even if $\Delta = 0$ and they will do so by an average size equal to $s + \Delta$. Hence, for this subset of firms, the average price reduction grows by Δ relative to the pre-shock equilibrium.[53] A fraction $f' - f$ of firms, which would have either increased or left their price unchanged if $\Delta = 0$, now reduce their price by $\tilde{s}$.

[52] Alvarez and Lippi (2014) derive this Ss pricing rule in a menu cost model under the assumption that marginal cost shocks follow a random walk process and desired markups are constant.

[53] In the presence of expected CHF overshooting (as observed in Figure 1) or strategic complementarities, the desired price may fall by less than Δ. Our qualitative results below are unchanged when we consider a smaller decline in desired prices, parameterized as a smaller value of Δ.

Putting these two pieces together, the change in the average size of price reductions is

$$s' - s = \frac{f}{f'}\Delta + \frac{f' - f}{f'}\left(\tilde{s} - s\right). \tag{9}$$

The first term in equation (9) contributes to increasing the average size of price reductions. The second term in equation (9) contributes to decreasing the average size of price reductions if new price changes are on average small relative to pre-shock price changes ($\tilde{s} < s$). The average size of price reductions falls if the second term in equation (9) is large and negative because there is a large increase in the fraction of price reductions and these new price reductions are small compared with pre-shock price reductions.[54]

We next show in a calibrated version of this simple pricing model that if shocks arrive frequently ($\lambda = 1$), the first term in the right-hand side of equation (9) dominates, and the average size of prices reductions rises. This result can be overturned if λ is sufficiently small, in which case $\tilde{s}$ is low relative to s and the second term in the right-hand side of equation (9) dominates.

We show this result numerically in the following calibration of the model. A time period is a month. For any given value of λ, we choose σ and y to target the following pre-shock equilibrium moments: (i) fraction of prices changing (increasing or decreasing) every month = 0.21, and (ii) average absolute size of price changes = 0.22. We consider two alternative values for the shock arrival probability λ: 1 (which we refer to as Gaussian) and 0.3 (which we refer to as Poisson). In order to match our two calibration targets, the Poisson specification requires thinner Ss bands y and more volatile cost shocks σ.[55] As discussed in Midrigan (2011), the Poisson specification gives rise to a more Leptokurtic distribution of cost changes (the kurtosis of price changes is 2.2 with $\lambda = 0.3$ and 1.3 with $\lambda = 1$).[56]

Starting in the pre-shock steady state distribution of price gaps in which $w_t = 0$, we consider a one-time

[54]If we make the length of the time interval sufficiently short (reducing σ correspondingly) then price reductions before the shock are of size y (so that $s = y$) and new price changes after the shock are no smaller than y (so that $\tilde{s} \geq s$), implying $s' > s$. Therefore, a necessary condition for $s' < s$ is that the time interval is sufficiently long such that there is a non-degenerate distribution of price changes greater than y.

[55]With $\lambda = 1$, we set $\sigma = 0.105$ and $y = 0.16$. With $\lambda = 0.3$, we set $\sigma = 0.21$ and $y = 0.08$. To assess the role of λ, we considered two alternative parameterizations. First, if we fix y and σ at their Gaussian-calibration levels and set $\lambda = 0.3$, the average size of price reductions falls after the CHF appreciation. Second, if we fix y and σ at their Poisson-calibration levels and set $\lambda = 1$, then the average size of price reductions rises after the CHF appreciation.

[56]Gertler and Leahy (2008) and Midrigan (2011) consider a slightly smaller probability of receiving an idiosyncratic cost shock ($\lambda = 0.2$). If the aggregate component of marginal costs, w_t, is constant in the pre-shock equilibrium, the fraction of price changes (our first calibrated moment above) is bounded above by λ. If we were to target our moment (i) above by setting $\lambda = 0.21$, this would require setting $y = 0$, so that prices are fully flexible. Our choice of λ implies that not all prices adjust after the appreciation of the CHF, as observed in our data.

4.2% permanent reduction in the aggregate component of marginal cost for imported goods at the retail level, that is, $w_t = \Delta = -0.042$ for $t \geq 0$. This choice of Δ corresponds to the average decline in the import price at the border plus distribution costs three months after the CHF appreciation that we report in Table 4.

Table H.1: *Price statistics of imported goods in Ss model and data*

	Data		Model			
			Gaussian	($\lambda = 1$)	Poisson	($\lambda = 0.3$)
	pre-shock	shock	pre-shock	shock	pre-shock	shock
Fraction up	0.13	0.09	0.11	0.06	0.11	0.08
Fraction down	0.08	0.21	0.11	0.18	0.11	0.18
Size up	0.23	0.22	0.22	0.22	0.23	0.21
Size down	0.22	0.16	0.22	0.23	0.22	0.20
Size new price reductions ($\tilde{s}$)	n.a.	n.a.	n.a.	0.18	n.a.	0.10
Size down large	0.29	0.28	0.22	0.23	0.28	0.28
Frac. down small	0.32	0.58	0.00	0.00	0.33	0.48

Notes: large is more than 15%, *small* less than 15%. Pre-shock corresponds to the period 2014 in the data and the pre-shock steady state in the model. Shock corresponds to the first quarter of 2015 in the data and the first period after the appreciation in the model.

Table H.1 displays price statistics for imported goods in the data, in the model with Gaussian shocks ($\lambda = 1$), and in the model with Poisson shocks ($\lambda = 0.3$). The "pre-shock" period corresponds to February 2014 in the data and to the pre-shock steady-state in the model. The "shock" period corresponds to February 2015 in the data and to the first period after the appreciation in the model.

Both model specifications imply a reduction in the fraction of price increases, a rise in the fraction of prices decreases, and a small reduction in the size of price increases, as observed in the data on retail prices of imported goods reviewed above. However, while the model with Gaussian shocks implies an increase in the size of price reductions (from 0.22 to 0.23), the model with Poisson shocks implies a drop in the size of price reductions (from 0.22 to 0.20). In the data, the average size of price reductions for imported goods falls from 0.22 to 0.15.

We can understand these results using equation (9). Both specifications of the model are calibrated to the same pre-shock frequency and absolute size of price adjustment, f and s. Both specifications produce roughly the same increase in the frequency of price reductions, f' (see Table H.1). The key difference between the two specifications is in terms of the absolute size of new price reductions: $\tilde{s} = 0.18$ with Gaussian shocks and $\tilde{s} = 0.10$ with Poisson shocks. With Poisson shocks, more firms are subject to small cost shocks, which only reduce their price in response to the aggregate cost reduction. This shift in the composition of price changes toward small values reduces the average size of price reductions. Consistent with this intuition, Table H.1 shows that with Poisson shocks, the average size of large price reductions (those larger than 15%) increases after the shock, as well as the fraction of firms with small price reductions (those smaller than 15%).

If we consider a larger reduction in border prices (i.e. a larger value of Δ), the increase in the frequency of price reductions and the reduction in the average size of price reductions are both larger.[57] This is consistent with the empirical results reported in Subsection 6.4: larger reductions in border prices (or foreign-currency invoiced border prices) lead to more frequent but smaller price reductions.[58]

Finally, we discuss the implications of the model for average (zero and non-zero) price changes. Denoting the average price change after k months by p_k, $p_1 = -0.029$, $p_3 = -0.040$, and $p_6 = -0.042$ with Gaussian shocks ($\lambda = 1$), and $p_1 = -0.017$, $p_3 = -0.030$, and $p_6 = -0.038$ with Poisson shocks ($\lambda = 0.3$).[59] As discussed in detail in Midrigan (2011), the model with Poisson shocks implies a smaller reduction in prices, on average, because of a weaker "selection effect" in the set of firms changing price. What we showed is that this selection effect also has very different implications for the direction of the intensive margin of price changes in response to an aggregate cost shock.

[57] In our baseline results, we assume $\Delta = 0.042$ corresponding to the average decline in border prices adjusted for distribution costs. If we set $\Delta = 0.059$ (corresponding to the top 75 percentile decrease in border prices), then the frequency of price reductions rises by 0.11 and the average size of price reductions falls by 0.027 (rather than 0.072 and 0.025, respectively)

[58] We considered two alternative model specifications which can produce a more Leptokurtic distribution of price changes: one with multi-product firms, as in Midrigan (2011), and one in which every period the Ss band y is zero (i.e. zero menu costs) with a certain probability, as in the Calvoplus model of Nakamura and Steinsson (2010). When parameterized with Gaussian shocks ($\lambda = 1$), the average size of price reductions implied by these alternative model specifications increases in response to a decline in aggregate costs, as in the single-product model with Gaussian shocks.

[59] Both model specifications imply average price reductions that are too large and rapid relative to the data reported in Table 4. A smaller value of Δ, for the reasons discussed in footnote 53, would imply a smaller reduction in average prices, while keeping the other model implications discussed in this section qualitatively unchanged.