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JEL Classification: E3, E31, E50, F14, F41

Keywords: large exchange rate shocks, exchange rate pass-through, Quality adjustment

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1 Introduction

Understanding the impact of exchange rate changes on the prices of exports and imports is a key question in international macroeconomics. Pass-through into the prices of internationally traded goods is usually found to be incomplete in the aggregate (see Burstein and Gopinath, 2013, for a survey). The margin of adjustment is that firms adjust prices by less than the exchange rate because of, for example, nominal rigidities in the invoicing currency, markup adjustments, local distribution costs, or, in the case of pass-through into export prices, imported intermediate inputs.[1]

Another possible margin of adjustment, which is less intensively documented, is that firms change the products that they sell abroad, in addition to adjusting prices.[2] Product adjustments occur when firms change the quality of an existing product or adjust the set of products on the market toward products with higher or lower levels of quality. In this paper, we study how the product quality of exported goods in a small, open economy responds to an exchange rate shock and the extent to which this adjustment accounts for exchange rate pass-through.

The exchange rate shock that we study is the large, sudden, and unexpected appreciation of the Swiss franc on January 15, 2015, shown in Figure 1. This appreciation was observed after the Swiss National Bank (SNB) removed the lower bound on the CHF against the euro, which it had maintained since its introduction on September 6, 2011. This episode is well suited for studying the effects of an exchange rate shock because it occurred after a period with very stable prices and an exchange rate that fluctuated very little for more than three years before the shock.[3] Additionally, other macroeconomic aggregates, such as GDP growth, unemployment, and interest rates, were very stable in Switzerland during this

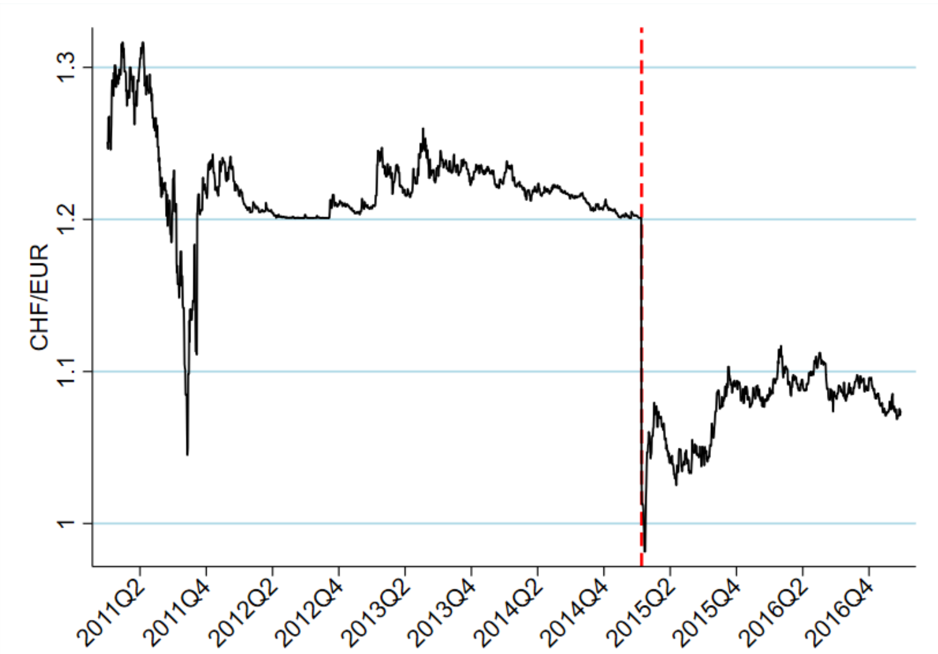
[1]See, for example, Engel (2002), Burstein, Neves, and Rebelo (2003), Atkeson and Burstein (2008), Gopinath and Itskhoki (2010), and Amiti, Itskhoki, and Konings (2014, 2019).

[2]For example, after the substantial appreciation of the Swiss franc in January 2015, the Swiss National Bank (SNB) conducted a survey of exporting firms to learn about their strategies to counter the negative effects of the exchange rate shock. The surveyed firms reported optimizing the mix of products as one of their main strategies for remaining competitive (SNB, 2015).

[3]See also Kaufmann and Renkin (2017, 2019), Bonadio, Fischer, and Sauré (2020), Auer, Burstein, and Lein (2021) and Auer, Burstein, Erhardt, and Lein (2019), who studied the effect of this exchange rate shock on prices. Funk and Kaufmann (2020) showed the implications for wage adjustments in the aftermath of this exchange rate shock and the associated negative inflation rates.

three-year period such that changes in prices or product quality adjustments are unlikely to be a result of the lagged effects of other large aggregate shocks (see Table A.1 in the appendix and Auer, Burstein, and Lein (2021)). Furthermore, the decision to remove the exchange-rate lower bound was triggered by external developments in the euro area (such as expectations of quantitative easing), and are thereby exogenous to price or quality developments in the domestic economy.[4] Such an episode with a large exogenous shift in the exchange rate is well-suited to study how export prices and export quality respond to a change in the exchange rate, while it is more difficult to provide causal estimates in periods where the exchange rate fluctuates freely and changes in the exchange rate are endogenous to prices or variables that are closely related to quality, such as productivity shocks, for example.

Figure 1: *CHF/EUR exchange rate and 2015 CHF appreciation*



Notes: This figure shows the CHF/EUR exchange rate from January 1, 2011, to December 31, 2016. The dashed line indicates the day of the removal of the lower bound on the CHF against the euro on January 15, 2015. Source: Bank of International Settlements

[4] Media reports suggest that the decision was closely related to expectations that the ECB would announce their bond purchasing program on the Thursday of the same week (i.e., January 19, 2015). For example, one of the largest newspapers in Germany (in terms of circulation), Handelsblatt (2015), reported that "Many economists expect the ECB to announce massive bond purchases at its council meeting next Thursday. It could then buy government bonds of the euro countries [...] This would tend to depreciate the EUR" (translated from German). See also a speech by SNB president Jordan (2016), in which he also relates the decision to expectations about further monetary easing in the euro area.

Using customs data from the Swiss Federal Customs Agency (FCA) that covers a large share of all exports from Switzerland, we study how the quality of exported products responds to the exchange rate shock. While we report results for imports in the appendix, we focus predominantly on exports for two reasons.[5] First, while all firms that mainly export to the euro area (by far the largest destination currency area for Swiss exports) are affected by the appreciation, it is less clear how much foreign firms exporting to Switzerland are affected. If Switzerland is only a small export destination (as it probably is for many foreign firms), it is unlikely that they would adjust their product quality (which is arguably costly), while it is more likely that Swiss exporting firms pay the cost for adjusting product quality if the appreciation impedes their competitiveness in their largest export market. Second, the appreciation induces demand effects of Swiss firms, which we cannot distinguish in the data from a quality adjustment in response to the decline in the relative prices of imports as follows: exporting firms often use imported intermediate inputs (Amiti, Itskhoki, and Konings, 2014), and therefore their demand for higher quality inputs to produce higher-quality export goods may increase, a channel for which we also find suggestive evidence, as discussed below (see also Bas and Strauss-Kahn, 2015, Bernini and Tomasi, 2015, Kugler and Verhoogen, 2012, Hallak and Sivadasan, 2013, Bastos, Silva, and Verhoogen, 2018).

We examine two quality adjustment margins. First, products can upgrade (downgrade) in quality. Second, the distribution of products within a product category can be sorted toward products with higher (lower) quality; thus, products with low (high) quality tend to exit disproportionately. We find that both quality adjustment margins are important and that Swiss exporting firms, which became less competitive abroad following the currency appreciation, tended to improve the quality of their products (quality upgrading) and to remove products from the market that had relatively low quality within their product category (quality sorting). Furthermore, quality upgrading and quality sorting are more pronounced for exports to high-income countries and the firms that improve their export quality also import higher-quality intermediate inputs.

[5] We conduct a similar analysis for imports that we report and describe in Appendix K and on the intermediate input channel discussed below in Appendix J.

We further decompose exchange rate pass-through (ERPT) into price and product quality adjustments. For most export prices used in studies quantifying ERPT, prices are adjusted for quality. Thus, if product quality endogenously responds to the exchange rate, quality changes impact ERPT estimates through the quality adjustment term. We document how large this effect is. We find that, while ERPT one to three quarters after the exchange rate shock is largely due to the adjustment of export prices, quality upgrading accounts for up to one half of the overall pass-through four to eight quarters after the exchange rate shock. Using counterfactual analysis, we furthermore show that one fourth of the pass-through is accounted for by quality sorting because products with low quality are more likely to exit the market. The remainder is due to changes in quality-adjusted prices.

Our results are robust to several aggregation approaches and variations in the assumptions underlying the quality estimation. In addition, we cross-validate the results using the microdata underlying the Swiss export price index (EPI) from the Swiss Federal Statistical Office (SFSO). In these data, quality is not inferred from an econometric model and therefore provides an important additional data source. In our main analysis based on the customs data from the FCA, we infer quality adjustments for product-level prices from information on export prices and quantities, where conditional on price, higher quantity (within a narrow product category) is associated with a higher quality (Khandelwal, Schott, and Wei, 2013). This is not the case in the micro data underlying the EPI: there, export prices are collected via surveys, and exporting firms are asked to indicate when the quality of their products changes. In this case, firms are asked about the current and, importantly, the last-period price of the product with quality changes. This approach allows the statistical office to include corrections for quality changes in its official EPI. Since our purpose is to study the effect of these quality changes on pass-through, we exploit this variation between prices adjusted for quality and prices not adjusted for quality to quantify the effect of quality adjustments on pass-through into quality-adjusted prices. We find effects in the same direction and of similar magnitude, that is, quality adjustments account for approximately one half of the overall pass-through in this dataset four to eight quarters after the appreciation.

Our paper relates to the literature that examines the role of quality for ERPT. Chen and Juvenal (2016) show empirically and theoretically that higher-quality goods perceive a lower demand elasticity in the export market and, therefore, exporters of higher-quality goods pass through a smaller exchange rate change share into local consumer prices. This implies that the pass-through in export prices measured in the exporter's currency, as we do in this paper, is higher. In their model, this is because distribution costs are assumed to be larger for high-quality goods relative to low-quality goods.[6] Auer, Chaney, and Sauré (2018) derive similar predictions from a model with non-homothetic demand, where high quality is valued more by consumers with higher income.[7] This implies that high-quality producing firms have more variable markups than low-quality producing firms and, therefore, absorb a larger share of an exchange rate shock in their markups and change local prices by less, implying a lower pass-through in local consumer prices and, therefore, a higher pass-through into the prices converted into the exporter's currency. The focus of this strand of the literature is on how firms set prices in foreign markets for products that differ in quality but not on how product quality is adapted in response to an exchange-rate change. The contribution of our paper is to show that product quality itself changes in response to exchange rate fluctuations, thereby contributing to pass-through into quality-adjusted prices. On the backdrop of this literature, our finding that the quality of exported products increases after the appreciation of the CHF suggests that firms improve quality to reduce perceived demand elasticities and thereby alleviate the quantity decline.

Our paper complements the literature that examines how the average quality of exported products responds to exchange rate shocks. Auer and Chaney (2009) show theoretically that when consumers have heterogeneous preferences for quality, exports should shift towards higher quality after an exchange rate appreciation and find some weak evidence for that

[6] Related predictions can be derived from Atkeson and Burstein (2008), Melitz and Ottaviano (2008), Auer and Chaney (2009), Berman, Martin, and Mayer (2012), Mayer, Melitz, and Ottaviano (2014), Bernini and Tomasi (2015), Bastos, Silva, and Verhoogen (2018), Medina (2020), or Chen and Juvenal (2020).

[7] There is empirical evidence that richer consumers tend to be less price sensitive and value quality more (see, for example Goetz and Rodnyansky, 2021, Auer, Burstein, Lein, and Vogel, 2022) and that richer countries tend to export and import products with higher quality (see, for example Schott, 2004a, Hummels and Klenow, 2005, Hallak, 2006, Hallak and Schott, 2011, Bastos, Silva, and Verhoogen, 2018).

prediction in US data.[8] Similarly, Fauceglia, Plaschnick, and Maurer (2017) and Fauceglia (2020) show for the same period we study that Swiss exporters tended to export higher quality on average after the appreciation. Our contribution is to quantify the effect of quality adjustments on exchange rate pass-through, focusing on a period with a clearly identified exchange rate shock. We furthermore decompose the aggregate pass-through into a component that is due to the adjustment of the prices of products that do not change quality and two components that are due to quality adjustments (sorting and upgrading), which affect ERPT into quality-adjusted prices.[9] One recent paper examines the endogenous quality sorting response and its implications for pass-through: Goetz and Rodnyansky (2021) show that an online apparel retailer in Russia offered lower quality products in its domestic market after the 2014 depreciation of the ruble. They show that the retailer imported fewer high-quality products after the devaluation relative to low-quality products due to a quality sorting effect, accounting for approximately 12% of the aggregate pass-through. We show that their results also carry over to the case of a large appreciation, exported products, and a broad set of product categories. Furthermore, we decompose the aggregate ERPT into a price adjustment component and the product quality upgrading effect, in addition to the quality sorting effect. Our results suggest that the contribution of product upgrading to ERPT is economically important, while we find a similar effect from quality sorting as Goetz and Rodnyansky (2021).

Our results are also related to the literature emphasizing important differences between

[8]By focusing on the endogenous quality response, our paper also relates to the theoretical literature on firms' product quality choices and the role of demand for quality. In these models, quality choice is endogenous and firms can change quality in addition to prices or quantities to compete. Firms do so to attract heterogeneous consumers who differ in quality valuations (see, for example Shaked and Sutton, 1982, Auer and Sauré, 2017). Costs are assumed to be convex in quality to ensure that many firms operate in such a vertically differentiated market (Shaked and Sutton, 1982, 1987).

[9]An endogenous quality response to an exchange rate appreciation is also consistent with Medina (2020), who shows that increased competition in low-quality segments, which is likely what exporting firms experience after the appreciation of their home currency, induces firms to upgrade their product quality by reallocating production factors. In a related work, Rodríguez-López (2011) shows that aggregate import and export prices may suffer from a survivor bias, because exchange rate shocks affect firms' export decisions and the extensive margin of trade, where low-productivity firms (selling lower-quality products) tend to exit the export market after an appreciation of the home currency. The endogenous response is also consistent with the evidence in Amiti and Khandelwal (2013) showing that lower tariffs raise the average quality of production for export products close to the world technology frontier, which are arguably most of the products that Switzerland exports.

quality-adjusted and quality-unadjusted trade prices: Feenstra and Romalis (2014) show that much of the variation in export unit values is explained by quality.[10] Nakamura and Steinsson (2012) show that product replacement bias, which is related to product upgrading and sorting, is large and that pass-through estimates are significantly larger when accounting for such bias. We show that the quality-adjustment term itself is responsive to changes in the exchange rate, particularly in the medium run, therefore confirming that using quality-adjusted prices or unit values is important not only for cross-country comparisons but also when studying ERPT.

This paper is structured as follows. In Section 2, we describe the two datasets and outline their complementary features. Section 3 explains the quality estimation and provides evidence on quality upgrading and quality sorting. Section 4 assesses the aggregate effects on ERPT, while Section 5 cross-validates our results with an alternative dataset. Section 6 concludes.

2 Data

This section describes our datasets and presents descriptive statistics. Our main analysis is based on customs data from the Swiss FCA. These data include quantities and values of the universe of trade flows and therefore allow us to distinguish product adjustments due to quality sorting from those due to quality up-/downgrading. We show that quality adjustments are also more prevalent after the exchange rate shock in the microdata underlying the official Swiss EPI provided by the SFSO.

The data from the Swiss FCA comprise the universe of export transactions registered at the Swiss customs office at the transaction level.[11] Each transaction includes the free on board (FOB) value in Swiss francs and the volume of the transaction[12], a Harmonized System 8-digit product code (HS8), in which the first 6 digits define the international product classification

[10] See also Schott (2004b, 2008), Hallak (2006), Hallak and Schott (2011), Khandelwal (2010) and Martin and Mejean (2014).

[11] In total, we observe 98.7% of total trade. See also Egger and Lassmann (2015), Egger and Erhardt (2016), and Bonadio, Fischer, and Sauré (2020) for applications and descriptions of the dataset.

[12] Even though some products contain information on units in addition to mass, we rely on the mass measure in our baseline to ensure comparability across products and because the unit measures are not available for all transactions. We perform a robustness analysis by replacing the mass measure with the unit measure where available, as discussed in Appendix S. We exclude observations that omit information on mass from the analysis (0.15% of transactions).

(HS6), and the last two digits are Switzerland-specific finer product categories, and a 3-digit "statistical key" specific to the FCA dataset that further divides the HS8 classification of particularly broad HS8 product codes into smaller groups for internal use at the FCA.[13] In addition, it includes the transaction date, a unique firm identifier, the zip code of the exporting firm, the invoicing currency, and the country of destination.[14]

We focus in our main analysis on exports to countries within the euro area. We focus on the euro area because the Swiss franc's floor was defined in terms of the EUR/CHF exchange rate, and the appreciation against the euro was thus very sharp and persistent. In Appendix H, we provide estimates for other countries, which can be viewed as a control group, because the CHF exchange rate vis-a-vis other currencies did not move as much and as persistently (see Figure H.1 in Appendix H). Our data range is from 2014 to 2016.[15] As in Auer, Burstein, and Lein (2021), we move all of the dates backward by 14 days such that the shock that originally occurred on January 15, 2015, occurred in our data on January 1, 2015. We do so to ensure that 2015Q1 includes all data after the shock to the EUR/CHF. Products i are defined as a combination of firm f, the $HS8$ product code and the 3-digit statistical key, and we may observe exports of the same product exported to different destination countries d.[16] We refer to the price p of a product in a transaction by constructing FOB unit values ($value/volume$),

[13] An example of such a statistical key is taken from FCA (2022) for the HS8 product code 9102.1100 "Wristwatches, electrically operated, whether or not incorporating a stopwatch facility– With mechanical display only". Here, the keys distinguish for example between "with short-time measurement, with case of steel" (key 125), "with short-time measurement, with case of plastics" (key 128), and "without short-time measurement, with case of mineral materials" (key 117). In the remainder of the text, we refer to the combination of the HS8 product code and the statistical key as the HS8 product group.

[14] It became mandatory to include the firm identifier, the so-called UID ("Unternehmensidentifikationsnummer", Enterprise Identification Number), on the customs declaration forms from 2016 onward. Each firm in Switzerland must be registered in the UID register (see SFSO (2015) for details). We were provided with a dataset by the FCA that links firm names with their UIDs in the data between 2016 and 2020. We use this information to carry the firm identifier UID backwards in time to available firm names for the 2014 and 2015 data. Using this procedure, we were able to assign a UID to 94.4% and 96.6% of all transactions in 2014 and 2015, respectively. Using the firm name strings directly is not possible because the firm name strings are not harmonized and vary greatly within the firm identifier UID, such that a firm name appears in many different forms in the data, see Egger and Erhardt (2016) for a detailed discussion of this issue. Since the firm identifier UID became mandatory in the data only in 2016, Bonadio, Fischer, and Sauré (2020) define product identifiers using the combination of zip code, 8-digit product classification, statistical key, and destination country. We present robustness checks using their product identification method in Appendix E.

[15] The data are not at the same level of detail in earlier years, which is why we start our analysis in 2014. We end our main analysis in 2016 because the exchange rate became less stable thereafter.

[16] Martin and Mejean (2014) use the same approach to identify observations in disaggregated French export data.

where value is the total value of the transaction in CHF and volume is consistently measured in kilograms.[17] Our main analysis is at the product-destination country level. Because we must compare products over time, we cannot conduct our analysis at a very high (daily) frequency, since most products are not exported on a daily or weekly basis. We therefore aggregate the product-destination country-level data to a quarterly frequency by computing quarterly unit values as total values over total volume per product i and destination d in a given quarter, $p_{i,d,q} = \sum_K value_{i,d} / \sum_K volume_{i,d}$, which is the weighted average of underlying prices across all transactions K observed within that quarter q. In our analysis below, we compare the changes in prices to the change in the EUR/CHF exchange rate, which is the quarterly average of the monthly average CHF/EUR exchange rate published by the SNB.

Our second data source, which we use to cross-check the key patterns in the data, is the microdata underlying the Swiss Producer Price Index (PPI) collected by the SFSO. This index includes a sub-index that comprises only exports, which is labeled the Swiss EPI. We use the data from January 2012 onward.[18] The data are collected using firm surveys (either online or via regular mail). Firms list their main products and associated selling prices and complete a separate form for exports such that the export prices for products can differ from the prices for the same products in the domestic market. In a survey, firms are asked to indicate when they replace a product on the market with a new product. If a firm indicates that the new product is similar to the old one but with different quality (for example, a new version of the old product), the new price is adjusted for quality by asking the firm to indicate the last-period price of the new product since two product lines usually co-exist for some months before the new product completely replaces the old product (see also SFSO (2016)).[19] In this case, the price series of the old and new products are combined, where the

[17] This definition has been used frequently in the trade literature, including, for example, Berman, Martin, and Mayer (2012), Khandelwal, Schott, and Wei (2013), Chen and Juvenal (2016) or Manova and Yu (2017). The data provide consistent nonzero information on the unit of measurement (e.g. pieces, liters, meter or sets) for 32.6 percent of our observations. Given the lower coverage, we use the definition of volume instead of unit of measurement throughout. Appendix S shows that our results are robust to using units instead of volume to compute prices for all observations, where units are available, and keeping the prices from the baseline for all observations where units are not available.

[18] The EPI data are available from 2011 onward; however, as noted also in Kaufmann and Renkin (2019), there is some unusual volatility present in some price series, which seem to be related to difficulties in collecting prices in the first year after launching the export price survey.

[19] If the new product is almost identical and of similar quality to the old product, no product adjustment

price information in the overlapping period serves as a quantification of the change in price that is due to a change in quality. Because prices refer to the first days of the survey month, the data recorded in January do not include the shock period, which is why we move all the dates one month backward such that 2015Q1 includes prices from the post-shock period.[20]

We choose the FCA data for the main analysis because these data allow us to observe quantities per transaction; thus, as we describe below, we are able to estimate the quality and to distinguish quality upgrading from quality sorting. Furthermore, it includes the universe of transactions registered and is therefore very comprehensive.[21] The disadvantage is that prices must be proxied by unit values and that the detailed data are available only from 2014 onwards, limiting the possibility to conduct a longer pretrend analysis. Unit values are subject to measurement error and quality has to be estimated as well, inducing another source of measurement error. In addition, we must infer how the prices of products would have evolved when they exit from the market. We address these concerns regarding measurement error in two ways. First, the potential measurement errors stemming from the use of unit values and estimated quality are not a concern in the SFSO data, as it includes prices, not unit values, and is available from 2012 onwards, thus allowing for a pretrend analysis.[22] The SFSO dataset also allows us to observe quality changes as indicated by firms themselves; thus, this information is not inferred from an econometric estimation and, thus, is not driven by the assumptions underlying these estimates. However, we cannot use the SFSO dataset to observe quality sorting because a product exit is typically not recorded directly in the month when the product exits.[23] We therefore use the SFSO data as a cross-check of our main findings and to

is recorded in the index construction. If the new product is not directly comparable to the old product, the price series of the old product is terminated, and a new series for the new product is initiated (SFSO, 2016).

[20] The SFSO data are published monthly. Therefore, we first aggregate the microdata at a monthly frequency also. However, most of the products in the EPI are surveyed on only a quarterly basis (SFSO, 2016), which is why we report pass-through rates at a quarterly frequency.

[21] The information on quality sorting in the EPI is limited because it does not include the universe of exported products, as the FCA data do. It is therefore difficult to tell whether products are no longer traded or firms did not respond to the survey.

[22] From 2012 to 2014, the exchange rate was very stable. Therefore, we should expect that no pretrends exist. See Appendix U for more details.

[23] If a firm does not complete the survey, the standard procedure is that the SFSO carries forward the price from the previous survey and, after at least three months of nonresponse, takes action to determine whether the product no longer exists. These imputed prices are not flagged. Thus, a product exit is often recorded later than it actually occurred.

check for robustness regarding unit values vs. prices, as well as estimated vs. firm-indicated quality changes. The second way is that we conduct various robustness checks using the FCA data, where we exclude very volatile product categories, which are more likely to suffer from measurement error (Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller, 2020), and where we estimate quality adjustments using alternative assumptions about the elasticity of demand (Appendix I and D, respectively). Our results are robust to these choices and, together with the observation that the main results show a similar pattern in the SFSO data, corroborate our interpretation.

Table 1: *Descriptive statistics*

	2012	2013	2014	2015	2016
FCA data					
Firms			30,880	34,639	44,545
HS8 product groups			7,850	7,848	8,358
Product identifiers			280,511	310,818	347,933
Observations			927,834	997,140	1,068,821
	2012	2013	2014	2015	2016
SFSO data					
Firms	783	670	708	941	812
Products	2,761	2,512	2,574	3,710	2,800
Observations	29,716	27,556	27,450	33,320	31,009

Notes: The upper panel reports the descriptive statistics for our baseline based on exports to the Euro area from customs data from the FCA at a quarterly frequency. The lower panel reports the microdata underlying the Swiss EPI collected by the SFSO at a monthly frequency.

The upper panel of Table 1 reports the number of firms, HS8 product groups, products (as defined by the combination of product code i and destination country d), and quarterly observations for the FCA data. Overall, we observe between 30,880 and 44,545 firms and approximately 300,000 products from more than $7,000$ HS8 product groups per year. The number of quarterly observations is close to one million. The number of firms, products and observations rises somewhat over time. The corresponding data for the SFSO survey are reported in the lower panel. Since this is a representative sample of export products, we observe a much smaller number of products (between 2,512 and 3,710) from between 670 and 941 unique firms, yielding between 27,450 and 33,320 monthly observations per year.

3 Product quality changes

In this section, we describe how we estimate product quality in the FCA dataset and how we adjust prices for quality. We further show how we distinguish between quality upgrading and quality sorting.

3.1 Estimation of product quality

In this subsection, we describe how we derive our quality estimate. Following Khandelwal, Schott, and Wei (2013), we assume that consumer preferences incorporate quality. Conditional on a given elasticity of substitution, when comparing two products in the same industry classification with the same price in the same period with different quality levels, the higher-quality product should be demanded in larger quantities. With the observations of prices and quantities at the product level, we can therefore infer the level of quality. To account for the gradual product adjustment process in response to the appreciation, we estimate quality at a quarterly frequency. The quality for each product-destination-quarter (i, d, q) observation can be estimated from the OLS regression, as follows:

$$v_{i,d,q} + \sigma_{HS4,d}\, p_{i,d,q} = \alpha_j + \alpha_{d,y} + \alpha_Q + \epsilon_{i,d,q}, \tag{1}$$

where q is the quarter, $v_{i,d,q}$ is the log export volume of products i to destination country d, and $p_{i,d,q}$ is the associated log price. The demand elasticities $\sigma_{HS4,d}$ on the left-had side of equation (1) are the HS 4-digit product category (HS4) and destination country d specific import demand elasticities estimated in Soderbery (2018).[24] Because the levels

[24] If no estimate for the product category HS4 and destination country combination $(HS4, d)$ is available from Soderbery (2018) (2.9% of transactions), we use the euro area median elasticity of the product category $HS4$ (0.5% of transactions). If no estimate on the product group is available, we set the elasticity of substitutions to the value $\sigma = 5$ following Manova and Yu (2017) (2.4% of transactions). We winsorize the estimates at a maximum of $\sigma_{HS4,d} = 11$ (0.4% of transactions). The HS 4-digit product categories are the lowest level of

of prices and quantities might not be comparable across product categories, we include HS 6-digit product classification (HS6) fixed effects.[25] To control for changes in aggregate income and price indexes in the destination countries, we include destination-year fixed effects $\alpha_{d,y}$. Furthermore, we include season (quarter-of-the-year) fixed effects α_Q to account for seasonal patterns in exports that could otherwise confound our quarterly estimates.[26]

Product quality is then inferred from the residual of equation (1) and the demand elasticity estimates, as follows:

$$\hat{\lambda}_{i,d,q} = \frac{\hat{\epsilon}_{i,d,q}}{\sigma_{HS4,d} - 1}.$$

We use this quality estimate $\hat{\lambda}_{i,d,q}$ to construct the *quality-adjusted* price for each product i to destination d in quarter q as $p^{adj}_{i,d,q} = p_{i,d,q} - \hat{\lambda}_{i,d,q}$.

3.2 Product upgrading

Based on the quality estimates described above, we infer whether the quality of existing products is upgraded, and in the following subsection, we analyze quality sorting. To be more precise, quality upgrading includes quality improvements to existing products and a shift of exports towards existing products with a higher quality if the highly detailed product definition (firm-HS8 product code-statistical key) and destination country cells would still include two or more products of different quality within these cells.

We proceed in two steps. First, we show that product quality, on average, increases from the pre-shock year, 2014, to the two following years, 2015 and 2016. To do so, we calculate

disaggregation in which these estimates are available and represent a fine definition of product categories. For example, the more aggregate HS4 category 6601 "Umbrellas; sun umbrellas (including walking stick umbrellas, garden umbrellas and similar umbrellas)" includes the HS6 category 660191 "Umbrellas and sun umbrellas; having a telescopic shaft, (excluding garden or similar umbrellas)".

[25] To perform a quality comparison, the products must be similar and comparable in terms of quantities consumed and utility provided. As in Martin and Mejean (2014), we use the HS 6-digit product classification as the basis for the quality comparison of HS8 product groups. HS6 is the most detailed level based on the international HS system, and digits 7-8 of the HS system refer to the customs regime and are not related to product characteristics but are informative of the exporting firm.

[26] Similar to Khandelwal, Schott, and Wei (2013), Martin and Mejean (2014) and Manova and Yu (2017), we estimate product quality within annual destination exports to compare the quality of the exported products within a year-destination and reduce seasonal destination factors influencing our quarterly estimates. The remaining seasonality is extracted by the season fixed effect α_Q.

the value-weighted yearly average quality estimate of each product-destination i, d, $\hat{\lambda}_{i,d,y} = \frac{\sum_{q \in y} \hat{\lambda}_{i,d,q} * value_{i,d,q}}{\sum_{q \in y} value_{i,d,q}}$. We regress the change in the quality estimate $\hat{\lambda}_{i,d,y}$ from one year $y-1$ to the next on a constant and product classification-destination fixed effects α_{jd}, as follows:

$$\hat{\lambda}_{i,d,y} - \hat{\lambda}_{i,d,y-1} = \beta + \alpha_{j,d} + \epsilon_{i,d,y}.$$

The key parameter that we report is β since it indicates, within the product classification-destination country cells, the extent to which the quality of products that existed in 2014 (before the appreciation) rose in 2015 (after the appreciation). We also compare it to differences in quality between 2015 and 2016 to examine whether we find a difference for the period where the exchange rate changes only slightly.

Table 2: *Evidence for quality upgrading*

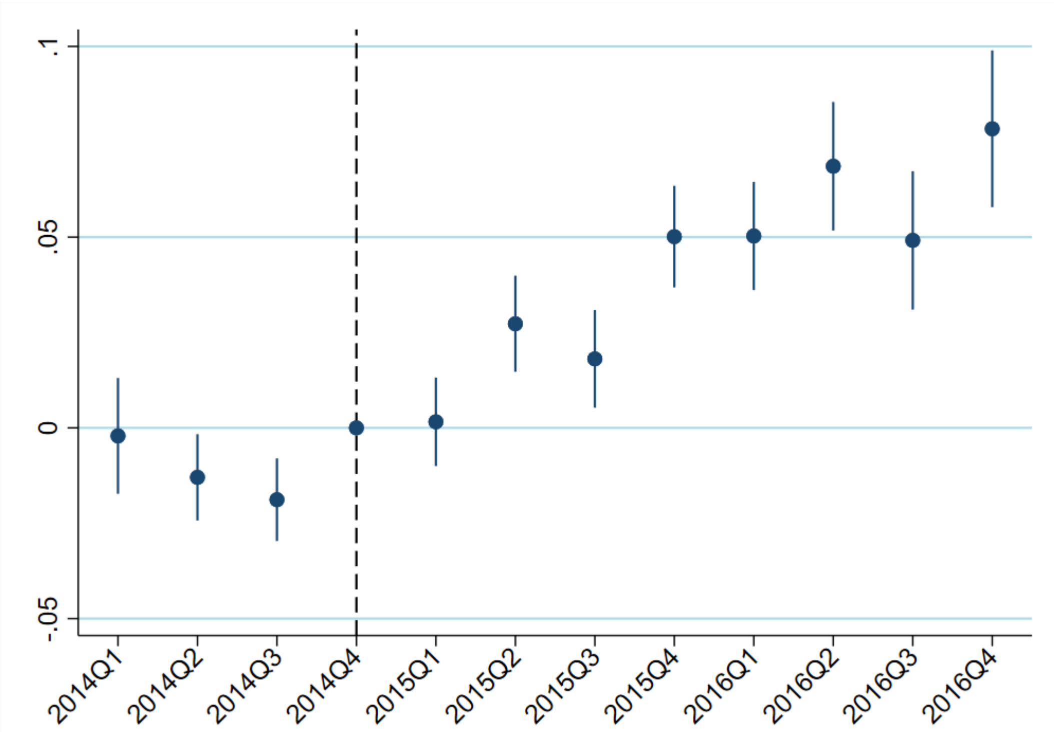
	Δ quality 2015 vs 2014	Δ quality 2016 vs 2014	Δ quality 2016 vs 2015
Constant	0.045***	0.071***	0.028***
	(0.002)	(0.002)	(0.002)
HS6/destination FE	Yes	Yes	Yes
R^2	0.08	0.09	0.06
No. of observations	249,573	222,286	264,276

Notes: Standard errors are in brackets, clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

Table 2 shows the results. Quality changes are positive between 2014 and 2015, on average, suggesting that quality largely improved after the exchange rate shock. Furthermore, quality upgrades between 2014 and 2015 (where the exchange rate appreciated by 12.1%) are significant and much larger than the increase from 2015 to 2016 (where the exchange rate depreciated only slightly by 2.1%). The difference between 2014 and 2016 shows that the effect is persistent (the appreciation of the exchange rate was 10.2% between 2014 and 2016).

In a second step, we assess the dynamics of the observed quality upgrading. For this purpose, we regress our quarterly quality estimate $\hat{\lambda}_{i,d,q}$ on product-destination country and quarter fixed effects. Figure 2 shows the estimates coefficients on the quarter dummies. We observe a gradual increase in product quality within product-destination country starting two quarters after the appreciation.

Figure 2: *Quality upgrading dynamics*



Notes: This figure shows the coefficients of the quarterly dummies β_q of the regression $\hat{\lambda}_{i,d,q} = \alpha_{i,d} + \sum_{q=2014Q1}^{2016Q4} \beta_q Q_q + \epsilon_{i,d,q}$, where $\hat{\lambda}_{i,d,q}$ are our quarterly quality estimates and $\alpha_{i,d}$ are product-destination country fixed effects. The coefficients on the quarterly dummies β_q represent the average quarterly percentage change in the quality estimates. Standard errors are clustered at the firm level.

We thus conclude that, on average, firms tend to upgrade their products. Whether this upgrade is large or small in economic terms cannot be evaluated from this simple statistic. We quantify the role of quality upgrading in aggregate ERPT in Section 4.

More detailed analyses by destination country and sector are provided in the appendix. We show in Appendix P that exports to destination countries with a higher GDP per capita tend to upgrade quality more than exports to destination countries with a lower GDP per capita, consistent with models of non-homothetic preferences.[27] In addition, in Appendix Table V.1, we report the estimates of changes in quality by sector. We observe positive quality changes in the largest export sectors, which are often characterized by a large proportion of differentiated products.

[27] Similar effects are found for quality sorting described in the next section.

We perform two robustness checks. First, quality upgrading may include a shift towards products of higher quality within the product-destination country cells (compositional shift). Even though we include this shift in our definition of quality upgrading, we provide a robustness analysis to obtain a sense of whether the quality upgrading effect is likely to be fully driven by this compositional shift. To do so, we show in Appendix I that when excluding product categories that are arguably more affected by the compositional shift, following Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller (2020), the quality change is of a similar magnitude. Second, we add a robustness check with an alternative quality measure based on Martin and Mejean (2014), which is described and reported in Appendix O. This alternative measure confirms the findings that firms tend to upgrade the quality of their products after the appreciation.

3.3 Product sorting

In addition to changing the existing products, firms can also remove products from their set of exports. In line with the notion of quality sorting, we test whether low-quality products are more likely to exit the export market.[28] We show the estimates for yearly averages for expositional purposes and report quarterly estimates in the appendix (Tables B.1 to B.3). To do so, we aggregate the data yearly, and we run the following regression:

$$I^{y}_{i,d}(D=1) = \beta_0 + \beta_1 X^{2014}_{i,d} + \alpha_j + \epsilon_{i,d},$$

where $I^{y}_{i,d}(D=1)$ is a dummy that is equal to 1 if a product is not exported in year $y \in 2015, 2016$ but was exported in 2014. Depending on the specification, $X^{2014}_{i,d}$ is the weighted average quality estimate $\hat{\lambda}_{i,d,2014}$, price $p_{i,d,2014}$, or quality-adjusted price $p^{adj}_{i,d,2014}$ before the appreciation.[29] We run these three specifications for each set of dummies $\{2015, 2016\}$. α_j is the HS6 product classification dummy.

[28]We do not include product entries in our analysis since product sorting largely concerns dropping products from a firm's product line and because, by definition, we have no price for the pre-shock period for products that enter after the shock.

[29]We construct the corresponding yearly price $p_{i,d,y} = \sum_k value_{i,d} / \sum_k volume_{i,d}$, where $k \in y$.

Table 3: *Relationship between quality and exits*

	(1) 2015	(2) 2016	(3) 2015	(4) 2016	(5) 2015	(6) 2016
Quality	-0.015***	-0.015***				
	0.001	0.001				
Price			-0.013***	-0.012***		
			0.001	0.001		
Quality-adjusted price					0.017***	0.017***
					0.001	0.001
HS-6 product group FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.07	0.06	0.05	0.05	0.06	0.06
No. of observations	480,531	480,531	480,531	480,531	480,531	480,531

Notes: Constant not shown. The first (second) column in each dependent variable corresponds to exits in 2015 (2016). Standard errors are clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

Table 3 shows that low-quality products are more likely to cease being exported in 2015 and 2016 (columns 1 and 2, respectively). Furthermore, we find that the same applies for products with a higher quality-unadjusted price (columns 3 and 4). High quality-adjusted prices, however, are more likely to be dropped (columns 5 and 6), in line with the notion that products with high quality-adjusted prices are less competitive.

As an additional indication that product sorting is present in the data in general, following Manova and Yu (2017), we show in Appendix Q that a positive correlation between quality and revenue exists in our data, suggesting that firms follow quality sorting strategies.

This may underestimate the effect of quality sorting if the product definition includes two or more products exported by the same firm to the same destination country that are of different quality within these cells (see also section 3.2) and if the product with lower quality exits while the higher quality product is still being exported. In the robustness check in Appendix I, where we exclude product categories that are arguably more affected by the compositional shift, we find estimates of similar magnitude for the quality sorting effect.

4 Aggregate effects on pass-through

In this section, we estimate the contribution of product adjustments to aggregate ERPT. In particular, we show how quality-unadjusted prices evolve and compare them to prices adjusted for quality (showing the effect of quality upgrading on ERPT) and how prices would have evolved had products with lower quality not been dropped from the set of exported products (showing the effect of quality sorting on ERPT). For the latter comparison, we construct a counterfactual price series for products that exit, as we describe in more detail in the next subsection. In subsection 4.2, we then report estimates of ERPT and the contributions of quality sorting and quality upgrading to it.

4.1 Counterfactual with no quality sorting

To examine the effect of quality sorting on pass-through, we ask how prices would have evolved without quality sorting. To do so, we extrapolate the prices that occurred in 2014 but not in 2015/2016 to create a counterfactual series of products that no longer existed in 2015 and 2016. We construct the counterfactual series under the assumption that prices had evolved with the median price for other products in the same product group, while we assume that the quality of these products remained unchanged. That is, we use the median yearly price change within a product group j ($\Delta\tilde{p}_{j,y}^{MED}$) to approximate the price change between y and $y+1$ for product-destinations that were observed before the shock but exited thereafter, where we calculate the yearly price change of product-destination i, d as the change between its weighted average prices in year y and year $y+1$. Hence, we impute the price for each exiting product-destination for the same quarter q in year $y+1$ as it was exported in year y as $\hat{p}_{i,d,q,y+1} = p_{i,d,q,y} + \Delta\tilde{p}_{j,y}^{MED}$, where $i \in j$. To derive the quality-adjusted price for imputed exports, we assume constant quality and use the quality estimate from quarter q in year y: $\hat{p}_{i,d,q,y+1}^{adj} = \hat{p}_{i,d,q,y+1} - \hat{\lambda}_{i,d,q,y}$. We repeat this procedure for 2016 including the imputed values of 2015.[30]

[30] We explain this in more detail and more formally in Appendix C.

4.2 Pass-through estimation

In this subsection, we report estimates of ERPT and the contributions of quality sorting and quality upgrading to it. In our analysis below, we compare the different (counterfactual) series. If we compare a series with prices unadjusted for quality and one with prices adjusted for quality, for example, the difference between the two will quantify the effect of quality upgrading on prices and pass-through.

To do so, we report pass-through estimates for three (counterfactual) series of export prices. The first is pass-through into prices adjusted for quality, including imputed prices for products that exited in 2015 or 2016, as described above. This series provides a counterfactual pass-through that controls for the effects of quality upgrading and quality sorting. We therefore label this the ERPT in a scenario with "no upgrading, no sorting" (scenario 1). Why do we label this series "no upgrading" when prices are adjusted for quality? Consider an example where the observed quality-unadjusted price of a product is unchanged after the exchange rate shock. Pass-through into this price would be zero if the quality had not been adjusted. Now, consider this product improved in quality, therefore the quality-adjusted price goes down and pass-through is not zero. We regard the quality-adjusted price as the one that controls for this quality upgrading, therefore, the effect of the quality change is taken out of the data, and it is labelled "no upgrading". The same applies to counterfactual series labelled "no sorting", which means that the product did not sort out of the market and therefore includes our imputed prices.

Second, we report pass-through into prices not adjusted for quality, including the counterfactual prices of products that were dropped from the set of exported goods. This series gives us the pass-through into prices that include quality upgrading effects but not quality sorting effects. We label this scenario "with upgrading, no sorting" (scenario 2).

Third, we report pass-through into prices that are unadjusted for quality and where product exits are, as in reality, not included in the data. This series is that of observed prices not adjusted for quality. We label this pass-through the ERPT in a scenario with "with upgrading, with sorting" (scenario 3).[31]

To estimate pass-through rates, we rely on an event study approach. Because the shock to the exchange rate was arguably exogenous to export prices and the product quality choices of Swiss exporters before the shock, we can estimate how much prices have changed from the pre-shock period (2014Q4 in our case) to the post-shock periods. To obtain an ERPT rate, we divide the log change in prices estimated from the event study coefficients by the log change in the exchange rate for the same horizon. Similar event-study designs have been applied to estimate ERPT for example in Bonadio, Fischer, and Sauré (2020), Kaufmann and Renkin (2019), or Auer, Burstein, and Lein (2021) for the Swiss appreciation episode and in Breinlich, Leromain, Novy, and Sampson (2019) or Corsetti, Crowley, and Han (2022) for the episode of the sterling depreciation after the Brexit referendum.[32]

Our main specification regresses the product-destination country quarterly price series on product-destination country fixed effects and time fixed effects, as follows:

$$p_{i,d,q}^{scen.1,2,3} = \alpha_{i,d} + \sum_{q=2014Q1}^{2016Q4} \beta_q Q_q + \epsilon_{i,d,q}, \tag{2}$$

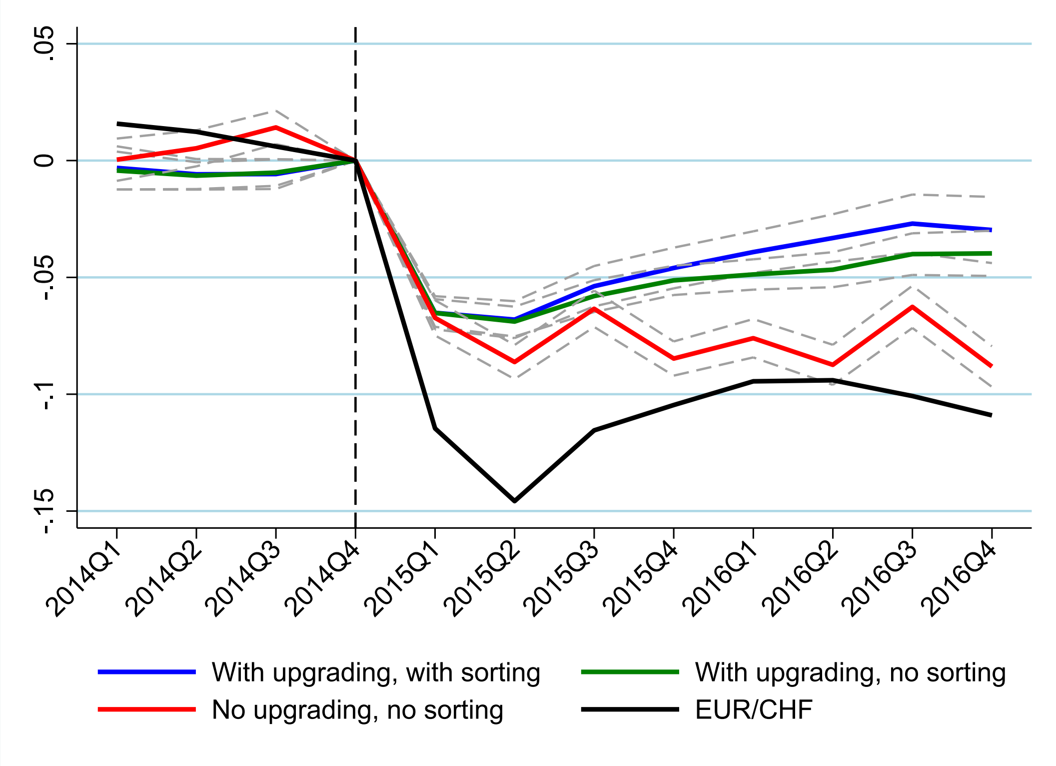
where $p_{i,d,q}^{scen.1,2,3}$ is the (counterfactual) price series of scenario 1, 2, or 3, as explained in the paragraphs above, $\alpha_{i,d}$ are product-destination country fixed effects, and Q_q is a set of quarterly dummies that is equal to 1 for a given quarter from 2014Q1,...2014Q3, 2015Q1,...,2016Q4, and zero otherwise. The quarter just before the shock, 2014Q4, is chosen as the baseline quarter. Standard errors are clustered at the firm level to account for potential correlation of error terms within firms across products, for example, because different products from the same firm may have correlated marginal costs, for example, because they source (imported)

[31] In principle, we have a fourth scenario, "no upgrading, with sorting". Since we focus on differences between scenarios later in this section, the effect of upgrading can also be computed as the difference between the "no upgrading, with sorting" and "with upgrading, with sorting" scenarios. The results that we obtain are very similar, as we report in Appendix R. We chose the comparison using the imputed observations because it is arguably closer to the SFSO EPI data, which often impute observations before they exit, and is therefore easier to compare. See the discussion in Section 2 for details.

[32] A typical approach to estimate ERPT rates in the absence of a clear and large exogenous shock to exchange rates, such as the Swiss episode or Brexit, is based on estimating dynamic lag regressions, where the period-to-period change in prices is projected on current and lagged first differences in the exchange rate and controls (see Burstein and Gopinath (2013) for example). We provide such an analysis in Appendix L

intermediate inputs from the same firm or country.[33] The β_q coefficients provide estimates for the average price difference between period q and 2014Q4 (in percent).

Figure 3: *Aggregate effects on pass-through*



Notes: This figure shows the regression coefficients β_q and 95% confidence intervals of regression (2). The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4. Standard errors are clustered at the firm level.

Figure 3 shows the estimates of the price changes in percentages (relative to 2014Q4) of each of the three scenarios together with the percentage change in the EUR/CHF exchange rate (relative to 2014Q4). The red line plots the coefficient estimates of the β's for each quarter for quality-adjusted prices, including imputed prices for products that exited (scenario 1, no upgrading and no sorting). Table 4 shows the associated pass-through rates in the second row (estimates of β divided by the first row). The first row of the table shows the difference

[33]This is also what would be suggested in Abadie, Athey, Imbens, and Wooldridge (2017) because the treatment may vary in intensity across firms with different imported intermediate input shares (as shown in Amiti, Itskhoki, and Konings (2014)). In addition, we show in Table M.1 in Appendix M that our estimated coefficients are also highly significant when clustering at the level of a) zip code, b) HS6 product category, c) HS4 category, and d) HS6 × destination country.

in exchange rate between 2014Q4 and the quarter indicated in the column header.

Pass-through rates in the first quarter after the shock are almost identical for all three scenarios because, arguably, quality adjustments cannot be implemented in the very short run. Our estimates suggest that pass-through rates are approximately 0.57 to 0.59 one quarter after the exchange rate shock. These estimates can be compared to estimates in the existing literature of short-run pass-through (SRPT) that quantify ERPT on impact. There are significant differences in SRPT into border import prices across countries (Burstein and Gopinath, 2013). Because we estimate ERPT into Swiss export prices, and Germany is the largest export destination country in our sample (40% of all exports in our baseline go to Germany), we compare our estimate for the first quarter after the shock to the SRPT estimate for import prices in Germany of 0.43 (SE 0.05) reported in Burstein and Gopinath (2013) (Table 7.4). Converted to producer currency, this would imply a change in the price of exports to Germany of 0.57 in response to a one percent change in the exchange rate. Our estimate of 0.57 to 0.59 is very similar to that point estimate. It is also comparable to the short-run estimates for the first three months after the shock provided in Bonadio, Fischer, and Sauré (2020), who show that export prices responded relatively swiftly to the exchange rate shock. This may be due to the observation that, in the Swiss data, approximately one third of all transactions are invoiced in EUR, for which ERPT is expected to be complete in the short run (this is the case for our estimates, too, see Appendix G for more details).[34]

Pass-through rates do not differ much between the three scenarios up to three quarters after the exchange-rate shock. These point estimates are most comparable to estimates for medium-run pass-through (MRPT) in the literature, that is, ERPT conditional on price adjustments.[35] As also shown in Auer, Burstein, Erhardt, and Lein (2019), many prices have

[34]We provide estimates for EUR invoiced and CHF invoiced transactions separately in Appendix G. The short-run responses we find are consistent with the literature that shows that pass-through into foreign-invoiced export prices in the short run is complete (or very close to), while it is incomplete for prices invoiced in domestic currency. See, for example, Gopinath, Itskhoki, and Rigobon (2010).

[35]An additional estimate of pass-through that is reported frequently in the literature is life-long pass-through (LLPT) over the entire life cycle of a product (Gopinath, Itskhoki, and Rigobon, 2010). This is probably difficult to compare to our estimates, because the event-study estimates are based on a time period of two years, while life-long pass-through requires longer time horizons that would allow us to observe products over their entire life cycle. Because the FCA (SFSO) data is consistently available only from 2014 (2012) onwards, the time period to compute LLPT is arguably too short.

changed at least once three quarters after the appreciation.[36] According to Burstein and Gopinath (2013), there are significant differences across countries in the point estimates for MRPT. For example, the MRPT of German exports to local prices in the US is 0.4 (in USD), whereas it is only 0.2 for all countries that export to the US (cf. Table 7.6 in Burstein and Gopinath (2013); Switzerland is not reported separately in these estimates). According to the estimates in Gopinath, Itskhoki, and Rigobon (2010), the pass-through rate of Swiss exports to US local prices is similar to that of Germany, at approximately 0.5 (Figure 2 in Gopinath, Itskhoki, and Rigobon (2010)). Our point estimates show that ERPT three quarters after the shock is approximately 0.55 in the exporter currency (CHF), which is in line with these MRPT estimates. Furthermore, we show in Table G.1 that approximately two-thirds of exports are invoiced in EUR and one-third in CHF. According to the literature on endogenous currency choice (Gopinath and Itskhoki, 2010), we should expect a relatively high aggregate MRPT because the desired pass-through of EUR invoiced export prices is expected to be higher than 0.5, whereas the desired pass-through of CHF invoiced export prices is expected to be lower than 0.5.

If quality changes were not controlled for but imputed prices for products that exit the market were included (scenario 2, with upgrading and no sorting), ERPT would be persistently lower than in quality-adjusted prices (scenario 1, no upgrading and no sorting) from 2015Q4 onwards (green line in Figure 3, estimates reported in row three of Table 4). The pass-through would be 0.45 in 2016, on average, over all quarters. The most interesting part is the difference between scenarios 1 and 2 because it quantifies the effect of quality upgrading. The ERPT into scenario 2 is 35 percentage points lower than the ERPT into scenario 1, which is estimated at 0.8 on average over all quarters in 2016. The effect of quality upgrading is therefore economically and statistically significant.

[36]We can condition on nonzero price changes only in the SFSO data, because unit values changes are rarely exactly zero. Estimates of MRPT that condition on price changes are reported for the SFSO data in Appendix L. Our estimate is 0.69, suggesting a relatively high MRPT compared to the US, but it is well in line with what would be expected for a country with a high share of exports invoiced in foreign currency, at least when currency choice is endogenous (Gopinath and Itskhoki, 2010).

Table 4: *Pass-through rates and CHF/EUR appreciation*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
EUR/CHF	-11.46	-14.58	-11.55	-10.46	-9.45	-9.40	-10.08	-10.90
No upgrading, no sorting	0.59	0.59	0.55	0.81	0.80	0.93	0.62	0.81
Upgrading, no sorting	0.57	0.47	0.50	0.49	0.52	0.50	0.40	0.36
Upgrading, with sorting	0.57	0.47	0.47	0.44	0.41	0.35	0.27	0.27

Notes: This table shows the percentage change in the EUR/CHF in the first row, together with pass-through rate for each scenario by quarter.

If the effects of quality changes were included in prices and product sorting was also included (scenario 3, with upgrading and with sorting), the pass-through rate would be 0.33 in 2016, averaged over all four quarters. The difference between scenarios 3 and 2 quantifies the role of product sorting. The difference in pass-through rates is 12 percentage points in 2016. These estimates suggest that quality sorting tends to occur sometime after the exchange rate shock, arguably because more time is needed for firms to bring new, higher-quality products to the market (quality sorting) than to adjust existing products (quality upgrading). This outcome is in line with Bonadio, Fischer, and Sauré (2020), who used daily data and reported no unusual exits around the time of the shock. Short-run pass-through estimates are, thus, not significantly affected by quality changes and are largely a result of price changes of existing products.

How much of the aggregate pass-through into export prices is due to price adjustments to unchanged products, quality upgrading and quality sorting? To answer this question, we decompose the total pass-through (the difference between the exchange rate change and the blue line in Figure 3) into pass-through that is due to changes in prices and pass-through that is due to quality adjustments. Since the effect of quality upgrading is shown in the difference between scenarios 1 and 2 and the effect of quality sorting in the difference between scenarios 2 and 3, we can use a simple decomposition to quantify the effect of each margin of adjustment (price adjustment, quality upgrading, and quality sorting). Denote the pass-through rates for each scenario $scen = 1, 2, 3$ by $\Lambda_q^{scen} = \frac{\beta_q}{\Delta e_q}$, where Δe_q is the log-difference of the exchange rate between quarter $q = 2015Q1, ..., 2016Q4$ and 2014Q4, and β_q is the average change in prices q quarters after the shock, as estimated in equation (2). We decompose the aggregate pass-through into three components, as follows:

$$\frac{ln(\Lambda_q^{scen1})}{ln(\Lambda_q^{scen3})} + \frac{ln(\Lambda_q^{scen2}/\Lambda_q^{scen1})}{ln(\Lambda_q^{scen3})} + \frac{ln(\Lambda_q^{scen3}/\Lambda_q^{scen2})}{ln(\Lambda_q^{scen3})}, \tag{3}$$

where the first term quantifies the contribution of changes in prices, the second term quantifies the contribution of quality upgrading, and the third term quantifies the contribution of quality sorting. For example, the aggregate pass-through, which includes both price adjustments and quality adjustments after 4 quarters, is $ln(0.44)$, as shown in the last row in Table 4. The contribution of price adjustments to aggregate pass-through is $ln(0.81)/ln(0.44)$, the contribution of quality upgrading is $ln(0.49/0.81)/ln(0.44)$, and the contribution of quality sorting is $ln(0.44/0.49)/ln(0.44)$. This outcome results in the observation that, after 4 quarters, 26% of the aggregate pass-through is due to incomplete price adjustments, 61% is due to quality upgrading, and 13% is due to quality sorting.

Table 5: *Contribution of margins of adjustment to aggregate pass-through*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
Incomplete price adjustment	0.94	0.69	0.78	0.26	0.25	0.07	0.36	0.16
Quality upgrading	0.06	0.29	0.12	0.61	0.50	0.60	0.34	0.61
Quality sorting	0.00	0.02	0.10	0.13	0.25	0.33	0.30	0.22

Notes: This table shows the contribution of each margin explained in the text to the overall aggregate exchange rate pass-through. "Price adjustments" corresponds to the "no upgrading, no sorting" series, "Quality upgrading" to the "with upgrading, no sorting" series and "Quality sorting" to the "with upgrading, with sorting" series.

While in the short run, the adjustment of prices is the most important component of pass-through, the effect of quality adjustments becomes more important in the medium run, after approximately one year. Table 5 shows the results of our decomposition for each quarter. Of the total pass-through in the first three quarters of 2015, 80%, on average, is due to pass-through into prices (adjusted for quality, including imputed prices for product exits), 16% is due to quality upgrading, and 4% is due to quality sorting. From Q4 2015 onwards, quality adjusted and unadjusted prices differ more significantly. The contribution to the total pass-through of incomplete price adjustment declines to 22%, while the contribution of quality upgrading and quality sorting account for 53% and 25%, respectively (averaged over all quarters from 2015Q4 onwards) .

As a robustness check, we compute a similar decomposition excluding imputed observations for product exits. That is, in principle, we have a fourth scenario, i.e., "no upgrading, with sorting". The effect of upgrading can also be computed as the difference between the "no upgrading, with sorting" and the "with upgrading, with sorting" scenarios. The results that we obtain are very similar, as we report in Table R.2 in Appendix R.

We conduct several additional robustness checks, including controlling for invoicing currency (Appendix G), intermediate input price changes (Appendix J.1), demand elasticity choices (Appendix D), estimates based on a more standard (not an event study) approach (Appendix L), estimates that exclude product categories that are more prone to measurement error in unit values (Appendix I) and including other countries (not just the euro area, where the CHF appreciation was most persistent) as a control group (Appendix H).

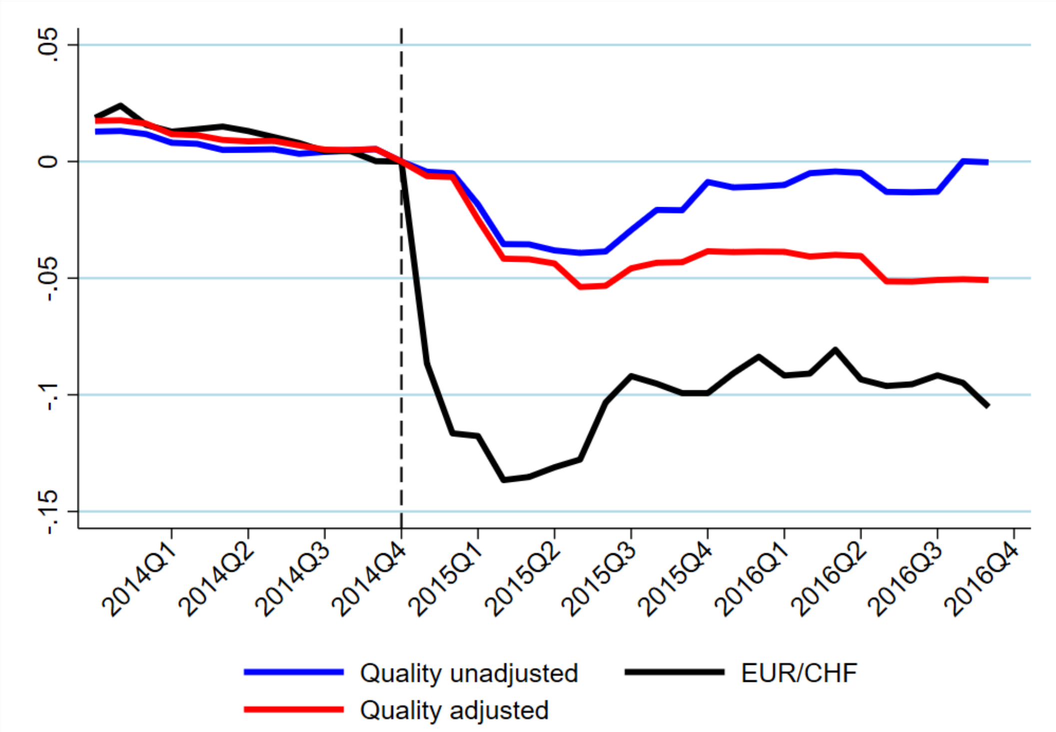
5 Cross-validation using alternative data

In this section, we cross-check our results based on the FCA data using the microdata underlying the Swiss EPI from the SFSO. Section 2 explains the data in greater detail. Based on the information about prices and price changes of products that change quality, we construct two series, as follows: one where we adjust prices for quality, as in the official price index, and one where we do not adjust prices for quality.

Figure 4 plots the official EPI as a red line (prices are quality adjusted, comparable to the "no upgrading, no sorting" scenario). This series represents our reconstruction of the official index based on the microdata.[37] It shows a similar pattern to our baseline data in Figure 3 with a pass-through rate of, on average, 35% in 2015 and 47% in 2016. Table 6 reports the pass-through rates per quarter. Although with a slightly muted dynamic, largely due to the lower data collection frequency, most of the decreases in both indexes occurred in 2015.

[37]Figure T.1 in Appendix T provides a comparison between our reconstruction based on the microdata and the official EPI. It does not match the official EPI exactly because we had to use more aggregate weights than the official index (we were not provided with weights per product, only per industry), and we omit the oil-related product categories 19 (Mineralölprodukte) and 6 (Erdöl and Erdgas) from the analysis to avoid confounding effects due to falling oil prices during the period under investigation. Therefore, our reconstruction only resembles the official index excluding energy, but the differences are very small.

Figure 4: *Pass-through in the export price index*



Notes: The reference period for data collection is the 1st to the 8th of a given month. For expository purposes, the indexes are shifted by one month such that January 2015 corresponds to prices collected from February 1 to 8. The ticks on the x-axis refer to the end of the quarter.

To reconstruct a series that does not control for the effect of quality changes, we aggregate the microprice data without adjusting prices for quality. The aggregation procedure using industry-level weights is the same as for the official price index. In this series (prices not adjusted for quality, comparable to the line "with upgrading, no sorting"), prices revert almost entirely to their pre-shock levels by the end of 2016 (blue line in Figure 4 and the last row in Table 6).

Table 6: *Pass-through in SFSO data*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
EUR/CHF	-11.46	-14.58	-11.55	-10.46	-9.45	-9.40	-10.08	-10.99
Excl adjustments	0.31	0.34	0.38	0.37	0.42	0.51	0.50	0.46
Incl adjustments	0.26	0.26	0.20	0.10	0.07	0.11	0.04	0.00

Notes: This table shows the pass-through rates for both SFSO series by quarter.

Table 7 shows the corresponding decomposition of aggregate pass-through using the same procedure as described for Table 5 above. In line with our findings in the FCA dataset, we can attribute approximately 33% (76%) of the aggregate pass-through to quality adjustments 1 (2) year(s) after the shock. In addition, in this dataset, we can observe the share of products for which a quality change is reported, which increase from 3.65% in 2014 to 11.54% in the two years after the appreciation. Similar to the results based on the FCA data, we observe higher long-run pass-through if we adjust prices for quality, while quality unadjusted prices tend to revert to their pre-shock levels after 2 years. This finding corroborates the role of quality adjustments in the aggregate ERPT obtained from the analysis of the FCA data above.

Table 7: *Contribution of margins of adjustment*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
Incomplete price adjustment	0.86	0.80	0.61	0.43	0.32	0.31	0.22	0.13
Quality upgrading and sorting	0.14	0.20	0.39	0.57	0.68	0.69	0.78	0.87

Notes: This table shows the contribution of each margin explained in the text to the overall exchange rate pass-through. "Price adjustments" corresponds to series "Quality adjusted", and "Quality upgrading and sorting" corresponds to "Quality unadjusted".

Additionally, the SFSO data allow us to study the two series over a longer history than the FCA data. Figure U.1 in Appendix U shows that there are no pretrends during the two years with a very stable exchange rate prior to the appreciation.

6 Conclusion

The pass-through of exchange rate shocks into export prices is usually found to be incomplete. In addition to changing prices, firms have other margins for responding to exchange rate shocks. One is by changing the quality of their products, thereby affecting pass-through into quality-adjusted prices. Another margin is to remove or add products from their product line, thereby also changing the set of products that contribute to the aggregate price index.

In this paper, we document that, one year after the surprise large appreciation of the CHF against the EUR in January 2015, a substantial share of aggregate pass-through into Swiss export prices came from the following two margins of product adjustment: first, improved product quality (quality upgrading), and second, low-quality products disproportionately exited the market.

These findings suggest that the adjustment of product scope is a margin that firms use to respond to exchange rate shocks and that estimates of pass-through are partially due to this product adjustment rather than the adjustment of quality-unadjusted prices. While many empirical estimates of ERPT rely on quality-adjusted import or export prices, thus including both price and quality adjustments in their estimates, our decomposition shows that the endogenous response of quality is economically important in the medium run. Theoretical models of ERPT often focus on explaining incomplete ERPT largely with incomplete price adjustments. Our estimates suggest that an endogenous quality choice is an important margin through which firms respond to an exchange rate shock.

Furthermore, if firms shift their sets of exported products toward products for which demand is less sensitive to exchange rate changes, these findings help to reconcile the observations that larger and long-lived exchange rate appreciations seemed to raise firm productivity (which is often associated with quality), at least this is an observation for Switzerland highlighted in Amstad and di Mauro (2017).

While this paper focuses on documenting the quality response after a large exchange rate shock and the contributions of these product adjustments to aggregate estimates of exchange rate pass-through, a next step would be to examine how export volumes and values respond differentially for firms that change quality more and firms that do not change quality much. This is beyond the scope of this paper but would be an interesting avenue for future research.

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Appendix to "Endogenous Product Adjustment and Exchange Rate Pass-Through"

A Supplementary data and summary statistics

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

	2012	**2013**	**2014**	**2015**	**2016**
Real GDP growth	1.0%	1.9%	2.4%	1.3%	1.7%
Real consumption growth	2.3%	2.6%	1.3%	1.7%	1.4%
Real export growth	3.0%	-0.1%	5.2%	2.6%	6.5%
Real import growth	4.4%	1.4%	3.3%	3.0%	4.4%
Exports/GDP	52.5%	51.6%	52.7%	50.9%	52.8%
Imports/GDP	41.6%	41.8%	42.0%	39.5%	41.0%
Exports of goods/GDP	31.0%	30.3%	30.7%	29.5%	30.4%
Imports of goods/GDP	28.7%	28.4%	28.1%	25.7%	26.4%
Inflation rate	-0.7%	-0.2%	0.0%	-1.1%	-0.4%

Notes: This table is taken from Auer, Burstein, and Lein (2021), Appendix A, Table A.1. The data sources are: State Secretariat of Economic Affairs (SECO), inflation data from the SFSO. Exports and imports include all goods and services, excluding "valuables" such as gold, which increase volatility significantly. In addition, we report exports and imports of goods excluding "valuables".

B Quarterly estimates of quality sorting

In this section, we report the quarterly version of the estimates shown in Table 3. Our main result that low-quality products tend to be sorted out of the market is shown also in the quarterly data.

Table B.1: *Relationship between quality and exits I*

	2015				2016			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2014Q1	2014Q2	2014Q3	2014Q4	2014Q1	2014Q2	2014Q3	2014Q4
Quality	-0.0116***	-0.0126***	-0.0126***	-0.0120***	-0.0116***	-0.0128***	-0.0129***	-0.0127***
	0.00082	0.00084	0.00083	0.00077	0.00089	0.00092	0.00092	0.00090
HS-6 product group FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.07	0.08	0.08	0.08	0.07	0.07	0.07	0.07
No. of observations	221,999	230,696	234,257	239,174	221,999	230,696	234,257	239,174

Notes: Constant not shown. The first (second) four columns correspond to exits in 2015 (2016). Clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

Table B.2: *Relationship between quality and exits II*

	2015				2016			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2014Q1	2014Q2	2014Q3	2014Q4	2014Q1	2014Q2	2014Q3	2014Q4
Price	-0.0094***	-0.0120***	-0.0131***	-0.0109***	-0.0068***	-0.0098***	-0.0112***	-0.0104***
	0.00124	0.00125	0.00121	0.00119	0.00197	0.00192	0.00187	0.00187
HS-6 product group FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.07	0.07	0.07	0.07	0.06	0.06	0.07	0.07
No. of observations	221,999	230,696	234,257	239,174	221,999	230,696	234,257	239,174

Notes: Constant not shown. The first (second) four columns correspond to exits in 2015 (2016). Clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

Table B.3: *Relationship between quality and exits III*

	2015				2016			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2014Q1	2014Q2	2014Q3	2014Q4	2014Q1	2014Q2	2014Q3	2014Q4
Quality-adjusted price	0.0126***	0.0135***	0.0132***	0.0130***	0.0133***	0.0143***	0.0141***	0.0140***
	0.00108	0.00110	0.00109	0.00100	0.00122	0.00127	0.00125	0.00120
HS-6 product group FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.07	0.08	0.08	0.08	0.07	0.07	0.07	0.07
No. of observations	221,999	230,696	234,257	239,174	221,999	230,696	234,257	239,174

Notes: Constant not shown. The first (second) four columns correspond to exits in 2015 (2016). Clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

C Counterfactual with no quality sorting

To examine the effect of quality sorting on pass-through, we ask how prices would have evolved without quality sorting. To do so, we extrapolate exports that occurred in 2014 but not in 2015/2016 to create a counterfactual series of products that no longer existed in 2015 and 2016. We construct these exports under the assumption that prices had evolved with the median price of other products in the same HS6 product group, while we assume that the quality of these products remained unchanged. As our aim is to extrapolate the price of a product one year forward, from year y to year $t+1$, we construct a median yearly price change based on quarterly exports, where a product can be exported in multiple quarters within year y, year $y+1$ or both.[A1] To construct the median yearly price change of a product group, (i) we construct the price change between quarter q in year y and the weighted average across quarters k in year $y+1$ for product-destination i, d, then (ii) calculate the weighted average price change across quarters q in year y to construct the yearly price change of product-destination i, d and (iii) take the median within product group j (where $i \in j$).

In detail, first, we calculate the log-price change between an observation of product-destination i, d's (quality-unadjusted) price in year y and any quarterly observation of product-destination i, d in year $y+1$, then we take the weighted average across these price changes. This yields an average price change for product-destination i, d for each quarter q in year y ($\Delta\bar{p}_{i,d,q,y|y+1}$). We calculate the log-change between each quarterly observation of product-destination i, d's (quality-unadjusted) price in year y and the weighted average price across all quarters $k = (Q1, ..., Q4)$ in year $y+1$:

$$\Delta\bar{p}_{i,d,q,y|y+1} = \sum_{k=Q1}^{Q4} \omega_{i,d,k,y+1} p_{i,d,k,y+1} - p_{i,d,q,y}$$

where $\omega_{i,d,k,y+1}$ is the share of exports of product-destination i, d in quarter k in total exports of product-destination i, d in year $y+1$. These product-destinations indexed by i, d comprise all product-destinations that do not exit in 2015 or 2016.

[A1] For the extrapolation we assume that the product is exported to the same destination and in the same quarter in $y+1$ as it was exported in year y.

Second, we construct the yearly price change of product-destination i, d ($\Delta\tilde{p}_{i,d,y|y+1}$) by calculating the weighted average of the price change for product-destination i, d ($\Delta\bar{p}_{i,d,q,y|y+1}$) across quarters q in year y. Formally, we calculate the weighted average price change of product-destination i, d as:

$$\Delta\tilde{p}_{i,d,y|y+1} = \sum_{q=Q1}^{Q4} \omega_{i,d,q,y} \Delta\bar{p}_{i,d,q,y|y+1}$$

where $\omega_{i,d,q,y}$ is the fraction of exports in quarter q in all exports of product-destination i, d in year y.

These steps correspond to taking the difference between the yearly weighed average price of product-destination i, d in year $y + 1$ and year y:

$$\Delta\tilde{p}_{i,d,y|y+1} = \sum_{k=Q1}^{Q4} \omega_{i,d,k,y+1} p_{i,d,k,y+1} - \sum_{q=Q1}^{Q4} \omega_{i,d,q,y} p_{i,d,q,y}$$

Lastly, we use the median yearly price change within a product group j ($\Delta\tilde{p}^{MED}_{j,y}$) to approximate the price change between y and $y + 1$ for product-destinations i, d that were observed before the shock but exited thereafter. Hence, we impute the price in year $y + 1$ for each exiting product-destination in each quarter and destination that it was exported in year y as:

$$\hat{p}_{i,d,q,y+1} = p_{i,d,q,y} + \Delta\tilde{p}^{MED}_{j,y}$$

To derive the quality-adjusted price for imputed exports, we assume constant quality and use the quality estimate from quarter q in year y:

$$\hat{p}^{adj}_{i,d,q,y+1} = \hat{p}_{i,d,q,y+1} - \hat{\lambda}_{i,d,q,y}$$

We repeat this procedure for 2016 including the imputed values of 2015.

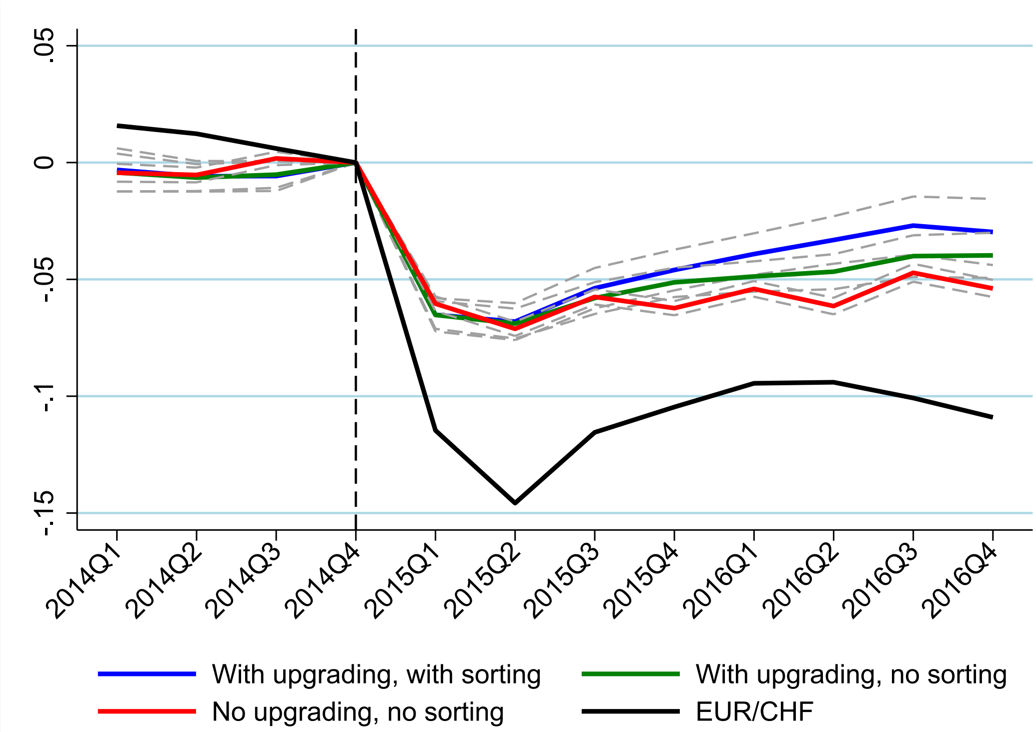
D Alternative demand elasticities

In this section, we report our main specification results from regression (2) with quarterly quality estimates based on a constant demand elasticity. We present robustness tests with $\sigma = 5$ as used in related literature (see for example Manova and Yu (2017)) and $\sigma = 2.9$ (median heterogeneous demand elasticity in our sample). We find that our results are robust to using constant demand elasticities, while the larger demand elasticity of $\sigma = 5$ reduces the scope of estimated product upgrading compared to our baseline. However, as Soderbery (2015) shows, previous estimates of import demand elasticities tended to overestimate elasticity. In section D.2 we show that our results with a constant demand elasticity of $\sigma = 2.9$ imply similar product upgrading as in our baseline.

D.1 Constant demand elasticity: $\sigma = 5$

This section shows our results with $\sigma = 5$ across all products and destinations as used in related literature (see for example Manova and Yu (2017)). The results in Figure D.1 confirm our aggregate results on quality upgrading and sorting with reduced scope of estimated product upgrading compared to our baseline.

Figure D.1: *Aggregate effects on pass-through: $\sigma = 5$*



Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2). The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4.

Table D.1: *Pass-through rates and CHF/EUR appreciation: $\sigma = 5$*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
EUR/CHF	-11.46	-14.58	-11.55	-10.46	-9.45	-9.40	-10.08	-10.90
No upgrading, no sorting	0.53	0.49	0.50	0.60	0.57	0.65	0.47	0.49
Upgrading, no sorting	0.57	0.47	0.50	0.49	0.52	0.50	0.40	0.36
Upgrading, with sorting	0.57	0.47	0.47	0.44	0.41	0.35	0.27	0.27

Notes: This table shows the percentage change in the EUR/CHF in the first row, together with pass-through rate for each scenario by quarter.

Table D.2: *Contribution of margins of adjustment to aggregate pass-through: $\sigma = 5$*

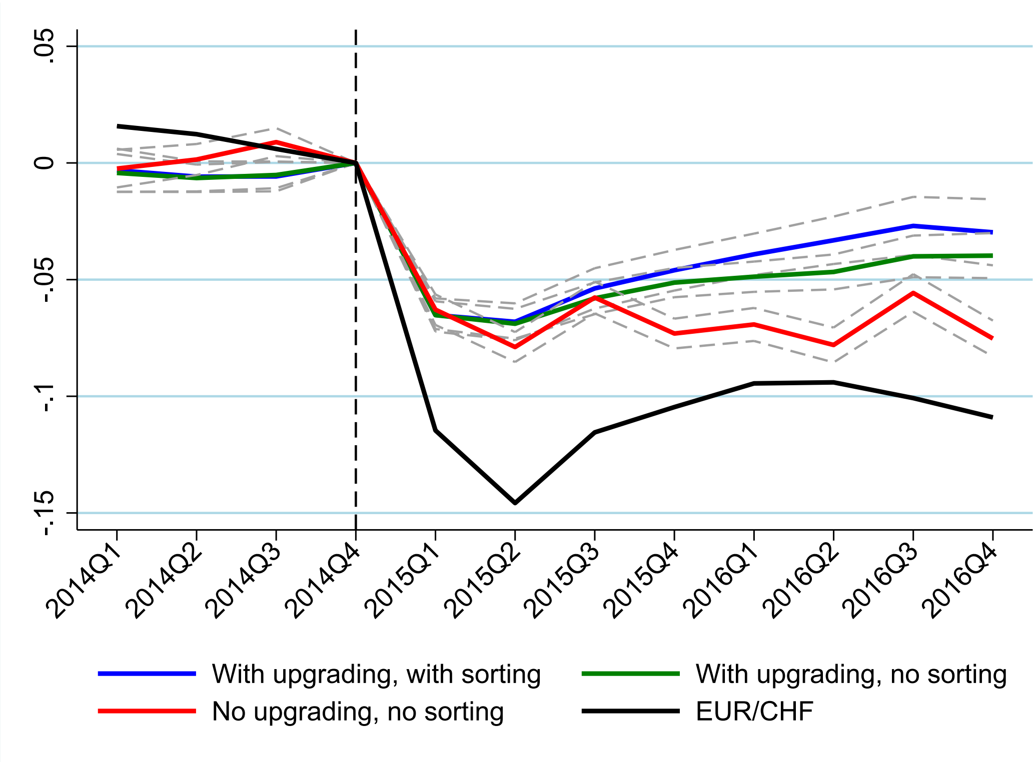
	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
Incomplete price adjustment	1.13	0.94	0.91	0.63	0.63	0.41	0.58	0.54
Quality upgrading	-0.14	0.04	-0.01	0.24	0.12	0.26	0.12	0.23
Quality sorting	0.00	0.02	0.10	0.13	0.25	0.33	0.30	0.22

Notes: This table shows the contribution of each margin explained in the text to the overall aggregate exchange rate pass-through. "Price adjustments" corresponds to series "no upgrading, no sorting", "Quality upgrading" to "with upgrading, no sorting" and "Quality sorting" to "with upgrading, with sorting".

D.2 Constant demand elasticity: $\sigma = 2.9$

This section shows our results with a constant $\sigma = 2.9$ across all products and destinations. The demand elasticity of $\sigma = 2.9$ corresponds to the median elasticity of our main specification based on heterogeneous demand elasticities across products and destination countries. The results in Figure D.2 confirm our aggregate results.

Figure D.2: *Aggregate effects on pass-through:* $\sigma = 2.9$



Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2). The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4.

Table D.3: *Pass-through rates and CHF/EUR appreciation:* $\sigma = 2.9$

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
EUR/CHF	-11.46	-14.58	-11.55	-10.46	-9.45	-9.40	-10.08	-10.90
No upgrading, no sorting	0.55	0.54	0.50	0.70	0.73	0.83	0.55	0.69
Upgrading, no sorting	0.57	0.47	0.50	0.49	0.52	0.50	0.40	0.36
Upgrading, with sorting	0.57	0.47	0.47	0.44	0.41	0.35	0.27	0.27

Notes: This table shows the percentage change in the EUR/CHF in the first row, together with pass-through rate for each scenario by quarter.

Table D.4: *Contribution of margins of adjustment to aggregate pass-through:* $\sigma = 2.9$

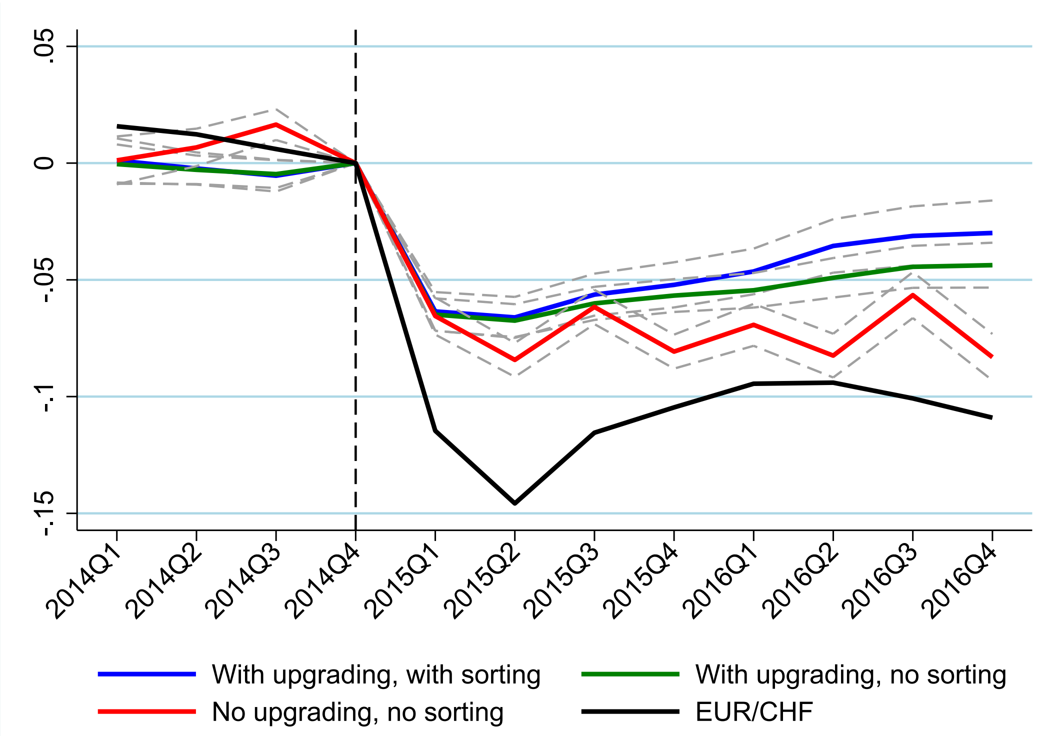
	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
Incomplete price adjustment	1.06	0.81	0.91	0.44	0.35	0.18	0.45	0.29
Quality upgrading	-0.06	0.18	-0.01	0.43	0.40	0.49	0.25	0.49
Quality sorting	0.00	0.02	0.10	0.13	0.25	0.33	0.30	0.22

Notes: This table shows the contribution of each margin explained in the text to the overall aggregate exchange rate pass-through. "Price adjustments" corresponds to series "no upgrading, no sorting", "Quality upgrading" to "with upgrading, no sorting" and "Quality sorting" to "with upgrading, with sorting".

E Firm identification based on zip code

In this section, we follow Bonadio, Fischer, and Sauré (2020) and define our product i using the combination of zip code, 8-digit product code and statistical key. Figure E.1 shows that our results are robust to this alternative definition of a product i.

Figure E.1: *Aggregate effects on pass-through based on alternative product definition*



Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2) based on an alternative product definition. The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4. Standard errors are clustered at the zip code level.

Table E.1: *Pass-through rates and CHF/EUR appreciation based on alternative product definition*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
EUR/CHF	-11.46	-14.58	-11.55	-10.46	-9.45	-9.40	-10.08	-10.90
No upgrading, with sorting	0.53	0.63	0.59	0.85	0.79	0.99	0.64	0.92
Upgrading, with sorting	0.55	0.45	0.49	0.50	0.49	0.38	0.31	0.27

Notes: This table shows the percentage change in the EUR/CHF in the first row, together with pass-through rate for each scenario by quarter.

Table E.2: *Contribution of margins of adjustment to aggregate pass-through based on alternative product definition*

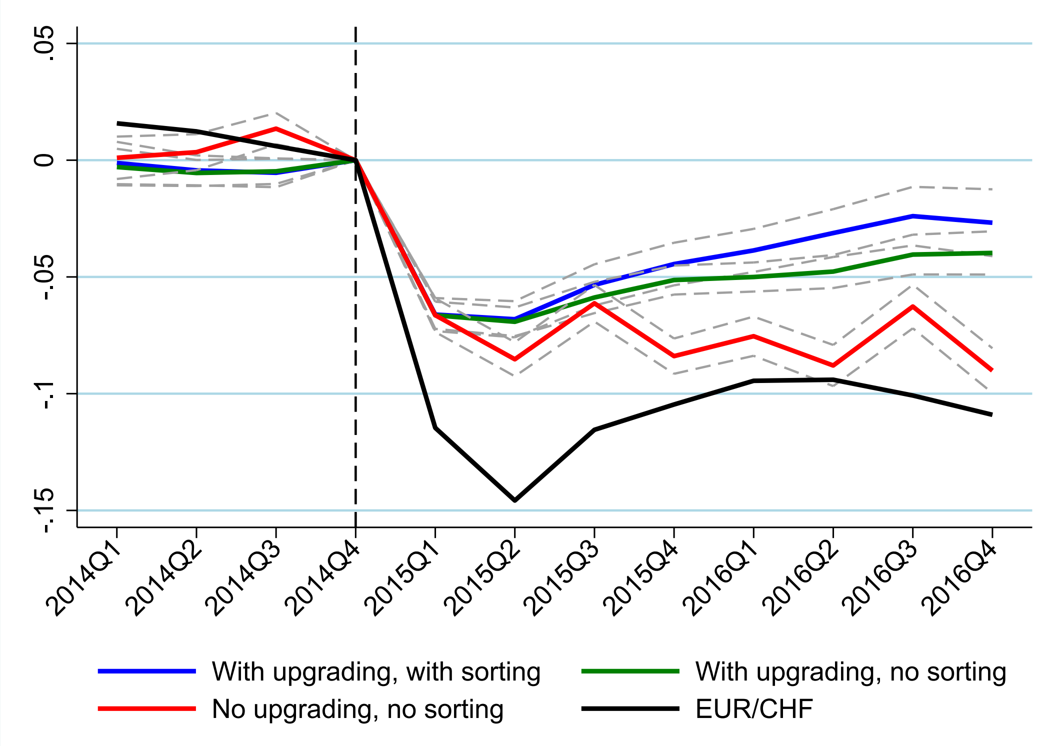
	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
Incomplete price adjustment	0.94	0.69	0.78	0.26	0.25	0.07	0.36	0.16
Quality upgrading	0.06	0.29	0.12	0.61	0.50	0.60	0.34	0.61
Quality sorting	0.00	0.02	0.10	0.13	0.25	0.33	0.30	0.22

Notes: This table shows the contribution of each margin explained in the text to the overall aggregate exchange rate pass-through. "Price adjustments" corresponds to series "no upgrading, no sorting", "Quality upgrading" to "with upgrading, no sorting" and "Quality sorting" to "with upgrading, with sorting".

F Product definition with mode of transportation

In this section, we include the mode of transport to define product i, as products with different levels of quality may be shipped using different modes of transportation. That is, we define a product i as a combination of firm f, $HS8$ product code, the 3-digit statistical key and mode of transportation. Figure F.1 shows that our results are robust to this alternative definition of a product i.

Figure F.1: *Aggregate effects on pass-through: product definition with mode of transportation*



Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2) based on an alternative product definition including the mode of transport. The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4.

G Pass-through estimates by invoicing currency

Here we show our main results by invoicing currency. Table G.1 reports the value share of CHF, EUR and USD invoicing shares for exports to the euro area. CHF and EUR invoiced exports account for 95% of all exports to the Euro area in our data.

Table G.1: *Invoicing currency shares in Euroarea exports*

	2014	2015	2016
CHF share	39.8	34.0	32.1
EUR share	54.7	61.6	63.4
USD share	4.1	4.0	4.3
Other share	0.2	0.2	0.2

Notes: This table shows the value shares of the indicated invoicing currency for each year in the FCA data for exports to the Euroarea.

Below, we decompose our aggregate result by invoicing currency. For this purpose, we restrict the sample to exports invoiced in CHF or EUR and include the invoicing currency in the definition of a product (that is, product i is defined as the combination of firm f, HS8 product code, statistical key and invoicing currency). Panel b) in Figure G.1 shows the result of regression (2) based on this restricted sample and confirms that the aggregate results does not change by including the currency of invoicing into the product definition (our baseline result from Figure 3 is shown in panel a) in Figure G.1 again for reference).

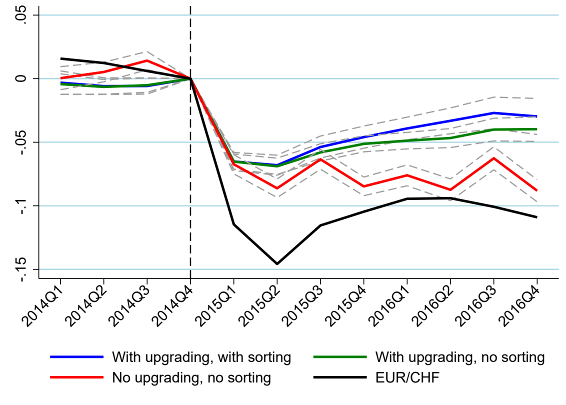
Panels c) and d) in Figure G.1 show our estimates for CHF and EUR invoiced exports separately, while Tables G.2 to G.5 provide the pass-through estimates and the decomposition into margins of adjustment.[A2]

Overall, our results indicate similar product upgrading dynamics independent of the invoicing

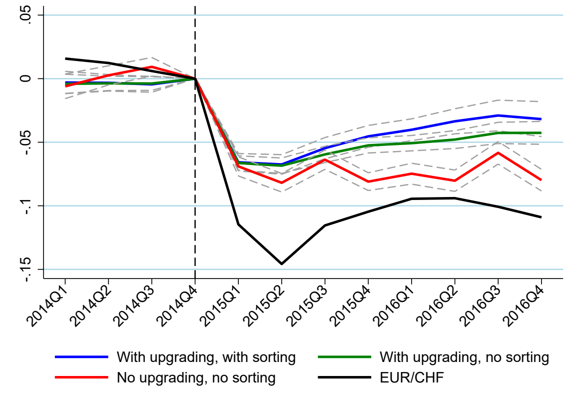
[A2] A single customs declaration can include multiple transactions. As the invoicing currency is declared in the customs declaration forms, the invoicing currency of transactions may be misspecified within a customs declaration in our data. In cases of conflict, the currency covering the largest value share of the declaration is reported.

currency. The estimates of ERPT reported in Tables G.2 and G.4 in the short run is much larger for exports invoiced in EUR, compared to exports invoiced in CHF (consistent with Gopinath, Itskhoki, and Rigobon (2010) and Bonadio, Fischer, and Sauré (2020), for example). Furthermore, pass-through remains higher for products invoiced in EUR over the entire estimation horizon after the shock, compared to CHF invoiced pass-through. This is also in line with estimates in the literature that show that pass-through conditional on a price change differ between products invoiced in producer currency and products invoiced in local currency and is usually interpreted as evidence for strategic complementarities in price setting (Gopinath, Itskhoki, and Rigobon, 2010, Gopinath and Itskhoki, 2010). At the same time, quality upgrading and quality sorting and their contribution to ERPT show similar dynamics.

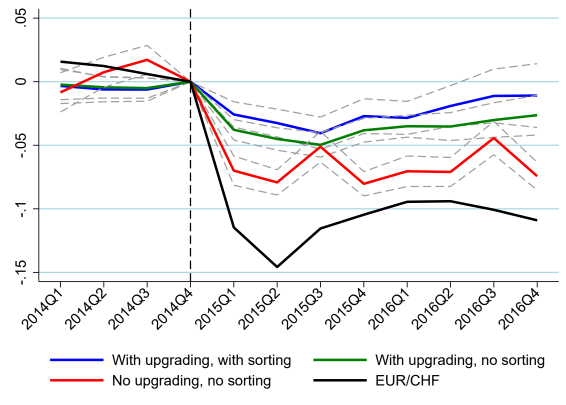
Figure G.1: *ERPT by invoicing currency*



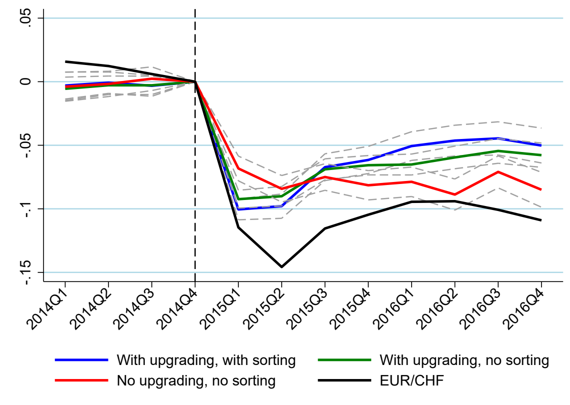
(a) Baseline



(b) Only CHF and Eur invoiced



(c) CHF invoiced



(d) EUR invoiced

Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2). Panels b), c) and d) include the invoicing currency in the definition of a product (that is, product i is defined as the combination of firm f, HS8 product code, statistical key and invoicing currency). The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4.

Table G.2: *Pass-through rates and CHF/EUR appreciation: CHF invoiced*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
EUR/CHF	-11.46	-14.58	-11.55	-10.46	-9.45	-9.40	-10.08	-10.90
No upgrading, no sorting	0.61	0.54	0.44	0.77	0.75	0.76	0.44	0.68
Upgrading, no sorting	0.33	0.31	0.43	0.37	0.37	0.38	0.30	0.24
Upgrading, with sorting	0.22	0.22	0.35	0.26	0.30	0.20	0.11	0.10

Notes: This table shows the percentage change in the EUR/CHF in the first row, together with pass-through rate for each scenario by quarter.

Table G.3: *Contribution of margins of adjustment to aggregate pass-through: CHF invoiced*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
Incomplete price adjustment	0.33	0.41	0.78	0.20	0.24	0.18	0.37	0.17
Quality upgrading	0.41	0.38	0.03	0.55	0.58	0.44	0.18	0.45
Quality sorting	0.26	0.22	0.19	0.25	0.17	0.38	0.45	0.38

Notes: This table shows the contribution of each margin explained in the text to the overall aggregate exchange rate pass-through. "Price adjustments" corresponds to series "no upgrading, no sorting", "Quality upgrading" to "with upgrading, no sorting" and "Quality sorting" to "with upgrading, with sorting".

Table G.4: *Pass-through rates and CHF/EUR appreciation: EUR invoiced*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
EUR/CHF	-11.46	-14.58	-11.55	-10.46	-9.45	-9.40	-10.08	-10.90
No upgrading, no sorting	0.60	0.58	0.65	0.78	0.83	0.94	0.70	0.78
Upgrading, no sorting	0.81	0.62	0.60	0.63	0.69	0.63	0.54	0.53
Upgrading, with sorting	0.88	0.67	0.58	0.59	0.54	0.49	0.44	0.46

Notes: This table shows the percentage change in the EUR/CHF in the first row, together with pass-through rate for each scenario by quarter.

Table G.5: *Contribution of margins of adjustment to aggregate pass-through: EUR invoiced*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
Incomplete price adjustment	3.93	1.38	0.80	0.47	0.29	0.08	0.43	0.32
Quality upgrading	-2.29	-0.17	0.16	0.41	0.30	0.56	0.32	0.50
Quality sorting	-0.63	-0.21	0.05	0.12	0.40	0.36	0.25	0.18

Notes: This table shows the contribution of each margin explained in the text to the overall aggregate exchange rate pass-through. "Price adjustments" corresponds to series "no upgrading, no sorting", "Quality upgrading" to "with upgrading, no sorting" and "Quality sorting" to "with upgrading, with sorting".

H Including destination countries outside the euro area

In the main analysis we focus on exports to the euro area, because the CHF appreciated persistently mostly against the EUR. While the CHF also initially appreciated against the USD for a few days, it swiftly returned to its previous levels (see Figure H.1).[A3]

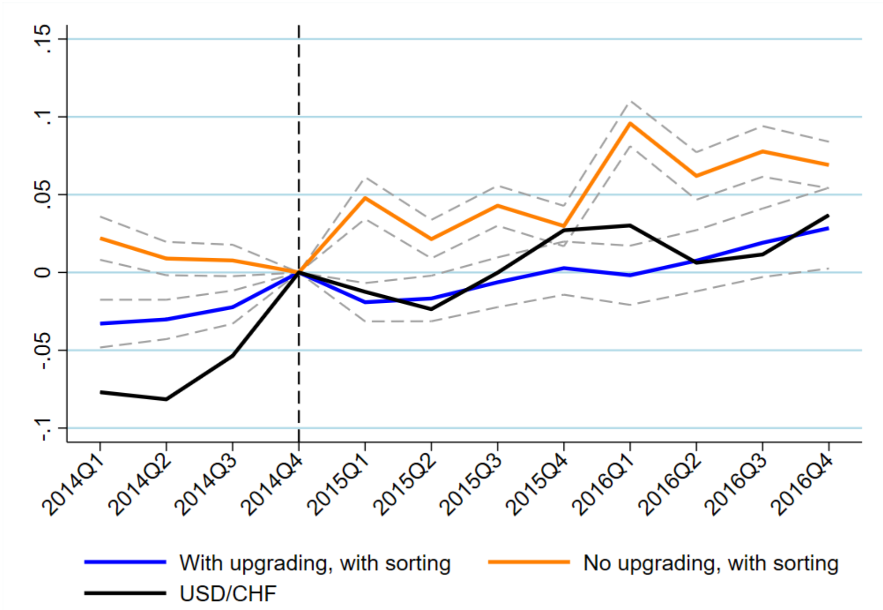
In this section we show how export prices and quality of exports with Switzerland's main trading partners outside of the Euro area have developed. Because the CHF did not appreciate as permanently and sharply against many other currencies, we would not expect quality upgrading to the same extent.[A4] Figure H.1 shows the change in export prices to the Switzerland's main trading partners outside of the Euro area relative to Q4 2014 for (quality-adjusted) prices using the same specification from equation 2. In line with the missing sustained appreciation of many other currencies, compared to the EUR/CHF exchange rate, we find no evidence of product adjustments in exports to destination countries outside of the Euro area. Table H.1 confirms this pattern by showing no indication of quality upgrading (if anything, it even indicates some quality downgrading to export markets outside the Euro area, in line with the slight *depreciation* of the CHF against the USD from Q1 2014 to Q4 2016.).

Next we estimate the exchange rate pass-through for the combined sample of exports to the euro area and Switzerland's main trading partners outside of the Euro area in a combined sample. For this, we estimate regression (2) and include an interaction term on the quarterly dummy with a dummy that is one if the destination country is not in the euro area. Table H.2 shows the results: while quality-unadjusted prices do not decline (most interaction coefficients in the first column are positive in the post-shock period), quality does not adjust significantly in some quarters and even suggests some quality downgrading in others.

[A3] Also forecasters on the Swiss economy from the KOF Consensus Forecast survey did not expect a prolonged appreciation of the CHF against the USD after the decision to abandon the floor of the EUR/CHF exchange rate had been communicated (Kaufmann and Renkin, 2017).

[A4] Switzerland's main trading partners outside of the Euro area included in the analysis are Australia, Brazil, Canada, China, United Arab Emirates, Hong Kong, India, Japan, South Korea, Saudi Arabia, Singapore, Taiwan, Thailand, Turkey and USA. See the Federal Statistical Office for details on Switzerland's main trading partners under `https://www.bfs.admin.ch/bfs/en/home/statistics/industry-services/foreign-trade/balance-import-export.assetdetail.17444470.html`.

Figure H.1: *ERPT for non-euro area trading partners*



Notes: This figure shows the regression coefficients β_q and 95% CI of regression (2) for Switzerland's main trading partners outside the Euro area. The series "with upgrading, with sorting" uses observed prices, and the series "no upgrading, with sorting" includes observed quality-adjusted prices. The dashed line indicates the pre-shock quarter 2014Q4.

Table H.1: *Sample including euro area and non-euro area countries*

	Δ quality 2015 vs 2014	Δ quality 2016 vs 2014	Δ quality 2016 vs 2015
Constant	-0.00	-0.03***	-0.02***
	(0.00)	(0.00)	(0.00)
HS6/destination FE	Yes	Yes	Yes
R^2	0.10	0.10	0.10
No. of observations	130,280	115,089	135,710

Notes: Standard errors in brackets, clustered at HS-8 product level; *** p<0.001, ** p<0.01 and * p<0.05.

Table H.2: *No evidence of quality upgrading for trading partners outside Europe*

	Price	Adjusted price	Difference	Price	Adjusted price	Difference
2014q1	-0.00	-0.02***	0.02*	0.02**	-0.02	0.04**
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
2014q2	-0.01	-0.01	0.00	0.00	0.01	-0.01
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
2014q3	-0.01	0.00	-0.01	0.00	0.01	-0.01
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
2015q1	-0.07***	-0.09***	0.02***	-0.04***	-0.06***	0.01
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
2015q2	-0.07***	-0.11***	0.04***	-0.06***	-0.09***	0.02
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
2015q3	-0.05***	-0.08***	0.03***	-0.04***	-0.08***	0.05**
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.02)
2015q4	-0.05***	-0.10***	0.05***	-0.05***	-0.08***	0.03
	(0.00)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2016q1	-0.04***	-0.11***	0.07***	-0.03***	-0.06***	0.03
	(0.00)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2016q2	-0.03***	-0.12***	0.08***	-0.03***	-0.08***	0.05**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2016q3	-0.03***	-0.09***	0.06***	-0.01	-0.06***	0.05**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2016q4	-0.03***	-0.11***	0.08***	-0.02*	-0.07***	0.05**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2014q1 × Non Euroarea=1	-0.03***	0.04***	-0.07***	-0.02*	0.05*	-0.07**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2014q2 × Non Euroarea=1	-0.02***	0.01*	-0.04***	-0.03*	0.02	-0.05*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2014q3 × Non Euroarea=1	-0.02**	0.01	-0.02*	-0.01	0.02	-0.03
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2015q1 × Non Euroarea=1	0.05***	0.14***	-0.09***	0.04***	0.16***	-0.11***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2015q2 × Non Euroarea=1	0.05***	0.13***	-0.08***	0.07***	0.13***	-0.06**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2015q3 × Non Euroarea=1	0.05***	0.13***	-0.08***	0.07***	0.17***	-0.10***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
2015q4 × Non Euroarea=1	0.05***	0.13***	-0.08***	0.05***	0.13***	-0.07**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)
2016q1 × Non Euroarea=1	0.04***	0.21***	-0.17***	0.06***	0.22***	-0.17***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.03)
2016q2 × Non Euroarea=1	0.04***	0.18***	-0.14***	0.07***	0.22***	-0.15***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)
2016q3 × Non Euroarea=1	0.05***	0.17***	-0.12***	0.08***	0.22***	-0.14***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)
2016q4 × Non Euroarea=1	0.06***	0.18***	-0.12***	0.08***	0.17***	-0.10***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.03)
Product × destination FE	Yes	Yes	Yes	No	No	No
Firm FE	No	No	No	Yes	Yes	Yes
R^2	0.91	0.98	0.96	0.51	0.16	0.09
No. of observations	3,721,592	3,721,592	3,721,592	4,480,271	4,480,271	4,480,271

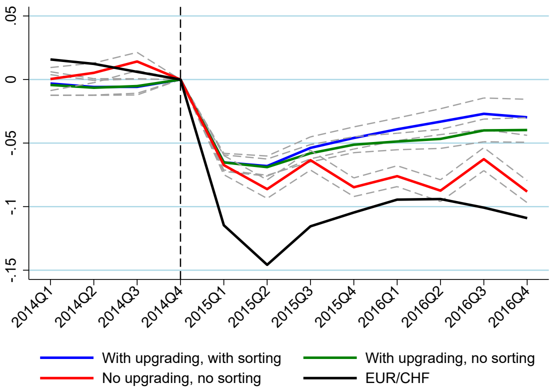
Notes: Standard errors in brackets, clustered at firm level; *** p<0.001, ** p<0.01 and * p<0.05.

I Accountings for potential compositional bias

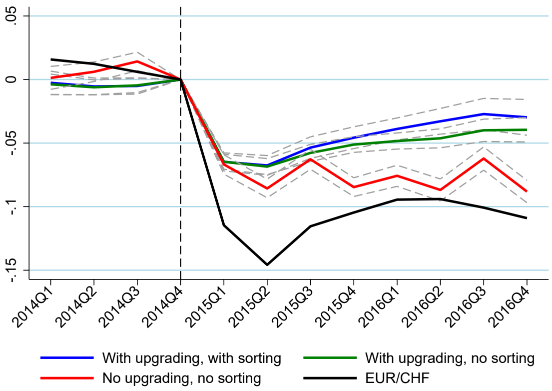
A well-known problem with constructing prices from customs data is the so-called unit value bias (Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller, 2020). As unit values are not actual prices, but calculated by dividing value by quantities, unit values can change due to compositional shifts, rather than price changes. Note, that we use as a definition of a product within a firm-destination cell a very detailed HS8 product code, and in addition, the variable "statistical key" described in chapter 2. The HS8 product code is very detailed and commonly used to differentiate products (for example, in Martin and Mejean (2014)). For example, the HS6 category *"2204.22 Wine of fresh grapes, incl. fortified wines, and grape must whose fermentation has been arrested by the addition of alcohol, in containers of* >2 *liters but* $<=10$ *liters (excl. sparkling wine)"* includes HS8 product code *"2204.2221 White wines for drinking, natural, incl. fortified wines, and grape must with fermentation prevented or arrested by the addition of alcohol, in containers holding* $>2l$ *but* $<=10l$*, within the limits of the tariff quota Nos. 23 to 25, of an alcoholic strength by volume* $>13\%$ *vol (excl. sparkling wine)"* and *"2204.2241 White wine for industrial use, natural, incl. fortified wines, and grape must with fermentation prevented or arrested by the addition of alcohol, in containers holding* $>2l$ *but* $<=10l$ *(excl. sparkling wine)"*, where we assume the former has higher quality than the latter. Furthermore, the size of the products, which is sometimes used to separate HS6 categories, may also serve as a characteristic for quality. In the example above, a wine in a bottle of less than two liters would be included in the HS6 category *"2204.21 Wine of fresh grapes, incl. fortified wines, and grape must whose fermentation has been arrested by the addition of alcohol, in containers of* $<=2l$ *(excl. sparkling wine)"*. In addition, we divide the HS8 product codes even further, if a statistical key is available. This makes the product definition even finer and arguably distinguishes products with higher and lower quality.

To address the concern that remaining compositional shifts, that is, shifts within firm-HS8 product code-statistical key-destination country cells, drive our results, we follow Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller (2020) and exclude HS6 product groups with a unit value variance higher than a particular threshold in the estimation. Such observations are more likely to be biased by the compositional shifts. Figure I.1 shows the results. Excluding product groups which are more likely to be biased from these compositional shifts does not affect our main results, neither the aggregate nor the relative importance of quality upgrading compared to quality sorting.

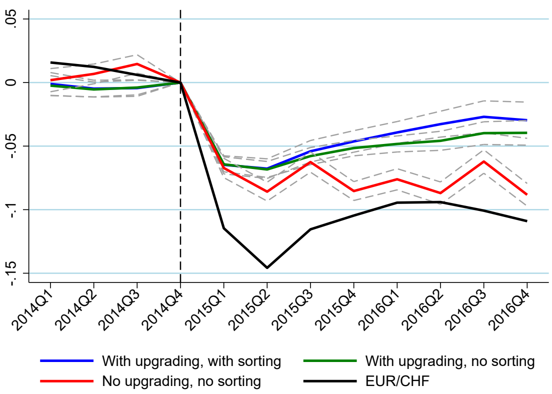
Figure I.1: *ERPT excluding product groups more prone to compositional bias*



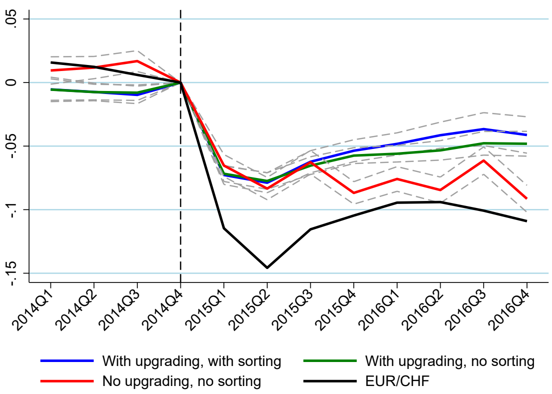
(a) Baseline



(b) Excl. top 5th percentile



(c) Excl. top 10th percentile



(d) Excl. top 25th percentile

Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2) on restricted data, where the most volatile (5th, 10th, 25th percentile) HS6 product groups by variation in unit values are excluded. The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4.

We report the corresponding evidence in aggregate quality upgrading for these subsamples in Tables I.1, I.2 and I.3 and for quality sorting in Tables I.4, I.5 and I.6. The restriction on the dataset does not affect our results.

Table I.1: *Evidence for quality upgrading: Excl. top 5th percentile*

	Δ quality 2015 vs 2014	Δ quality 2016 vs 2014	Δ quality 2016 vs 2015
Constant	0.045***	0.070***	0.028***
	(0.002)	(0.002)	(0.002)
HS6/destination FE	Yes	Yes	Yes
R^2	0.06	0.07	0.06
No. of observations	246,779	219,869	261,392

Notes: This tables report the results of Table 2 on restricted data, where the most volatile (5th percentile) HS6 product groups by variation in unit values are excluded. Standard errors in brackets, clustered at HS-8 product group level; *** p<0.001, ** p<0.01 and * p<0.05.

Table I.2: *Evidence for quality upgrading: Excl. top 10th percentile*

	Δ quality 2015 vs 2014	Δ quality 2016 vs 2014	Δ quality 2016 vs 2015
Constant	0.044***	0.069***	0.028***
	(0.002)	(0.002)	(0.002)
HS6/destination FE	Yes	Yes	Yes
R^2	0.06	0.07	0.06
No. of observations	240,812	214,694	255,097

Notes: This tables report the results of Table 2 on restricted data, where the most volatile (10th percentile) HS6 product groups by variation in unit values are excluded. Standard errors in brackets, clustered at HS-8 product group level; *** p<0.001, ** p<0.01 and * p<0.05.

Table I.3: *Evidence for quality upgrading: Excl. top 25th percentile*

	Δ quality 2015 vs 2014	Δ quality 2016 vs 2014	Δ quality 2016 vs 2015
Constant	0.042***	0.072***	0.030***
	(0.002)	(0.002)	(0.002)
HS6/destination FE	Yes	Yes	Yes
R^2	0.07	0.08	0.07
No. of observations	176,048	157,161	187,391

Notes: This tables report the results of Table 2 on restricted data, where the most volatile (25th percentile) HS6 product groups by variation in unit values are excluded. Standard errors in brackets, clustered at HS-8 product group level; *** p<0.001, ** p<0.01 and * p<0.05.

Table I.4: *Relationship between quality and exits: Excl. top 5th percentile*

	(1) 2015	(2) 2016	(3) 2015	(4) 2016	(5) 2015	(6) 2016
Quality	-0.016***	-0.015***				
	0.001	0.001				
Price			-0.014***	-0.012***		
			0.001	0.001		
Quality-adjusted price					0.017***	0.017***
					0.001	0.001
HS-6 product group FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.06	0.06	0.05	0.05	0.06	0.06
No. of observations	474,648	474,648	474,648	474,648	474,648	474,648

Notes: This tables report the results of Table 3 on restricted data, where the most volatile (5th percentile) HS6 product groups by variation in unit values are excluded. Constant not shown. The first (second) column in each dependent variable corresponds to exited in 2015 (2016). Clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

Table I.5: *Relationship between quality and exits: Excl. top 10th percentile*

	(1) 2015	(2) 2016	(3) 2015	(4) 2016	(5) 2015	(6) 2016
Quality	-0.016***	-0.015***				
	0.001	0.001				
Price			-0.014***	-0.012***		
			0.001	0.001		
Quality-adjusted price					0.017***	0.017***
					0.001	0.001
HS-6 product group FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.06	0.06	0.05	0.05	0.06	0.06
No. of observations	461,683	461,683	461,683	461,683	461,683	461,683

Notes: This tables report the results of Table 3 on restricted data, where the most volatile (10th percentile) HS6 product groups by variation in unit values are excluded. Constant not shown. The first (second) column in each dependent variable corresponds to exited in 2015 (2016). Clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

Table I.6: *Relationship between quality and exits: Excl. top 25th percentile*

	(1) 2015	(2) 2016	(3) 2015	(4) 2016	(5) 2015	(6) 2016
Quality	-0.017***	-0.017***				
	0.001	0.001				
Price			-0.013***	-0.012***		
			0.001	0.002		
Quality-adjusted price					0.019***	0.019***
					0.001	0.001
HS-6 product group FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.07	0.06	0.05	0.05	0.07	0.06
No. of observations	337,210	337,210	337,210	337,210	337,210	337,210

Notes: This tables report the results of Table 3 on restricted data, where the most volatile (25th percentile) HS6 product groups by variation in unit values are excluded. Constant not shown. The first (second) column in each dependent variable corresponds to exited in 2015 (2016). Clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

J Imported products and export quality

How do imports of intermediate goods relate to quality adjustments in exports? This section of the appendix addresses this question. The FCA data has provided us with customs data also for imports into Switzerland. We can thus estimate quality changes for imports in a similar manner as for exports. We assume that a firm, that exports products, uses the products it imports as intermediate goods in the production process. Similar to our definition for exports in the body of the paper, we first estimate import quality changes, which we label $\lambda_{m,s,q}$, where m corresponds to the product i in the main text and denotes a combination of Swiss firm f, HS8 product code and the 3-digit statistical key, s is the source country, and q denotes the quarter. We estimate the quality of product-sourcing country m, s analogous to Section 3 with demand elasticities $\sigma_{HS4,CH}$ for Switzerland estimated in Soderbery (2018):

$$v_{m,s,q} + \sigma_{HS4,CH}\, p_{m,s,q} = \alpha_j + \alpha_{s,y} + \alpha_Q + \epsilon_{m,s,q}, \tag{A1}$$

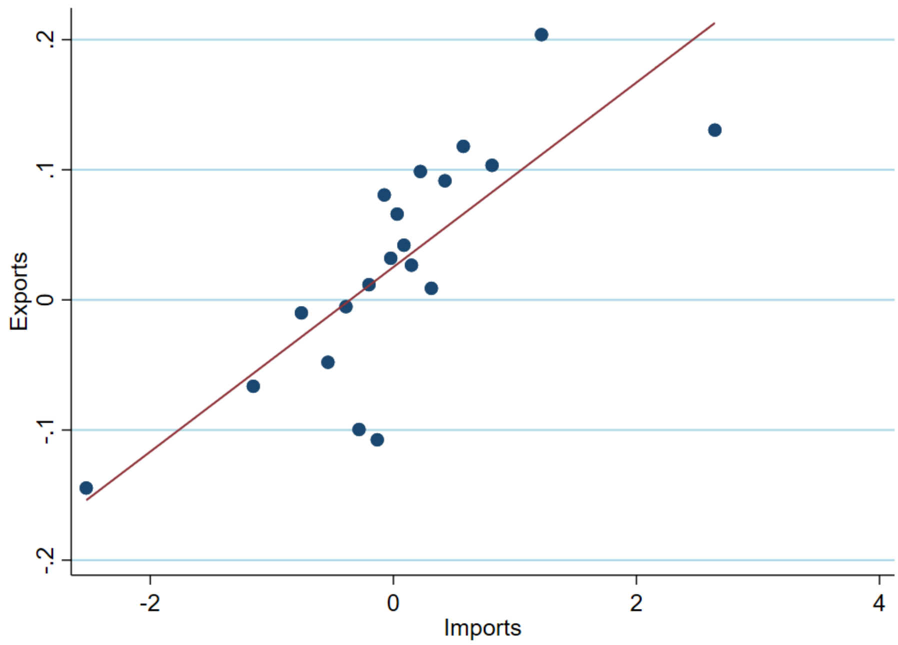
where q is the quarter, $v_{m,s,q}$ is the log import volume of products m to Switzerland from sourcing country s, and $p_{m,s,q}$ is the associated log price. Because we cannot observe which imported products are used as intermediates for which exported products within a firm, we conduct the analysis at the firm level. To relate firm-level import quality changes to firm-level export quality changes, we aggregate to yearly frequency, because intermediate inputs imported in one quarter may be used to produce exported goods in the next quarter. Yearly averages should reduce these potential lagged effects. We use the average quarterly quality estimate of product-country combination i, d per year ($\lambda_{i,d,y}$) and compute the value-weighted average quality of a firm's imports and its exports to the euro area of each year (f, y):

$$\lambda_{f,y} = \frac{\sum_{i,d\in f} \lambda_{i,d,y} * value_{i,d,y}}{\sum_{i,d\in f} value_{i,d,y}}$$

where $value_{i,d,y}$ is the yearly (import) export value of product i (from) to country d of firm f, $i, d \in f$ are the products exported (imported) by firm f and $\lambda_{i,d,y}$ is the average quality estimate of product-destination i, d in year y.

We find a positive and significant relationship between the contemporaneous yearly change in the average quality of imported goods ($\Delta\lambda_{fy}^{Imp}$) and exported goods ($\Delta\lambda_{f,y}^{Exp}$) at the firm level. ($\beta = 0.07$, standard error clustered at the firm level $= 0.015$), as shown in Figure J.1. These findings suggest that firms that import higher-quality intermediate products also produce higher-quality exports.

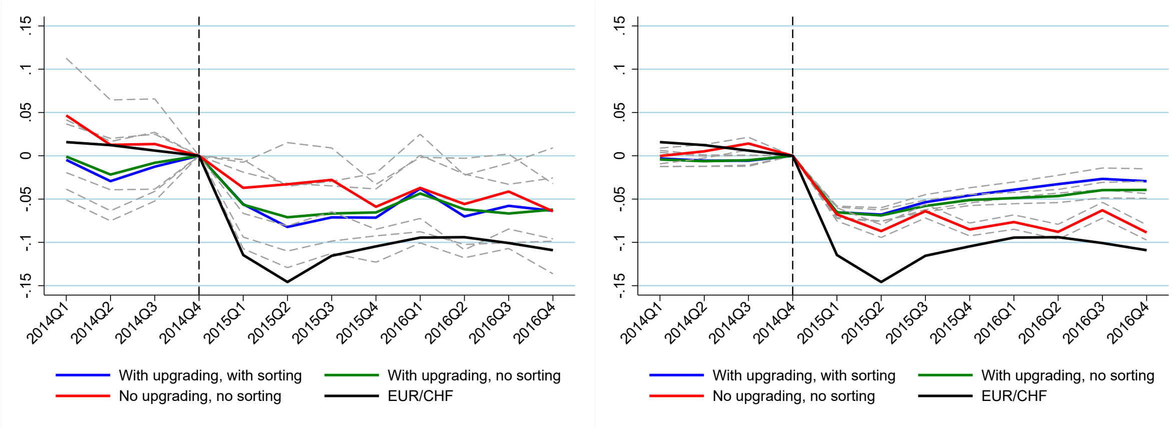
Figure J.1: *Correlation between quality upgrading in imports and exports*



Notes: This figure shows a binscatter with 20 bins of the contemporaneous change of yearly average quality estimates of exports (imports) on the y-(x-) axis per firm.

Next, we estimate our ERPT regression (2) for products from importing and non-importing firms separately. We match 87% of exporting firms with at least one import transaction. Figure J.2 shows the ERPT estimations for both groups separately. While the estimates for importing firms are very similar to the baseline estimates, the estimates for the non-importing firms are too imprecise, such that the differences in estimation precision make it difficult to compare the two groups.

Figure J.2: *ERPT for importing and non-importing firms*



(a) Non-importing firms

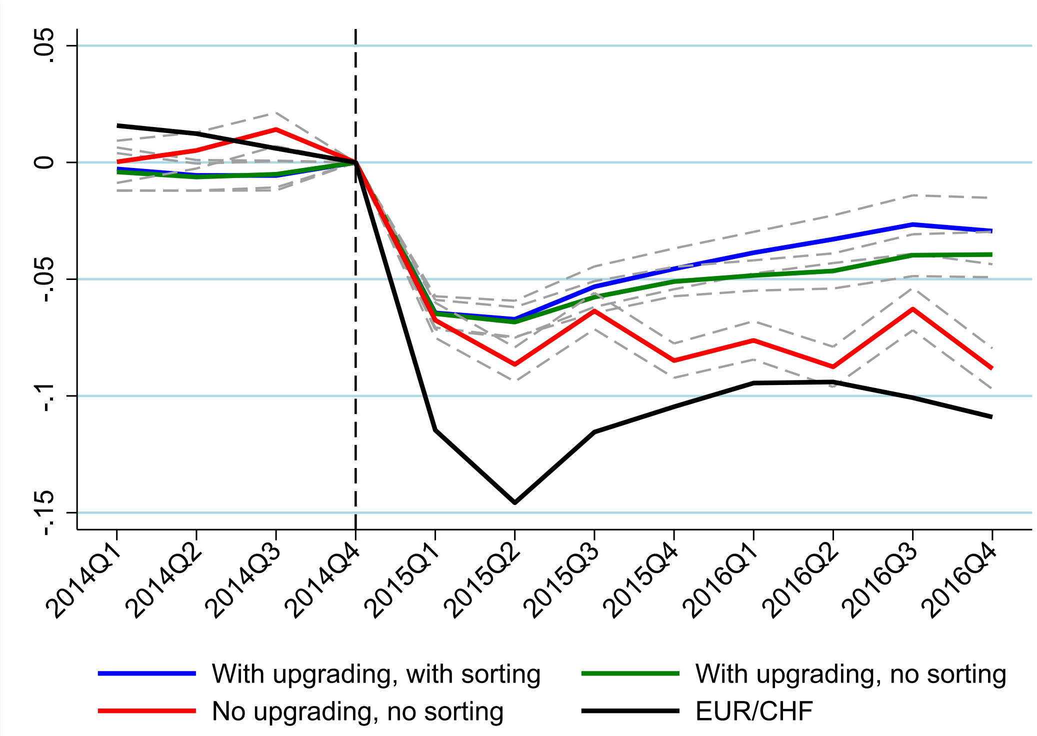
(b) Importing firms

Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2) for firms that do not import (panel(a)) and import (panel(b)) separately. The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4.

J.1 Pass-through estimates including import price as control

In this subsection, we add the firms quarterly average import price as additional control to regression (2). The additional control does not affect our results as shown in Figure J.3 and Table J.1.

Figure J.3: *Aggregate effects on pass-through: controlled for firms' average import price*



Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2) with the firm's quarterly average import price as additional control. The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4.

Table J.1: *Regression coefficients*

	Price
2014q1	-0.00
	(0.00)
2014q2	-0.01
	(0.00)
2014q3	-0.01
	(0.00)
2015q1	-0.06***
	(0.00)
2015q2	-0.07***
	(0.00)
2015q3	-0.05***
	(0.00)
2015q4	-0.05***
	(0.00)
2016q1	-0.04***
	(0.00)
2016q2	-0.03***
	(0.01)
2016q3	-0.03***
	(0.01)
2016q4	-0.03***
	(0.01)
Import price	0.01***
	(0.00)
Product × destination FE	Yes
R^2	0.91
No. of observations	2,442,107

Notes: Standard errors in brackets, clustered at firm level; *** p<0.001, ** p<0.01 and * p<0.05.

K Pass-through and quality adjustments in import and domestic prices

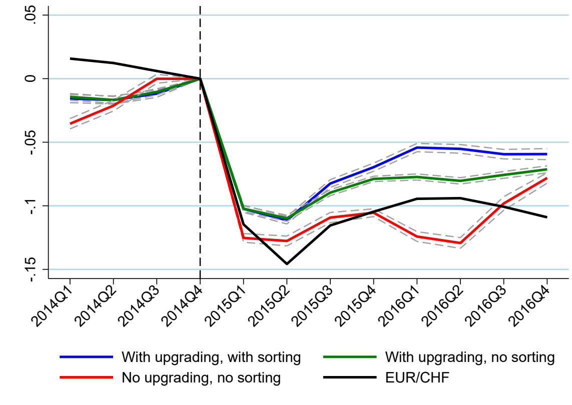
K.1 FCA data

In this section, we show our counterfactuals corresponding to Figure 3 for imports. Moreover, we split the imports into intermediate inputs and final goods. The overall results show similar patterns to exports. That is, we observe an improvement in quality through quality upgrading and sorting. We then decompose imports into intermediate inputs and final goods. We observe an increase in quality in imported intermediate inputs accompanying the increase in export quality. This observation confirms similar results in the literature, for example, Bas and Strauss-Kahn (2015), Kugler and Verhoogen (2012) or Hallak and Sivadasan (2013).[A5]

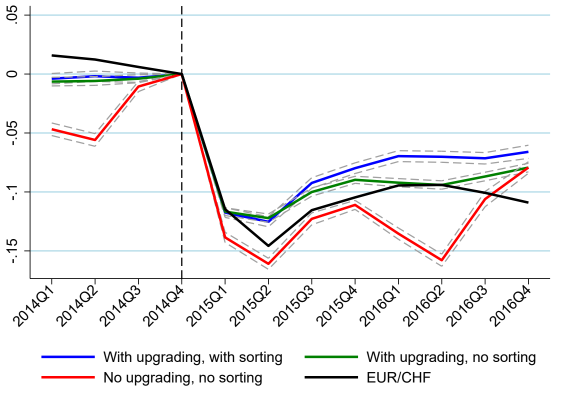
Moreover, the decomposition reveals changes in quality in imported final goods, indicating increased demand for higher-quality goods following increased purchasing power of Swiss households after the appreciation. These findings are in line with results suggesting that higher-income countries import and export higher-quality goods (Fieler, 2011) and strengthen models associating willingness to pay for quality with income, e.g., Auer, Chaney, and Sauré (2018).

[A5]See Section J for details on the quality estimation for imports.

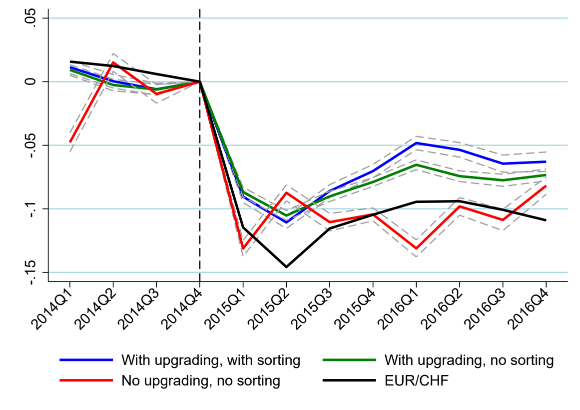
Figure K.1: *Pass-through into import prices*



(a) Total



(b) Intermediate inputs



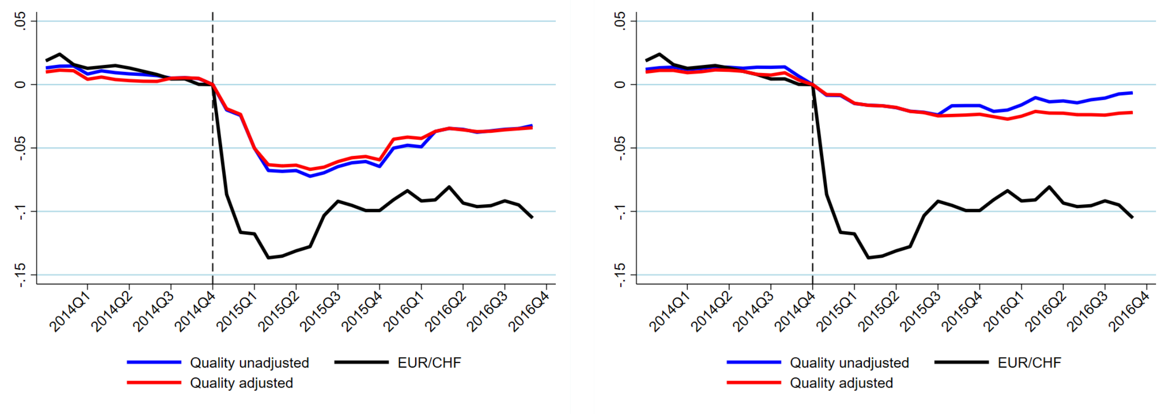
(c) Final goods

Notes: These figures show the regression coefficients β_q and the 95% CIs of regression (2) for imports in total and for the subgroups "intermediate inputs" and "final goods". The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed line indicates the pre-shock quarter 2014Q4.

K.2 SFSO data

In this section, we show our counterfactuals corresponding to Figure 4 for the import and the domestic price index in Figure K.2. In the left panel for imports, we observe no difference between our series including and excluding quality adjustments. However, import data have the caveat that the buyer and not the producer of the product reports product adjustments to the SFSO, potentially influencing the observed dynamics. In the right panel, we observe a similar dynamic for domestic products (products in the producer price index that are sold in the domestic market) with some quality improvements, as for exports, but in a smaller magnitude.[A6]

Figure K.2: *Official import price index and domestic price index*



(a) Imports (b) Domestic

Notes: The reference period for data collection is the 1st to the 8th of a given month. For expository purposes, the indexes are shifted by one month such that January 2015 corresponds to prices collected from February 1 to 8. The ticks on the x-axis refer to the end of the quarter.

[A6]We exclude quality adjustments reported in January 2016 due to the revision of the index in December 2015.

L Estimates for short-run and medium-run pass-through

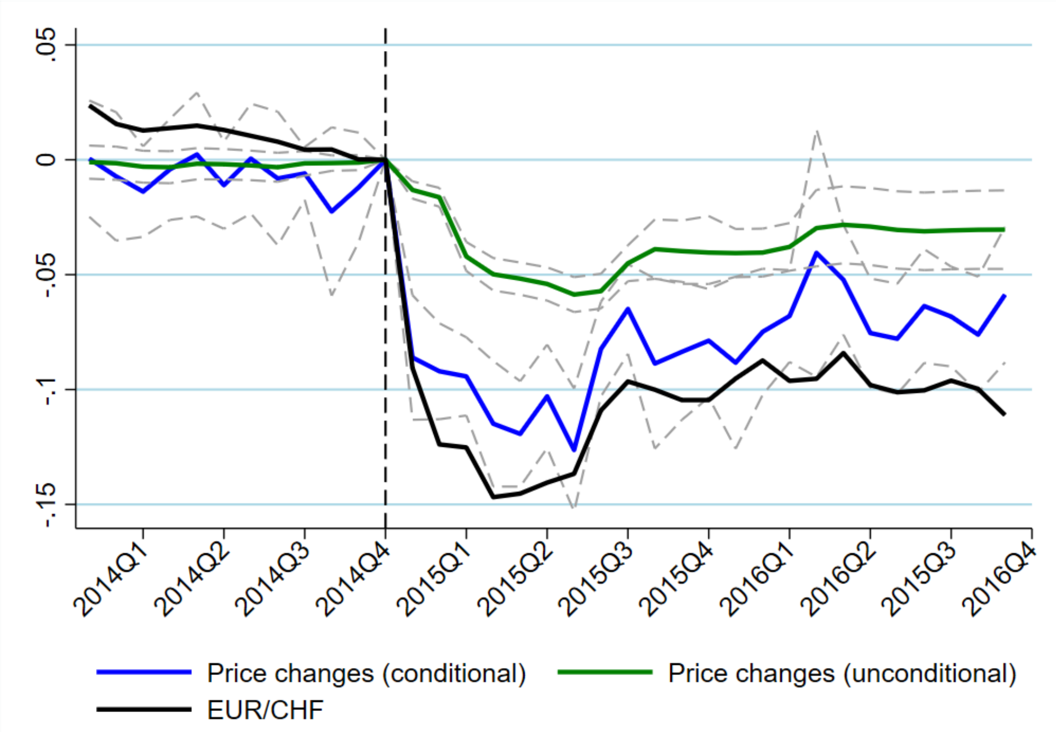
In this section, we estimate the ERPT in the SFSO data in two different ways. Figure L.1 and Table L.1 show our ERPT estimates following our event study approach. The shown coefficients are estimated from the following OLS regression:

$$p_{i,m} = \alpha_i + \sum_{m=2014m1}^{2016m12} \beta_m M_m + \epsilon_{i,m}, \tag{A2}$$

where $p_{i,m}$ is the reported log price, α_i are product fixed effects, and M_m is a set of monthly dummy that is equal to 1 for a given month from 2014m1,...2014m11, 2015m1,...,2016m12, and zero otherwise. The month just before the shock, 2014m12, is chosen as the baseline month.[A7] Standard errors are clustered at the firm level. We estimate the regression (A2) on our entire sample (unconditional) and on a sample restricted to those observations which have a non-zero price change in Swiss franc (conditional).

[A7]The reference period for data collection is the 1st to the 8th of a given month. For expository purposes, the indexes are shifted by one month such that January 2015 corresponds to prices collected from February 1 to 8.

Figure L.1: *ERPT SFSO*



Notes: This figure shows the regression coefficients β_m and 95% CIs of regression (A2). The series "Price series (conditional)" restricts the sample to those observations which have a non-zero price change in Swiss franc. The series "Price series (unconditional)" estimates on our entire sample. The dashed vertical line indicates the pre-shock quarter 2014Q4.

Table L.1: *ERPT SFSO*

	log price	log price
2014m1	-0.00	0.00
	(0.00)	(0.01)
2014m2	-0.00	-0.01
	(0.00)	(0.01)
2014m3	-0.00	-0.01
	(0.00)	(0.01)
2014m4	-0.00	-0.00
	(0.00)	(0.01)
2014m5	-0.00	0.00
	(0.00)	(0.01)
2014m6	-0.00	-0.01
	(0.00)	(0.01)
2014m7	-0.00	0.00
	(0.00)	(0.01)
2014m8	-0.00	-0.01
	(0.00)	(0.01)
2014m9	-0.00	-0.01
	(0.00)	(0.01)
2014m10	-0.00	-0.02
	(0.00)	(0.02)
2014m11	-0.00	-0.01
	(0.00)	(0.01)
2015m1	-0.01***	-0.09***
	(0.00)	(0.01)
2015m2	-0.02***	-0.09***
	(0.00)	(0.01)
2015m3	-0.04***	-0.09***
	(0.00)	(0.01)
2015m4	-0.05***	-0.11***
	(0.00)	(0.01)
2015m5	-0.05***	-0.12***
	(0.00)	(0.01)
2015m6	-0.05***	-0.10***
	(0.00)	(0.01)
2015m7	-0.06***	-0.13***
	(0.00)	(0.01)
2015m8	-0.06***	-0.08***
	(0.00)	(0.01)
2015m9	-0.05***	-0.06***
	(0.00)	(0.01)
2015m10	-0.04***	-0.09***
	(0.01)	(0.02)
2015m11	-0.04***	-0.08***
	(0.01)	(0.02)
2015m12	-0.04***	-0.08***
	(0.01)	(0.01)
2016m1	-0.04***	-0.09***
	(0.01)	(0.02)
2016m2	-0.04***	-0.07***
	(0.01)	(0.01)
2016m3	-0.04***	-0.07***
	(0.01)	(0.01)
2016m4	-0.03***	-0.04
	(0.01)	(0.03)
2016m5	-0.03***	-0.05***
	(0.01)	(0.01)
2016m6	-0.03***	-0.08***
	(0.01)	(0.01)
2016m7	-0.03***	-0.08***
	(0.01)	(0.01)
2016m8	-0.03***	-0.06***
	(0.01)	(0.01)
2016m9	-0.03***	-0.07***
	(0.01)	(0.01)
2016m10	-0.03***	-0.08***
	(0.01)	(0.01)
2016m11	-0.03***	-0.06***
	(0.01)	(0.02)
Cumulated	No	Yes
Product FE	Yes	Yes

Notes: Standard errors in brackets, clustered at firm level; *** p<0.001, ** p<0.01 and * p<0.05.

In addition, in Table L.2 we report the medium-run ERPT estimates following Burstein and Gopinath (2013), where we report β of the following regression:

$$\Delta p_{i,m} = \alpha_i + \beta \Delta_c e_{i,m} + \epsilon_{i,m}, \tag{A3}$$

where $\Delta p_{i,m}$ is the change in log price in Swiss franc of the reported product i in month m, α_i are product fixed effects and $\Delta_c e_{i,m}$ is the change in the EUR-CHF nominal exchange rate over the period for which the previous price of product i was unchanged.

The first column in Table L.2 shows an estimate for SRPT, which includes the simple one-period first difference of the unconditional price change on the left hand side and the one-period first difference of the exchange rate on the right hand side (all in logs). The estimate of 0.13 shows a relatively small pass-through in the short run. The estimate of MRPT reported in the second column includes the cumulated change in the exchange rate since the last price adjustment on the right hand side and also conditions on observations with non-zero price changes. The estimate of MRPT is 0.67 and discussed in more detail in the body of the paper.

Table L.2: *Short run and medium run ERPT*

	SRPT	MRPT
dlog EUR/CHF	0.13***	
	(0.02)	
cumulated dlog EUR/CHF		0.69***
		(0.05)
Cumulated	No	Yes
Product FE	Yes	Yes

Notes: Standard errors in brackets, clustered at firm level; *** p<0.001, ** p<0.01 and * p<0.05.

M Pass-through estimates at varying clustering levels

Table M.1 reports our estimates of regression (2) with varying cluster levels.

Table M.1: *Varying clustering levels*

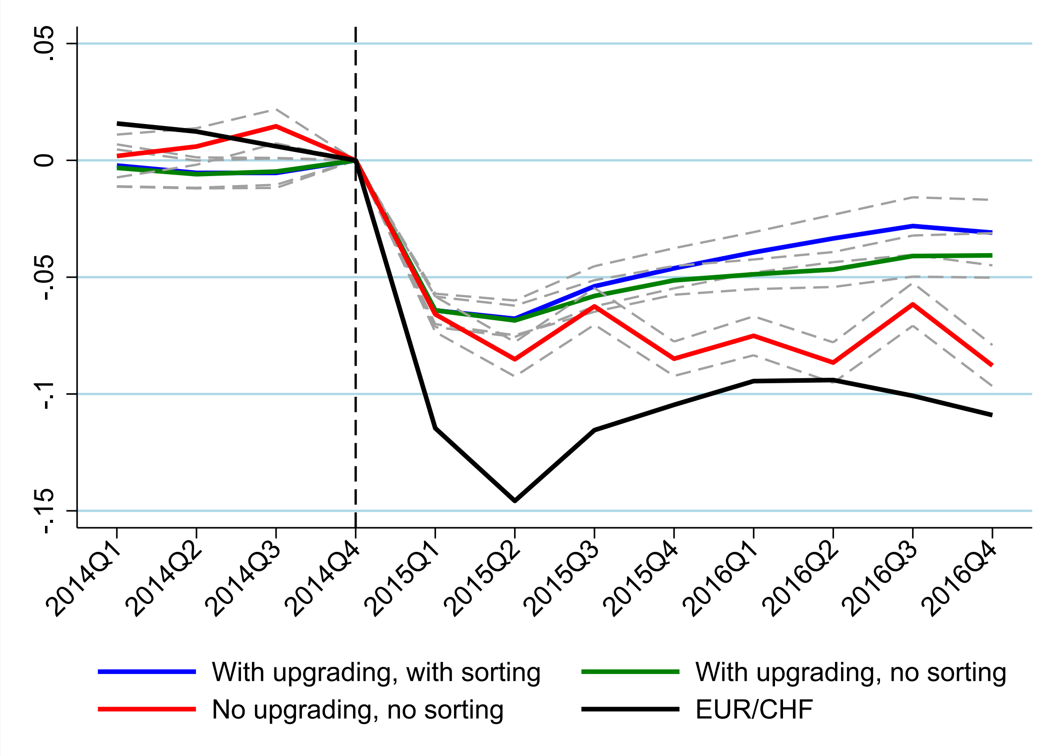
	Firm			Zip code			HS8			Destination HS6			HS6			HS4		
	Scen 3	Scen 2	Scen 1	Scen 3	Scen 2	Scen 1	Scen 3	Scen 2	Scen 1	Scen 3	Scen 2	Scen 1	Scen 3	Scen 2	Scen 1	Scen 3	Scen 2	Scen 1
2014q1	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2014q2	-0.01	-0.01*	0.01	-0.01	-0.01*	0.01	-0.01*	-0.01*	0.01	-0.01*	-0.01**	0.01	-0.01*	-0.01**	0.01	-0.01*	-0.01**	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2014q3	-0.01	-0.01	0.01***	-0.01	-0.01	0.01***	-0.01	-0.01	0.01***	-0.01*	-0.01*	0.01***	-0.01	-0.01	0.01***	-0.01	-0.01	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2015q1	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
2015q2	-0.07***	-0.07***	-0.09***	-0.07***	-0.07***	-0.09***	-0.07***	-0.07***	-0.09***	-0.07***	-0.07***	-0.09***	-0.07***	-0.07***	-0.09***	-0.07***	-0.07***	-0.09***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)
2015q3	-0.05***	-0.06***	-0.06***	-0.05***	-0.06***	-0.06***	-0.05***	-0.06***	-0.06***	-0.05***	-0.06***	-0.06***	-0.05***	-0.06***	-0.06***	-0.05***	-0.06***	-0.06***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2015q4	-0.05***	-0.05***	-0.08***	-0.05***	-0.05***	-0.08***	-0.05***	-0.05***	-0.08***	-0.05***	-0.05***	-0.08***	-0.05***	-0.05***	-0.08***	-0.05***	-0.05***	-0.08***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2016q1	-0.04***	-0.05***	-0.08***	-0.04***	-0.05***	-0.08***	-0.04***	-0.05***	-0.08***	-0.04***	-0.05***	-0.08***	-0.04***	-0.05***	-0.08***	-0.04***	-0.05***	-0.08***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
2016q2	-0.03***	-0.05***	-0.09***	-0.03***	-0.05***	-0.09***	-0.03***	-0.05***	-0.09***	-0.03***	-0.05***	-0.09***	-0.03***	-0.05***	-0.09***	-0.03***	-0.05***	-0.09***
	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
2016q3	-0.03***	-0.04***	-0.06***	-0.03**	-0.04***	-0.06***	-0.03***	-0.04***	-0.06***	-0.03***	-0.04***	-0.06***	-0.03***	-0.04***	-0.06***	-0.03***	-0.04***	-0.06***
	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
2016q4	-0.03***	-0.04***	-0.09***	-0.03**	-0.04***	-0.09***	-0.03***	-0.04***	-0.09***	-0.03***	-0.04***	-0.09***	-0.03***	-0.04***	-0.09***	-0.03***	-0.04***	-0.09***
	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
Product × destination FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.91	0.93	0.98	0.91	0.93	0.98	0.91	0.93	0.98	0.91	0.93	0.98	0.91	0.93	0.98	0.91	0.93	0.98
No. of observations	2,442,107	3,553,459	3,553,459	2,442,107	3,553,459	3,553,459	2,442,107	3,553,459	3,553,459	2,442,107	3,553,459	3,553,459	2,442,107	3,553,459	3,553,459	2,442,107	3,553,459	3,553,459

Notes: Standard errors in brackets, Scen 1 corresponds to "no upgrading, no sorting", Scen 2 to "with upgrading, no sorting" and Scen 3 to " with upgrading, with sorting"; *** p<0.001, ** p<0.01 and * p<0.05.

N ERPT excluding pharmaceutical products and organic chemicals

In this section, we estimate regression (2) excluding the two large product categories "Pharmaceutical products" (HS 2-digit category 30) and "Organic chemicals" (HS 2-digit category 29). The exclusion does not affect our results as shown in Figure N.1.

Figure N.1: *Aggregate effects on pass-through: excluding pharmaceutical products and organic chemicals*



Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2) excluding the product categories "Pharmaceutical products" (HS 2-digit category 30) and "Organic chemicals" (HS 2-digit category 29). The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4.

O Alternative quality measure

In this section, we use an alternative measure of quality changes. Following the approach developed by Aw and Roberts (1986) and Boorstein and Feenstra (1987) and recently outlined by Martin and Mejean (2014), we focus on consumption baskets and examine changes in market shares to measure changes in aggregate quality following the appreciation. The intuition of this approach is that the mean quality of exports increases when consumption reallocates toward expensive products that deliver more utility for the consumer.

To be consistent with Martin and Mejean (2014), we aggregate our data to yearly observations y and use the HS6 product classification to define a product group j. We do so by totaling value and volume over all of the transactions in a given year. We then measure the change in quality within a product group-destination country cell jd between years as:

$$\Delta log\lambda_{jd,y} = \sum_{f}(\omega^{N}_{fjd,y-1} - \omega^{R}_{fjd,y-1})\Delta\omega^{R}_{fid,y}$$

where we total across firms f, $\omega^{N}_{fid,y-1}$ is the nominal market share of firm f in product group-destination country cell jd in year $y-1$, and $\omega^{R}_{fjd,y-1}$ is the real market share.

Under the assumption that the price and quality of a product are positively correlated, this measure is positive if demand shifted toward those firms that have a larger market share in nominal than in real terms ($\omega^{N}_{fjd,y-1} > \omega^{R}_{fjd,y-1}$). These exporters are particularly those with high prices (Martin and Mejean, 2014). Assuming a positive correlation between prices and quality, this finding implies that exports reallocate toward high-quality exporters between years y and $y-1$, increasing the average quality of exports.

To test for a quality increase, we regress the (yearly) change in the quality estimate $\Delta log\lambda_{jdy}$ on a constant and destination fixed effects α_d to control for differences in destination countries:

$$\Delta log\lambda_{jdy} = \beta + \alpha_d + \epsilon_{idy},$$

The key parameter that we report is β, which indicates the extent to which, after controlling for destination fixed effects α_d, our aggregate quality measure increased for firms exporting in year y and $y-1$.

Table O.1: *Destination country and quality upgrading*

	$\Delta log\lambda\_jd, 2015, 2014$	$\Delta log\lambda\_jd, 2016, 2015$	$\Delta log\lambda\_jd, 2016, 2014$
β	0.06***	0.05***	0.06***
	(0.00)	(0.00)	(0.00)
Destination FE	Yes	Yes	Yes
No. of observations	29,918	30,309	28,459

Notes: Standard errors in brackets, clustered at HS6 product classification; *** p<0.001, ** p<0.01 and * p<0.05

The results in Table O.1 confirm that we observe, on average, a quality increase across destination countries. However, this approach does not allow us to derive quality-adjusted prices.

P Quality adjustments and destination country income

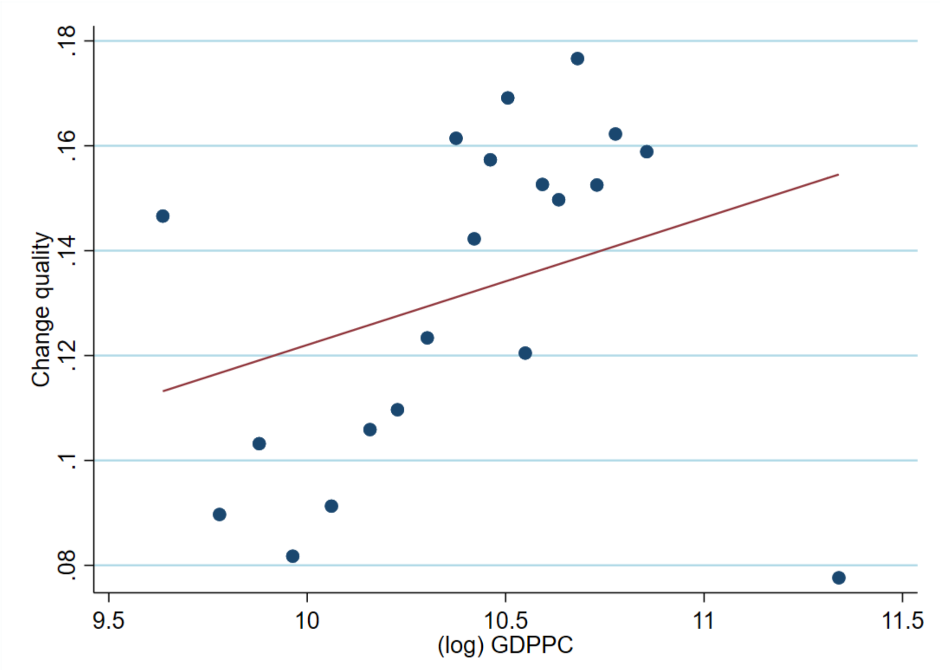
In this section, we show that there is a positive relationship between the extent of quality upgrading (sorting) and the export destination country's GDP per capita (GDPPC).

For quality upgrading, we estimate the equation

$$\Delta\lambda_{jd} = \beta_0 + \beta_j + \alpha * ln(GDPpc_d) + \epsilon_{jd}$$

where λ_{jd} is the weighted average quality change within HS6 product group-destination country cell jd. $GDPpc_d$ is the GDPPC from destination country d (data obtained from the World Bank World Development indicator database). We depict the estimated relationship in Figure P.1. The coefficient α is estimated at 0.024 (robust standard error 0.011).

Figure P.1: *Correlation between quality upgrading and destination country GDP per capita*



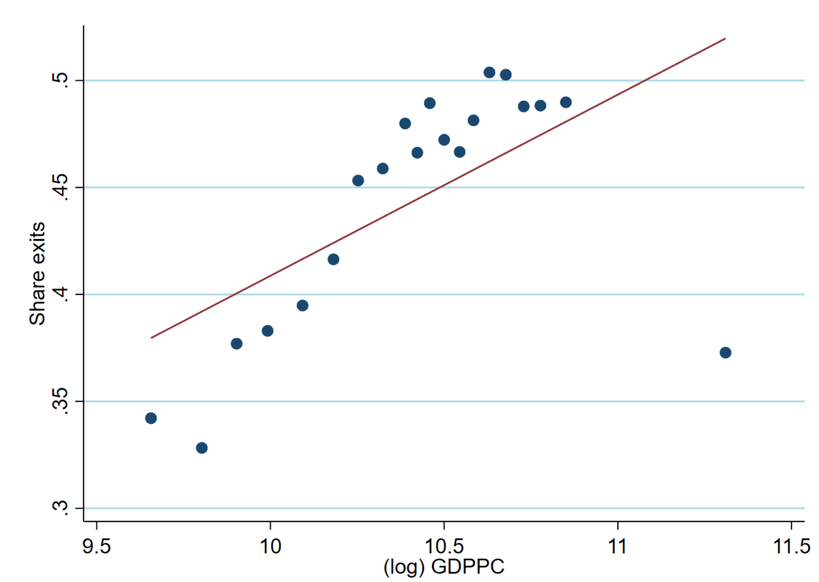
Notes: This figure shows a binscatter with 20 bins of destination country log GDP per capita (GDPPC) and the estimated change in quality within HS6 product group-destination country cell.

Similarly, for quality sorting, we estimate the equation

$$exitshare_{jd} = \beta_0 + \beta_j + \alpha * ln(GDPpc_d) + \epsilon_{jd}$$

where $exitshare_{jd}$ is the share of products that exit either in 2015 or in 2016 within HS6 product group-destination country cell jd. We show the estimated relationship in Figure P.2. The coefficient α is estimated at 0.08 (robust standard error 0.004).

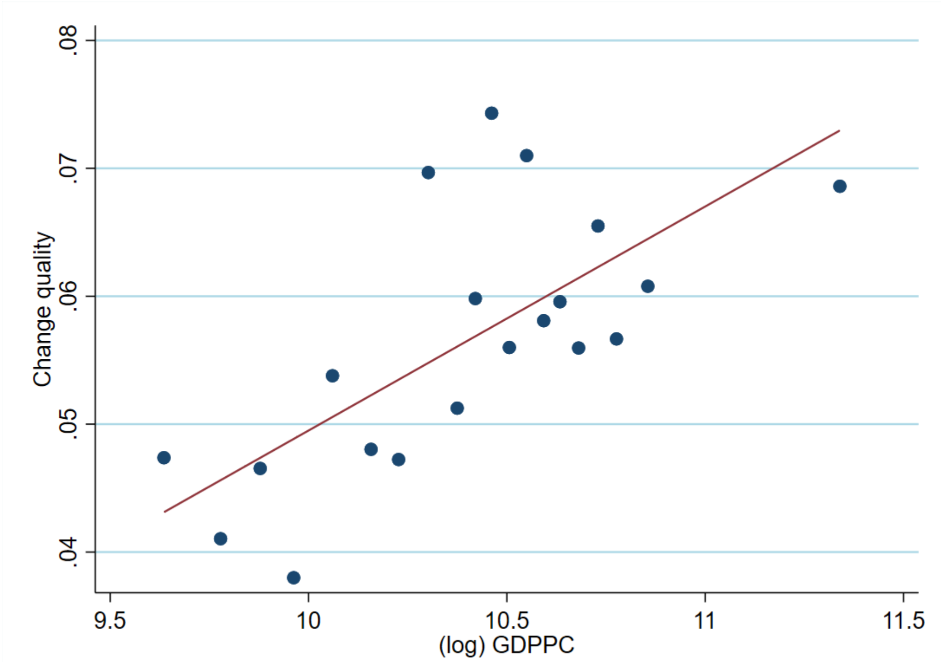
Figure P.2: *Correlation between share of product exits and destination country GDP per capita*



Notes: This figure shows a binscatter with 20 bins of destination country log GDP per capita (GDPPC) and the share of product exits within HS6 product group-destination country cell. Exit of product in either 2015 or 2016.

We observe similar dynamics if we use the alternative quality estimates based on the methodology outlined in Appendix O. We show the estimated relationship in Figure P.3. The coefficient is estimated at 0.02 (robust standard error 0.005).

Figure P.3: *Robustness: correlation between quality change and destination country GDP per capita*



Notes: This figure shows a binscatter with 20 bins of destination country log GDP per capita (GDPPC) and the estimated change in quality described in the robustness analysis in Appendix O.

These findings are also consistent with Brambilla, Lederman, and Porto (2012), who show that exporting to high-income destinations affects firm behavior, while exporting per se does not. In particular, they show that economies trading with high-income countries require higher levels of skilled workers and pay higher wages than economies that trade with low- or middle-income countries. This is because producing high-quality goods that tend to be demanded more by high-income countries requires higher skill levels. The fact that Switzerland is a country with relatively high skill levels and real wages suggests that our finding that Swiss exporters improve quality in particular in the exports that go to high-income countries is consistent with the Brambilla, Lederman, and Porto (2012) model.

Because we cannot observe the destination country in the microprice data underlying the export price index from the SFSO, we cannot conduct a robustness analysis on that dataset.

Q Further evidence for quality sorting

To test whether Swiss exporters follow quality sorting, we first test for a positive correlation of export prices and export revenues across products within a firm and across firm-destination country within a product group. To do so, we run the following regression:

$$\bar{p}_{i,d,q} = \beta_0 + revenue_{i,d,q} + \alpha_{x,q} + \epsilon_{i,d,q}$$

where $\bar{p}_{i,d,q}$ are quarterly demeaned prices, $revenue_{i,d,q}$ are log quarterly sales, and $\alpha_{x,q}$ is either a product group-quarter fixed effect (Table Q.1) or a firm-quarter fixed effect (Table Q.2). We cluster standard errors at the firm level.

Table Q.1: *Relationship between revenues and prices I*

	(log) prices (HS-8)	(log) prices (HS-6)	Quality
(log) revenue	0.03***	0.03***	0.68***
	(0.00)	(0.00)	(0.01)
Product/quarter FE	Yes	Yes	Yes
R^2	0.07	0.10	0.35
No. of observations	2,883,563	2,884,602	2,981,207

Notes: Constant not shown. In the first (second) column, prices are demeaned with the quarterly average across HS8 (HS6) product classification. Standard errors in brackets, clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

Table Q.1 shows a positive correlation between prices (quality) and revenues, across firm-destination country within a product group-quarter, indicating that Swiss exporters follow quality sorting as opposed to efficiency sorting (Manova and Yu, 2017).

Across product group-destination country within a firm-quarter, Table Q.2 shows a positive correlation between prices (quality) and revenues, again is in line with Swiss exporters following quality sorting as opposed to efficiency sorting (Manova and Yu, 2017).

Table Q.2: *Relationship between revenues and prices II*

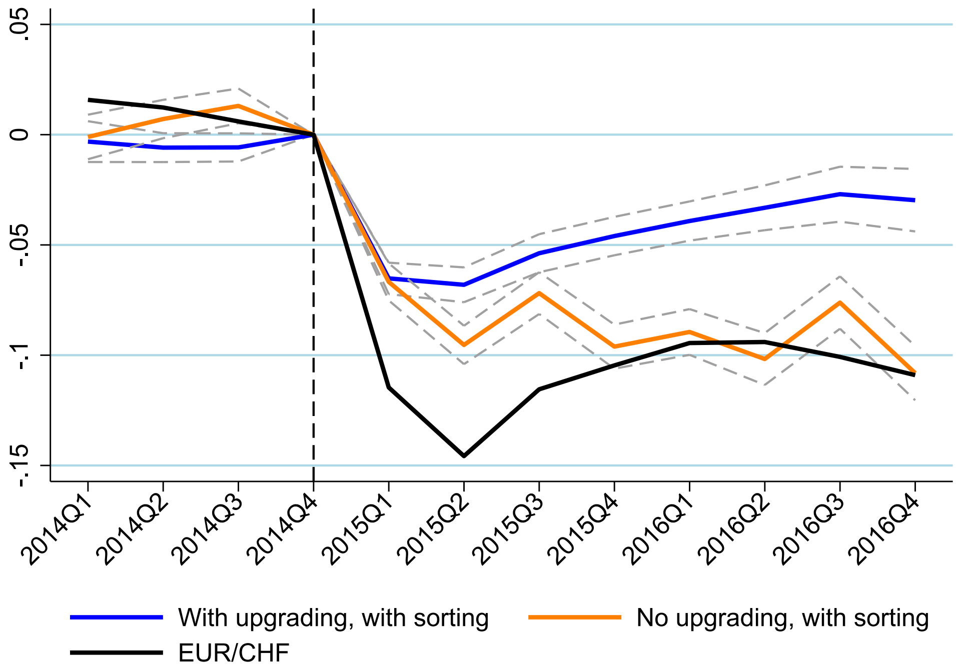
	(log) prices (HS-8)	(log) prices (HS-6)	Quality
(log) revenue	0.02***	0.02***	0.50***
	(0.00)	(0.00)	(0.00)
Firm/quarter FE	Yes	Yes	Yes
R^2	0.31	0.32	0.23
No. of observations	2,795,209	2,796,040	2,885,957

Notes: Constant not shown. In the first (second) column, prices are demeaned with the quarterly average across HS8 (HS6) product classification. Standard errors in brackets, clustered at the firm level; *** p<0.001, ** p<0.01 and * p<0.05.

R Pass-through estimation excluding imputed observations

Figure R.1 shows our ERPT decomposition excluding imputed observations and Tables R.1 and R.2 show pass-through rates and the decomposition of aggregate pass-through into margins of adjustment, respectively. The effects of quality upgrading and sorting are similar as in the main analysis.

Figure R.1: *Aggregate effects on pass-through: No imputed observations*



Notes: This figure shows the regression coefficients β_q and 95% CI of regression (2). The series "with upgrading, with sorting" uses observed prices, and the series "no upgrading, with sorting" includes observed quality-adjusted prices. The dashed line indicates the pre-shock quarter 2014Q4.

Table R.1: *Pass-through rates: No imputed observations*

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
EUR/CHF	-11.46	-14.58	-11.55	-10.46	-9.45	-9.40	-10.08	-10.90
No upgrading, with sorting	0.58	0.65	0.62	0.92	0.95	1.08	0.76	0.99
Upgrading, with sorting	0.57	0.47	0.47	0.44	0.41	0.35	0.27	0.27

Notes: This table shows the pass-through for each series by quarter.

Table R.2: *Contribution of margins of adjustment: No imputed observations*

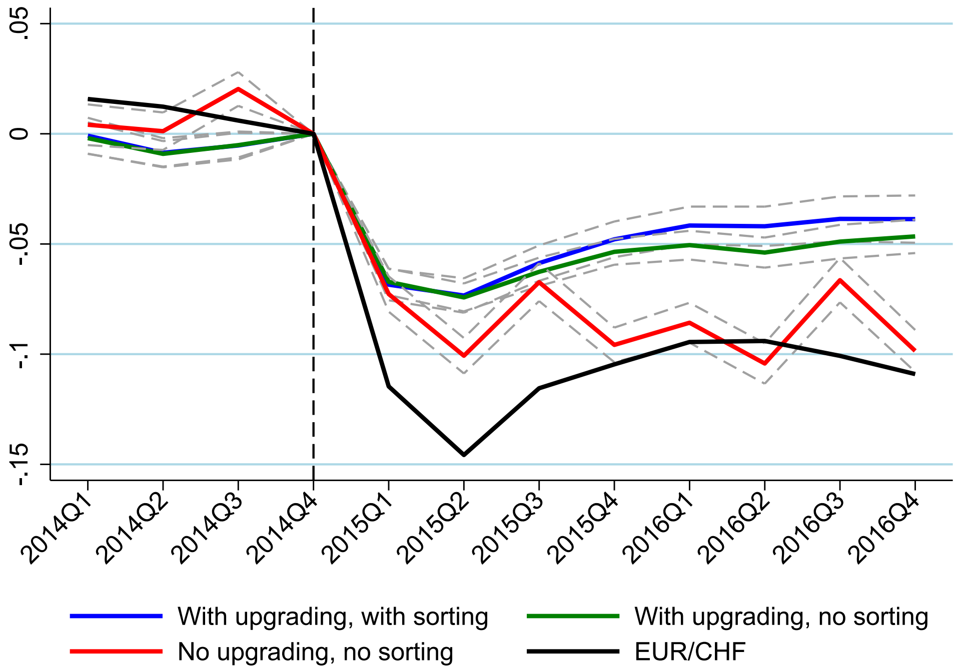
	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
Incomplete price adjustment	0.96	0.56	0.62	0.10	0.06	-0.08	0.21	0.01
Quality upgrading and sorting	0.04	0.44	0.38	0.90	0.94	1.08	0.79	0.99

Notes: This table shows the contribution of each margin explained in the text to the overall aggregate exchange rate pass-through. "Price adjustments" corresponds to series "no upgrading, with sorting" and "Quality upgrading and sorting" to "with upgrading, with sorting".

S Pass-through estimation with unit price

In this section we estimate the ERPT into (quality-adjusted) prices based on value per unit instead of mass for those observations, for which we have information on the unit of measurement. Following Bonadio, Fischer, and Sauré (2020), we label these prices "unit price". For 32.6 percent of our observations we have consistent non-zero information across transactions on the unit of measurement (e.g. pieces, liters, meter or sets) for the period under study. In Figure S.1 we estimate the EPRT into price, where we use unit prices for the 32.6 percent of our observations with information and unit value for the remaining observations. The variation does not affect our results.

Figure S.1: *Aggregate effects on pass-through: Unit price*



Notes: This figure shows the regression coefficients β_q and 95% CIs of regression (2) based on value per unit instead of mass for those observations, for which we have information on the unit of measurement (32.6 percent). The series "with upgrading, with sorting" uses observed prices, the series "with upgrading, no sorting" uses observed and imputed prices, and the series "no upgrading, no sorting" includes observed and imputed quality-adjusted prices. The dashed vertical line indicates the pre-shock quarter 2014Q4.

In addition, we compare the point estimates when we replace mass with units in the calculation of unit values for the subset of observations (the 32.6 percent) where we have consistent information for both measures in Table S.1 below. We find similar results for both definitions.

Table S.1: *Comparing quality upgrading in unit value and unit prices*

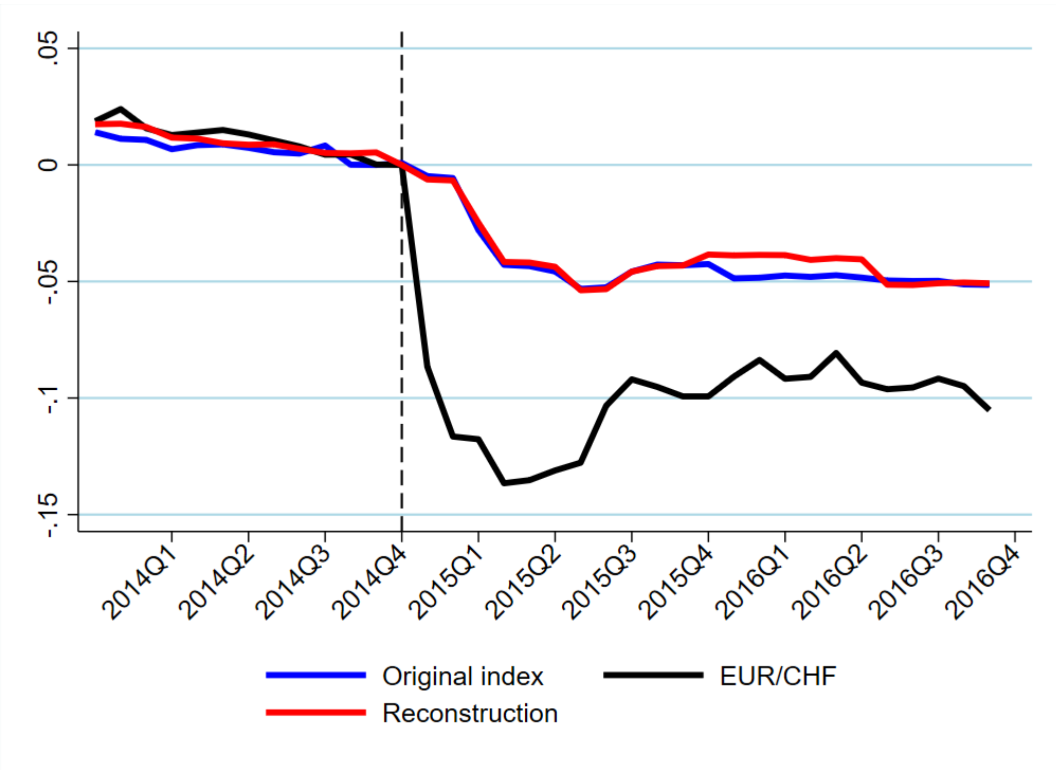
	Unit value	Adjusted Unit value	Difference Unit value	Unit price	Adjusted Unit price	Difference Unit price
2014q1	-0.00	0.00	-0.01	0.01	0.01	0.00
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
2014q2	-0.01	0.02*	-0.03*	-0.02**	0.02	-0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
2014q3	-0.01*	0.02**	-0.03***	-0.01	0.03**	-0.04**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
2015q1	-0.06***	-0.06***	0.00	-0.07***	-0.07***	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
2015q2	-0.07***	-0.10***	0.03*	-0.08***	-0.11***	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
2015q3	-0.05***	-0.08***	0.03**	-0.07***	-0.09***	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
2015q4	-0.05***	-0.11***	0.06***	-0.06***	-0.13***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
2016q1	-0.05***	-0.09***	0.05***	-0.05***	-0.10***	0.05**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
2016q2	-0.03**	-0.10***	0.07***	-0.06***	-0.11***	0.05**
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
2016q3	-0.02*	-0.08***	0.06**	-0.06***	-0.07***	0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
2016q4	-0.03*	-0.14***	0.10***	-0.06***	-0.13***	0.07***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
Product × destination FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	796527	796527	796527	796527	796527	796527

Notes: Standard errors in brackets, clustered at firm level; *** p<0.001, ** p<0.01 and * p<0.05.

T Comparison to the official export price index

As mentioned in the main text, we aggregate the micro export price data using industry weights, while the SFSO aggregates use first weights for each firm within an industry and then weights for the industry, to obtain the aggregate EPI. We were not provided with firm weights (for confidentiality reasons). Furthermore, we exclude oil-related products from our analysis to avoid potential confounding effects of the oil price change in 2014. Our reconstruction based the SFSO's industry weights, weighting firms within an industry equally, shows that the deviations are relatively small: Figure T.1 shows the dynamics of the official EPI in blue and our reconstruction (quality adjusted) in red.

Figure T.1: *Export price index*

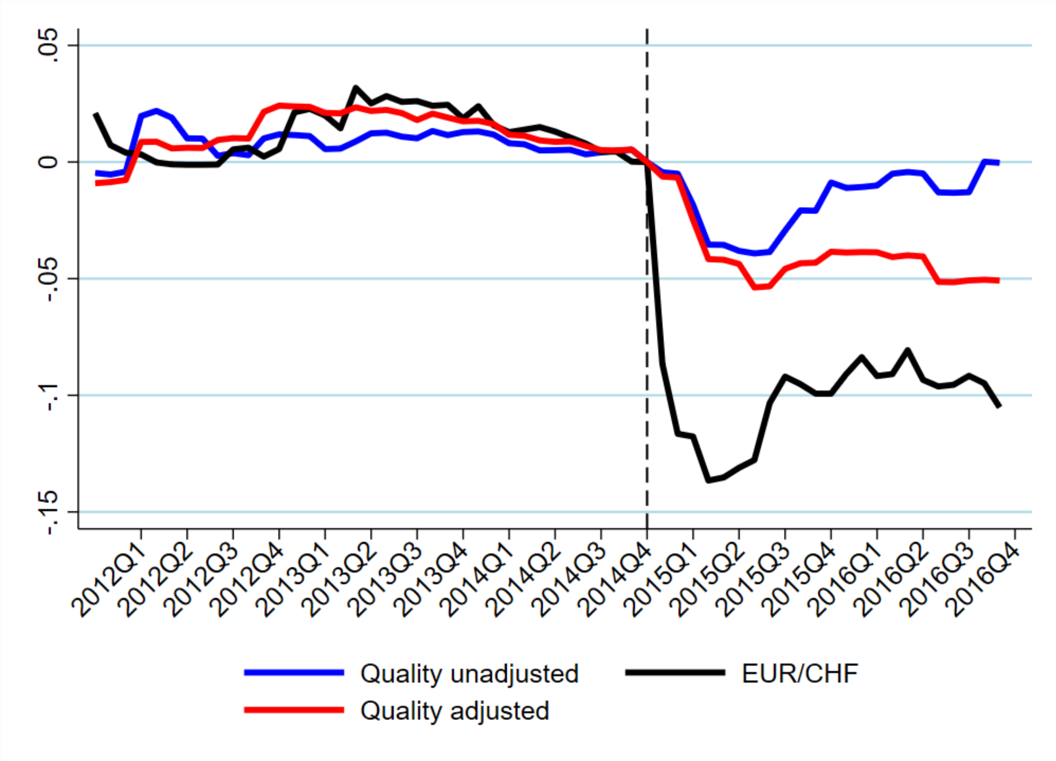


Notes: The reference period for data collection is the 1st to the 8th of a given month. For expository purposes, the indexes are shifted by one month, such that January 2015 corresponds to prices collected from February 1 to 8. The ticks on the x-axis refer to the end of the quarter. Source original index: SNB

U Pretrend analysis

Figure U.1 shows the dynamics of the EPI including quality adjustments (in blue) and excluding quality adjustments (in red) for a longer time horizon. We do not observe any pretrends prior to the appreciation, suggesting that the price and quality changes we observe are not a continuation of existing trends.

Figure U.1: *Dynamics of the export price index*



Notes: The reference period for data collection is the 1st to the 8th of a given month. For expository purposes, the indexes are shifted by one month, such that January 2015 corresponds to prices collected from February 1 to 8. The ticks on the x-axis refer to the end of the quarter.

V Export share and quality changes

Table V.1 shows the 20 largest HS2 sectors sorted by export share and the average change between 2014 and (2015) 2016 of the value-weighted yearly average quality estimates ($\Delta\lambda_j$). We tend to observe larger changes in the quality estimates in sectors characterized by a larger proportion of differentiated products (ρ_j) (eg. "Aircraft, spacecraft and parts thereof", "Pharmaceutical products", "Clocks and watches and parts thereof") compared to sectors with lower shares (e.g., "Raw hides and skins (other than furskins) and leather", "Iron and steel" or "Coffee, tea, mate and spices"). Splitting the 96 HS2-sectors by median quality change yields an overall higher average proportion of differentiated products in sectors with larger quality change compared to smaller quality changes (0.70 vs 0.59, p=0.12 two-sided t-test). Product differentiation is based on the Rauch (1999) classification of differentiated products.

Table V.1: *Export share and quality changes*

Sector	(1) 2014	(2) 2015	(3) 2016	(4) $\Delta\lambda_j$	(5) ρ_j
Pharmaceutical products	20.0	20.8	22.2	0.4	1.0
Organic chemicals	11.6	12.5	13.0	0.6	0.1
Pearles, stones, precious metals and articles thereof; imitation jewellery; coin	10.7	11.7	12.7	1.6	0.4
Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof	9.4	10.3	10.2	0.2	1.0
Raw hides and skins (other than furskins) and leather	8.2	0.1	0.1	-2.0	0.8
Optical, measuring, medical (and other) instruments and apparatus	6.3	7.1	7.0	0.3	1.0
Electrical machinery and equipment; recorders and reproducers	5.0	5.3	5.1	0.3	1.0
Clocks and watches and parts thereof	4.5	5.5	4.5	0.4	1.0
Plastics and articles thereof	3.0	3.1	3.1	0.3	0.5
Iron or steel articles	1.6	1.8	1.7	0.4	0.9
Coffee, tea, mate and spices	1.4	1.4	1.3	-0.1	0.2
Essential oils and resinoids; perfumery, cosmetic or toilet preparations	1.4	1.4	1.3	0.1	0.7
Aluminium and articles thereof	1.3	1.5	1.5	0.1	0.6
Vehicles; other than railway or tramway rolling stock	1.3	1.5	1.4	0.2	1.0
Chemical products n.e.c.	0.9	1.0	0.8	0.4	0.7
Iron and steel	0.9	0.9	0.8	-0.1	0.2
Paper and paperboard; articles of paper pulp, of paper or paperboard	0.8	0.9	0.7	0.2	0.4
Tools, implements, cutlery, spoons and forks, of base metal	0.8	0.9	0.8	0.1	1.0
Paints, varnishes and products replated to tanning, dyeing and colouring	0.8	0.8	0.8	0.1	0.4
Aircraft, spacecraft and parts thereof	0.7	0.9	0.6	0.3	1.0

Notes: Columns (1) to (3) denote the yearly export share of each of the largest 20 HS2 sectors. $\Delta\lambda_j$ indicates the weighted average change of our quality estimate between 2014 and (2015) 2016. ρ_j shows the proportion of differentiated products (Rauch, 1999).