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Abstract

The empirical trade literature has traditionally studied exchange rate pass-through (ERPT) into imported consumer goods prices but not into imported input prices. It also implicitly assumed full ERPT into imported input prices in studying their role in exchange rate adjustments of exports, which is a rather strong assumption. In this paper, we bridge both these gaps using self-constructed indices of intermediate input prices to investigate the effect of exchange rate fluctuations on export prices using disaggregated quarterly trade data for Switzerland over 2004-2011. We find evidence for high pass-through rates into imported input prices that are not transmitted to foreign consumers. This suggests the use of cheaper imported inputs ("natural hedging") to offset adverse effects of currency appreciation on export profit margins. Interestingly, we also find that Swiss exporters may not have adjusted export pricing and natural hedging practice in response to the Franc's appreciation during the Eurozone crisis.

Keywords: exchange rates, exchange rate pass-through, international trade, prices

JEL classification: F31, F41

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1 Introduction

The ERPT literature has paid little attention to the exchange rate sensitivity of imported input prices. This issue is important for two reasons. First, adjustments of marginal costs due to exchange rate changes could explain part of the low ERPT generally observed in the data (see Burstein and Gopinath, 2013). The related rationale for studying this marginal cost channel is the potential role of imported inputs as a tool to "naturally" hedge exchange rate risks; exporters may have the means to offset some of the adverse effect of exchange rate appreciations on profit margins through cheaper imported inputs. However, this natural hedging is only effective if imported input prices vary with exchange rates and these cost changes are not completely passed on to foreign consumers on the export side.

It turns out that the recent empirical literature mainly focuses on (semi-)final goods price adjustments and investigates the cost effect due to imported inputs only indirectly using measures such as the share of imported intermediate inputs in total intermediate inputs (Greenaway et al., 2010), or in studies with firm data, the ratio of total imports to total sales or costs (Amiti et al., 2012 and Berman et al., 2012). These studies however do not look at actual price developments of imported inputs as a result of exchange rate shocks. Thus, they implicitly assume full ERPT into imported input prices[1], which is a rather strong assumption, given the overwhelming existing evidence of partial ERPT into import prices in general (see for instance Campa and Goldberg, 2005).

In a significant departure from this literature, we study ERPT into imported input prices using bilateral and disaggregated unit values as proxies for import prices. We use these unit values to construct indices of average imported input prices that are faced by each sector over time and investigate their role in the price setting behaviour of exporters. To the best of our knowledge, this paper is the first (i) to investigate in detail how imported input prices faced by each (exporting) industry develop over time. Next, (ii) to study the effectiveness of "natural hedging" of exchange rate risk, we quantify the effect of exchange rate fluctuations on these imported input prices and (iii) examine total pass-through effects on export prices; that is the combined effect of pricing to market and cost adjustments via imported input prices on export prices when the exchange rate fluctuates. While the second step (ii) also provides insights on the potential contribution of the marginal cost or imported input channel in generating incomplete ERPT, the last step (iii) reveals whether exporters

[1] To the best of our knowledge, the only exceptions to this are Athukorala and Menon (1994) and Amiti et al. (2012). Athukorala and Menon (1994), however, do not use disaggregated indices for imported input prices as we do. Amiti et al. (2012) cite our paper as they use a similarly constructed imported input price index in one specification.

use “natural hedging” to stabilise profit margins (mark-ups) in destination markets.

We use quarterly product level trade data at the HS 8-digit level for Switzerland between 2004 and 2011 in our analyses. Analysing imported input prices in Switzerland is particularly interesting as the Swiss economy has high ratios of imported intermediate inputs relative to total intermediate inputs, especially in the manufacturing sector (see Table 3), and about half of total imports are processed and re-exported (see Seco, 2011). In the event of significant “natural hedging” it is thus a relevant question whether Swiss exporters are (at least to some extent) spared from losing competitive advantage despite the strong appreciation of the Swiss Franc (CHF). Last but not least, investigating this issue with Swiss data also contributes to the topical debate on the “strong” CHF. According to a study by the State Secretariat for Economic Affairs (Seco, 2011), imported goods prices fell by 40 % three or four quarters after the appreciation. However, the prices did not fall as much as the CHF appreciated. While the focus of that discussion was more related to imported consumer goods, it might be that prices of imported inputs did not fully adjust as well, which provides another motivation for this study and a reason to also investigate the “recent strong Franc” period separately.

Despite their shortcomings, using unit values as proxies for prices is common in the ERPT literature because of their wide availability. Compared to most studies, unit values in this paper are relatively more accurate reflections of prices as they are calculated quarterly at a highly disaggregated level and are trading partner-specific. This reduces the effect of changes in product quality or composition on estimates that can occur even within 8-digit product categories.[2] Furthermore, unit values allow us to discriminate between intermediate and consumer goods, making ours the first paper to construct industry-level imported input price indices.[3]

The paper proceeds as follows. Section 2 provides a brief review of the relevant literature. Section 3 introduces the theoretical framework which forms the basis for the empirical set up in Section 5. Section 4 presents the recent evolution of imported input prices and describes the data. Section 6 describes the results from estimation and Section 7 concludes.

[2]The use of higher frequency data to calculate unit values and for the regression analysis is an advantage over the yearly data employed by Amiti et al. (2012) and Berman et al. (2012). Specifically, the estimates are arguably less affected by quality and compositional changes due to higher time series variation within a given time period and, additionally, the time series properties can be tested. As opposed to these studies, one shortcoming of our data is that we cannot control for firm characteristics.

[3]The official import price index for Switzerland is not available for inputs.

2 Related literature

This section highlights results and empirical issues from previous work closely related to our paper. A complete overview of the extensive pass-through literature is beyond the scope of this brief review (for more extensive literature reviews see Burstein and Gopinath, 2013, Goldberg and Knetter, 1997 and Greenaway et al., 2010).

In a contemporaneous study, Amiti et al. (2012) investigate ERPT into export prices considering firms' import intensities and destination market shares. They show that firms employing a higher share of imported inputs and with larger market shares in export markets have lower ERPT. In contrast, we emphasise the use of imported inputs as a mechanism to keep profit margins stable in periods of exchange-rate volatility. Although they also provide evidence for the exchange-rate sensitivity of input prices at the firm-level, using higher frequency data we estimate sectoral pass-through rates into imported input prices in an empirical framework that controls more carefully for changes in country-specific economic conditions and product-driven differences in marginal costs.

Athukorala and Menon (1994) examine the pricing behaviour of Japanese exporters by taking into account the aggregate changes of intermediate costs arising from exchange rate movements. Similar to Amiti et al. (2012), their investigation of quarterly export prices reveals that if the cost-saving effect of exchange rate appreciations is considered the pass-through rate into foreign currency prices for total manufacturing exports declines from 0.78 to 0.67. Their results also reveal a high sectoral heterogeneity in ERPT, which indicates that sectoral estimations should be performed.[4] In this paper, we go a step further by investigating average ERPT into export prices for 15 goods sectors using price data (unit values) at a highly disaggregated and bilateral level. Moreover, we explicitly include disaggregated proxies of imported input prices faced by exporting industries in each period. Finally, we also estimate how these intermediate import prices react to exchange rate changes (again using highly disaggregated data) to investigate whether "natural hedging" is effective.

In another study using a panel of French firms, Berman et al. (2012) find a positive "cost adjustment effect" (positive coefficient on the interaction between the real exchange rate and firm intermediate imports over sales) on producer currency export prices, and thus - in line with Amiti et al. (2013) and Athukorala and Menon (1994) - smaller ERPT into foreign currency prices when taking cost changes into account. Thus, the estimations in all

[4] Separate estimations for seven manufacturing sub-industries suggest a substantial upward aggregation bias: at the disaggregated level, total ERPT ranges from 0.04 for textiles to 0.53 for transport equipment. All estimates are thus lower than 0.67 at the aggregated level.

three studies imply that "natural hedging" is at least partly effective because exchange-rate driven cost fluctuations are incompletely passed on to foreign consumers. Consequently, the remaining input cost variation is used to cushion movements in the exporters' profit margins. We are the first to investigate this issue in more detail.

Relatedly, Greenaway et al. (2010) investigate a panel of UK manufacturing firms and suggest that the negative effect of an exchange rate appreciation on firm exports is lower in industries that import a greater share of inputs. According to Greenaway et al. (2010), their imported-input-weighted exchange rate, which varies at the sectoral-level, should account for import price changes resulting from exchange rate changes. In contrast to our paper, they implicitly assume that an appreciation of the domestic currency would lower import prices without actually studying them.

As indicated by Athukorala and Menon (1994) and Greenaway et al. (2010), industry variation in the pass-through rates are likely to reflect differences in the cost structures across industries. Along the same line, Campa and Goldberg (1997) and Hummels et al. (2001) point to the increasingly important role of global supply chains, and accordingly to the share of imported inputs as an important determinant of industry cost structure. Acknowledging the cost contribution of imported inputs, we emphasise the cost sensitivity of imported inputs to exchange rate movements and its subsequent effect on export pricing. The sensitivity of prices at the importer side also influences ERPT at the exporter side, but this interconnection has surprisingly not received adequate attention in the empirical ERPT literature. Aksoy and Riyanto (2000) formalise this issue and show that ERPT in the downstream export market depends on the pricing behaviour of foreign upstream suppliers. Finally, Ihrig et al. (2006) argue that the decline of pass-through rates into domestic prices experienced in all G-7 countries over the last two decades may also be a consequence of the steady rise of cross-border production arrangements.

In other relevant work, Goldberg and Campa (2010) calibrate a structural model of the CPI sensitivity to exchange rates with data from 21 OECD countries. They find that the goods cost shares of imported inputs are the dominant channel through which exchange rate shocks are transmitted into consumer prices. For the calibration exercise, they use the strong assumption that an exchange rate change is completely passed through into the imported input prices. This contrasts, for instance, with the low pass-through rates into US import border prices reported by Gopinath and Rigobon (2008) and Gopinath et al. (2010). As argued by Goldberg and Hellerstein (2008), this is strongly suggestive but not rigorous evidence that imported inputs invoiced in USD play an important role in the pricing of US import goods. Campa and Gonzalez Minguez (2006) show that differences of ERPT into domestic prices in the euro area countries may be explained by the degree of openness to non-euro imports of each country. Campa and Goldberg (1995) and Campa and Goldberg (1999) provide evidence for the US, UK, Japan and Canada that suggests that sectoral investment rates respond to exchange rate fluctuations depending primarily on a sector's exposure to imported inputs and export markets.[5] Yet the issue of how pricing on the export side is related to imported input costs remains unresolved in all the cited studies. Our study fills this gap in the pass-through literature by recognising explicitly in the empirical framework that the exporters' pricing decisions may have become inextricably intertwined with the pricing behaviour of foreign input suppliers.

3 Theoretical framework

3.1 Import price equation

We assume an exporting sector s specific Cobb-Douglas production function with the share α_s corresponding to imported inputs and the share $1 - \alpha_s$ to domestic inputs including labour services.

$$Q_s = (K^*)^{\alpha_s} \cdot (K)^{1-\alpha_s} \,, \tag{1}$$

The marginal cost function dual to (1) is given by :

$$MC_s(W, W^*(E), \alpha_s, E) = A_s \cdot W^{1-\alpha_s} \cdot (EW^*(E,Z))^{\alpha_s} \,, \qquad A_s = \alpha_s^{-\alpha_s} \cdot (1-\alpha_s)^{\alpha_s - 1}, \tag{2}$$

where W is the price of domestic inputs, W^* denotes the price of imported inputs denominated in the foreign currency and E is the bilateral exchange rate between Switzerland and the import source country defined as CHF per unit of the foreign currency. Z includes all factors that affect the foreign currency price of imported inputs W^*, such as the state of the business cycle or increases in producer prices due to changes in foreign wages or commodity prices. Taking logs and totally differentiating (2) leads to the following expression:

[5] Their empirical findings suggest that a depreciation of the domestic currency tends to reduce investments particularly in competitive sectors that employ a large fraction of imported inputs, whereas high mark-up sectors with lower imported input shares are less affected by exchange rates. A possible explanation is again that the sensitivity of imported input prices to exchange rates differs across sectors, probably reflecting distinct competitive environments.

$$\tilde{MC_s} = \widetilde{A} + (1-\alpha_s)\widetilde{W} + \alpha_s \left(\tilde{E} + \frac{\partial w^*}{\partial W^*}\frac{\partial W^*}{\partial e}\tilde{E} + \frac{\partial w^*}{\partial W^*}\frac{\partial W^*}{\partial z}\tilde{Z} \right) \tag{3}$$

where a "$\backsim$" over a variable denotes percentage changes and small letters denote the log of the variables. It is clear from (3) that a higher share of imported inputs, α_s, results in a higher sensitivity of marginal costs to exchange rate fluctuations. Price changes of imported inputs in CHF can be decomposed into the direct effect $\widetilde{E}$ on the Swiss price of imported inputs and the indirect consequence of an exchange rate change on the pricing behaviour of foreign suppliers, $\tilde{W}^* = \frac{\partial w^*}{\partial W^*}\frac{\partial W^*}{\partial e}\tilde{E}$. An interesting limiting case is local currency pricing (LCP) in which the pass-through rate is zero or formally:

$$\widetilde{E} + \frac{\partial w^*}{\partial W^*}\frac{\partial W^*}{\partial e}\tilde{E} = 0 \tag{4}$$

The price reducing effect of an appreciation is here completely offset by the price increases of the foreign suppliers. More generally, percentage changes of imported input prices in CHF, $\tilde{P_s^m}$, due to exchange rates movements, which corresponds to the term in brackets in (3), can be defined as follows:

$$\tilde{P_s^m} = \left(1 + \frac{\partial w^*}{\partial e}\right) \cdot \tilde{E} + \frac{\partial w^*}{\partial z} \cdot \widetilde{Z}, \tag{5}$$

Thus the effect of a percentage change in the bilateral exchange rate $\tilde{E}$ depends on the elasticity of the foreign currency input prices to exchange rates or equivalently on the elasticity of mark-ups to exchange rates, $\frac{\partial w^*}{\partial e}$. If this elasticity equals zero, we obtain full pass-through. Conversely, if foreign suppliers adjust foreign prices and mark-ups when the exchange rate fluctuates, pass-through will be less than complete, $\frac{\partial w^*}{\partial e} < 0$, or amplified, $\frac{\partial w^*}{\partial e} > 0$. In line with equation (5), the simplified empirical equation takes the following logarithmic specification using first-differences and adding time dimension t (details in Section 5.1):

$$dp^m_{t,s} = \theta_t + \lambda_s + \beta_s de_t + \epsilon_{t,s} \tag{6}$$

where d is the first-difference operator, β_s corresponds to the sector-specific pass-through coefficient. $\beta_s = 1$ would mean that this sector is characterised by full pass-through or producer currency pricing (PCP). In contrast, $\beta_s = 0$ indicates zero pass-through or local currency pricing (LCP) of foreign input suppliers in the Swiss market as illustrated in equation (4).[6]

[6]All exchange rate movements are fully absorbed in the mark-ups of foreign suppliers in this case.

In the intermediate case, $\beta < 1$, we have incomplete pass-through, which suggests that foreign input suppliers raise their prices and mark-ups when the CHF appreciates. Knetter (1989) points out that this occurs when foreign input suppliers' perceived elasticity of demand rises with the local price (CHF). Then, a depreciation of the supplier's currency, $\tilde{E} < 0$, induces foreign suppliers to increase their profit margins. This relationship would be reflected in the negative elasticity between the foreign input price and the exchange rate in equation (5), $\frac{\partial w^*}{\partial e} < 0$. Conversely, a $\beta > 1$ shows that exchange rate changes are transmitted into imported input prices in an amplified manner. This could indicate that the foreign input suppliers' demand elasticity may fall with the Swiss price of foreign inputs resulting in $\frac{\partial w^*}{\partial e} > 0$. Full pass-through, $\frac{\partial w^*}{\partial e} = 0$, indicates that the perceived demand elasticity does not change with the local price.[7]

A set of fixed effects $\theta_t + \lambda_s$ in (6) captures changes in foreign input prices in a specific sector s and over time t that can be attributed to changes in the economic conditions, the production costs ($\tilde{Z}$ in 5) in the exporting country, demand conditions in the importing country or changes in commodity prices.

3.2 Export price equation

In an imperfectly competitive environment such as the popular monopolistic competition framework, economic agents are price setters and their first order conditions from profit maximisation can be stated in the following way:

$$P^e_{j,s} = MK_{js}\left(\frac{P^*_{js}(E)}{P_j}, Z_j, MC_s(E,W)\right)\cdot MC_s(E,W), \qquad MK_{js} = \frac{P^e_{js}}{MC_s}, \quad P^*_{j,s} = \frac{P^e_{j,s}(E)}{E}, \tag{7}$$

where $P^e_{j,s}$ is the FOB average export price in CHF of sector s delivering to country j, $P^*_{j,s}$ is the corresponding price in local currency, MC_s denotes the sector-specific marginal cost (see also equations 2 and 3) and $MK_{j,s}$ represents the sector-destination specific mark-ups. Taking logs and totally differentiating (7) with respect to the bilateral exchange rate in terms of CHF per unit of the destination currency E, the destination price index P_j, the demand-shifter Z_j and the domestic input prices W we obtain:[8]

[7] This would be the case with a CES demand function.

[8]
$$\frac{\partial mk_{j,s}}{\partial MC_s} \leq 0, \quad \frac{\partial mc_s}{\partial e} \geq 0, \quad \frac{\partial mk_{j,s}}{\partial P_j} > 0, \quad \frac{\partial mk_{j,s}}{\partial Z_j} > 0, \quad \frac{\partial mc_s}{\partial W} > 0$$

$$\tilde{P}^e_{j,s} = \left(\frac{\partial mk_{j,s}}{\partial P^*_{j,s}}\frac{\partial P^*_{j,s}}{\partial e}\right)\cdot\tilde{E} + \left(\frac{\partial mk_{j,s}}{\partial MC_s}\frac{\partial MC_s}{\partial e} + \frac{\partial mc_s}{\partial e}\right)\cdot\tilde{E}+ \tag{8}$$

$$+\frac{\partial mk_{j,s}}{\partial p_j}\cdot\tilde{P}_j + \left(\frac{\partial mk_{j,s}}{\partial MC_s}+1\right)\cdot\frac{\partial mc_s}{\partial w}\cdot\tilde{W} + \frac{\partial mk_{j,s}}{\partial z_j}\cdot\tilde{Z}_j,$$

The exporter's price equations (7) and (8) show that the variable mark-up is a function of the ratio between the price of the Swiss export good price in local currency, $P^*_{j,s}$, divided by an average price index, P_j, that encompasses close substitutes available in market j. A negative reduced-form relationship between mark-up and relative price (or, equivalently, incomplete ERPT), $\frac{\partial mk_{j,s}}{\partial\left(P^*_{js}/P_J\right)} < 0$, can arise not only in the monopolistic competition framework but is common to many models of international pricing (see Burstein and Gopinath, 2013).[9] More generally, the export price reaction to exchange rate changes depends on the reaction of the mark-ups to currency movements, $\frac{\partial mk_{j,s}}{\partial P^*_{j,s}}\frac{\partial P^*_{j,s}}{\partial e}$. As on the import side, this elasticity depends on how exporters perceive the demand schedule in a specific export market. For instance, a positive relationship between a CHF depreciation and the mark-up, $\frac{\partial mk_{j,s}}{\partial P^*_{j,s}}\frac{\partial P^*_{j,s}}{\partial e} > 0$, holds whenever a firm is confronted with a residual demand that exhibits an increasing elasticity with the local price - this is the case for demand functions that are less convex than in the CES case - irrespective of the form of imperfect competition as highlighted by Knetter (1989) and illustrated by Yang (1997) and Dornbusch (1987) for extended Dixit-Stiglitz and Cournot frameworks.[10] [11] With such a perceived demand function, exporters that face an appreciated currency , $\tilde{E} < 0$, try to remain competitive by reducing mark-ups. A mark-up elasticity of one, $\frac{\partial mk_{j,s}}{\partial P^*_{j,s}}\frac{\partial P^*_{j,s}}{\partial e} = 1$, corresponds to local currency pricing (LCP) wherein the mark-up fully absorbs exchange rate movements. If the demand curve is more convex than in the CES case, it could occur that exporters increase the mark-up when the exporter's currency appreciates leading to an overreaction of local prices to exchange rate changes.

The second term in (8) illustrates the effect of exchange rate changes on marginal costs and mark-ups working through imported input prices.[12] Contingent on the imported input price reactions (see equations 5 and 6), exporters may benefit from lower marginal costs through

[9] see for instance Corsetti and Dedola (2005) and Atkeson and Burstein (2008).

[10] In the extended Dixit-Stiglitz framework of Yang (1997) based on Dornbusch (1987), firms take into account their non-negligible effect of quantity decisions on the aggregate industry price index. Atkeson and Burstein (2008) show that the endogenous mark-up in our sense, $\frac{\partial mk_{j,s}}{\partial e} > 0$, that leads to incomplete pass-through can be even introduced in a CES-framework with small modifications.

[11] Our derivation of the exporter's pricing and pass-through in (7) and (8) is therefore not limited to monopolistic competition frameworks but holds more generally as well.

[12] Please note that the bilateral exchange rate variable, $\tilde{E}$, in the first and second term of (8) can differ according to the origins of the imported inputs used and the specific destination of an export good.

cheaper foreign inputs when their currency appreciates, $\frac{\partial mc_s}{\partial e} \geq 0$, and may also increase profit margins, $\frac{\partial mk_{j,s}}{\partial MC_S}\frac{\partial MC_s}{\partial e} \leq 0$. The mark-up adjustment depends again on the perceived demand elasticity. Furthermore, as in Melitz and Ottaviano (2008), more competitive export markets are characterised by lower local prices, P_j, for similar goods, and thus higher demand elasticities which force exporters to reduce export prices, $\frac{\partial mk_{j,s}}{\partial p_j} > 0$. From (8) one can also note that controlling for differences and changes of marginal costs, preferably at the product level, is important due to their direct impact on export prices and through their effect on the price-cost margins since sectors with lower marginal costs MC_j are able to set higher mark-ups, $\frac{\partial mk_{j,s}}{\partial MC_s} \leq 0$.[13] Z_j is a demand shifter related to destination-specific preferences for a good but also on general economic conditions in market j. Stronger preferences and better conditions both increase the exporters' ability to raise export prices and margins, $\frac{\partial mk_{j,s}}{\partial z_j} > 0$.

Equation (8) leads us directly to our simplified empirical specification (details in Section 5.1):

$$dp^e_{t,j,s} = \theta_{t,j} + \eta_s + \gamma_1 * de_t, + \gamma_2 * dp^m_{t,s} + \varepsilon_{t,j,s}, \tag{9}$$

where γ_1 denotes the pricing-to-market coefficient (PTM) and corresponds to the mark-up elasticity to exchange rates in equation (8), $\gamma_1 = \frac{\partial mk_{js}}{\partial P^*_{js}}\frac{\partial P^*_{js}}{\partial e}$. A PTM coefficient equalling one, $\gamma_1 = 1$, represents local currency pricing (LCP) in the sense that export prices in CHF and mark-ups move one-to-one with exchange rates. As a consequence, a CHF appreciation erodes profit margins. ERPT into local prices (in FCU) would then be zero. More specifically, the ERPT (in local/foreign prices) is calculated as $1 - \gamma_1$, and therefore are negatively related to PTM behaviour. γ_2 corresponds to the cost-adjustment coefficient and shows how export prices change when imported input prices change. As a result, it should be clear that not accounting for the cost-effect of exchange rate movements on the prices of imported inputs may create a bias in the pass-through estimations on the export side - as also argued by Goldberg and Knetter (1997). The remaining variables affecting export prices as emphasised in equation (8) are captured by a set of fixed effects $\theta_{t,j} + \eta_s$ to account for changes in marginal costs, demand conditions at destination and product-specific differences of competitive pressure, preferences and production costs.

[13] This holds again for demand curves that are less convex than in the CES case (i.e. elasticity increases with price).

4 Data

We use quarterly and bilateral trade data based on HS 8-digit products between Q4-04 and Q3-11 taken from the Swiss Federal Customs Administration. The dataset is reduced to the 37 most important trading partners for Switzerland (including all OECD countries and the BRICS and covering more than 90% of Swiss international trade flows).

To account for the dynamics of imported input prices in our export price equation, time-varying sectoral input price indices are calculated based on supplier-specific imported input unit values at the 8-digit level.[14] These sectoral imported input price indices are then re-weighted according to the import share of each input sector in the respective export sector.[15]

More formally, these price indices are constructed as follows:

$$P^m_{t,so} = \sum_{si} \left\{ \left[\sum_{k,i} \left(\left(W^{k,i}_{si} \right)_t * \left(P_{t,k,si,i} \right) \right) \right]_{t,si} * \left(R^{si}_{so} \right) \right\}, \tag{10}$$

where t is the time period, i is the source country of imports, k is the HS 8-digit input product, si is the I-O imported input sector and so is the I-O output sector. $P_{t,k,si,i}$ is the supplier-specific import price of products in sector si at the HS 8-digit level and time t.[16] $W^{k,i}_{si}$ is the import share of product k from source country i of total imported inputs in sector si. This term is included to obtain an average import weighted imported input price for each input sector si. Ultimately, these imported input prices indices are re-weighted with R^{si}_{so}, corresponding to the share of imported inputs from sector si in output/export sector so. A limiting feature of our data is that these I-O weights, R^{si}_{so}, do not vary over time, and thus are assumed to remain constant across the whole study period. Thus, $P^m_{t,so}$ is the average imported intermediate input price faced by each (output) sector so in each period t.[17]

On the import side (Table 1), the dependent variable is constructed as the first-difference of log imported input unit values ($P_{t,k,si,i}$ in the formula above). The main independent

[14] The classification of inputs (or intermediates) used in this paper is available at: http://wits.worldbank.org/wits/data_details.html

[15] The respective shares are calculated from the 2001 I-O table for Switzerland. The sector classification used to calculate the indices corresponds to those used in Swiss I-O tables. Each I-O table sector consists of one up to five 2-digit ISIC product groups.

[16] These product prices correspond to unit values; that is, the total import value of a specific product is divided by the total weight in kg.

[17] In Figure 1 these price indices are set to 100 for January 2005 and correspond to averages over the previous 12 months.

variable is constructed as the first-difference of log nominal exchange rates. Similarly, on the export side (Table 2), the dependent variable corresponds to the first-difference of log export product unit values (CHF/kg) and the exchange rate variable is constructed in the same way as on the import side. The additional control on the export side is the first-difference of log indices of sectoral imported input unit values that are faced by exporters in each sector ($P^m_{t,so}$ in the formula above). Thus, the variables of interest, being the first-differences of logs, correspond to growth rates of the underlying level variables. The dependent variables in both datasets are on average (almost) zero in each sector. The growth rates of exchange rates have naturally no variation across sectors and are also zero on average. The price indices of imported inputs are weighted averages at the sectoral level (that is, they vary only across time and not across products within sectors). Average growth rates of these indices are more heterogeneous across sectors than the other variables, for e.g. -2% for Chemicals & pharmaceuticals, +6 % in the Iron & steels sector. The standard deviation and the minimum and maximum bounds are however lower compared to those of the dependent variables in both datasets.

<Insert Tables 1 and 2 here>

Prima facie, our data suggest that Swiss industries practised considerable "natural hedging". The first column of Table 3 shows ratios of imported inputs relative to the sum of total inputs and total compensation to employees (or total production costs) while the second column shows ratios of imported inputs relative to total inputs. Data and the sector classification are taken from the 2001 input-output table (I-O table) for Switzerland published by the OECD. As Table 3 highlights, imported inputs make up more than 10 % of total production costs in all Swiss sectors and are particularly high in some manufacturing sectors (e.g. Textiles 27 %, or Electrical machinery 25 %). By construction, these figures are even higher when looking at the simple ratios of imported relative to total intermediate inputs (e.g. Textiles 38 %, or Electrical machinery 31 %).

<Insert Table 3 here>

"Natural hedging" is only an effective tool to lower exchange rate risks if imported input prices react to exchange rate fluctuations. To gain more insight into the price and exchange rate developments, we plot the constructed indices of imported input prices faced by Swiss industries against the nominal effective exchange rate index (calculated by the Bank of International Settlement) over January 2005-September 2011 (see Figure 1). As energy prices are likely to make up a significant amount of production costs, imported input prices faced by Swiss industries are likely to be correlated with energy prices. To visualise this relationship, Figure 1 also includes a line for a crude oil price index (calculated as the simple average of three spot crude oil prices in CHF; Dated Brent, West Texas Intermediate, and the Dubai Fateh). All indices are set to 100 in January 2005. To eliminate seasonal fluctuations, all reported figures correspond to averages of the last 12 months (e.g. the oil price index for March 2005 corresponds to the average oil price index between April 2004 and March 2005).

<Insert Figure 1 here>

Figure 1 is divided into three panels (1-3). Each panel looks at imported input price developments for sectors facing a similar pattern. The time axis is roughly divided into five phases: boom, commodity crisis, economic crisis, economic recovery, strong Franc. Panel 1 sectors import intermediates with the least price fluctuations and are at first sight the least responsive to oil price shocks, in particular from January 2008 to May 2009. During the commodity crisis, imported input prices even decreased slightly while crude oil prices almost doubled. Panel 2 and Panel 3 sectors clearly show the expected positive relationship between oil prices and imported input prices. Panel 3 sector prices are relatively more volatile (in both directions) than Panel 2 sectors. For some Panel 3 sectors (e.g. Iron & steel) imported input prices increased by a factor of four between January 2005 and September 2008, which is a considerably larger price hike compared to the oil shock during the same period.

Figure 1 also shows that the nominal effective exchange rate index is relatively stable from January 2005 to January 2009, and is followed by a steady appreciation of the CHF over 2009 and a sharp appreciation in 2010 and 2011. Interestingly, during 2009 input prices show a decline during the period of steady CHF appreciation but a rise in the "strong" CHF phase up until May 2011; this suggests that these prices were more correlated with oil prices during this period (with approximately a six month lag). It was only after May 2011 that the price decreasing impulse of the strong Franc seemed to overcompensate for the price increasing tendencies of the oil price hike, thereby providing preliminary evidence for the role of "natural hedging" in lowering exchange rate risks. Thus, in the course of continued CHF appreciation, prices of imported inputs started to fall, which is likely to have decreased the exposure of Swiss exporters to the adverse exchange rate.

5 Empirical strategy and econometric issues

Our theoretical derivations in Section 3 directly lead to estimations in first differences in line with equations (6) and (9). To emphasise the need for estimations in first differences not only from a theoretical but also from an econometric point of view, we performed panel unit root tests on our import and export price as well as exchange rate series. Taking account of cross-sectional dependence (particularly important in our exchange rate series) and seasonalities (particularly important in our price series), we could not decisively reject the null of unit roots and thus the non-stationarity of our time series[18]. The results from these tests thus provide a further justification for an estimation in first-differences.

5.1 ERPT into imported input prices

The empirical equation (6) for ERPT into imported input prices is estimated for each I-O input sector si separately. The HS 8-digit input product dimension k and partner country dimension i are introduced and lagged exchange rate terms are added to allow for the possibility of gradual adjustment of these prices. Thus, we estimate regressions based on bilateral import data at the HS 8-digit level and the estimated parameters are pooled at the I-O input sector level si, as follows:

$$dp^{m}_{t,i,k} = \theta_{p,i} + \lambda_{hs6} + \sum_{t=0}^{-2}(\beta_t * de_{t,i}) + u_{t,i,k}. \tag{11}$$

where the index si is omitted, d is the first-difference operator, t is the time component defined as one quarter, p is time phase including four quarters (Q4 of one year to Q3 of the next year), i is the foreign supplier and k refers to the intermediate product. Notations are consistent with those used in Section 3, where lower case letters designate logarithms. The average short-run relationship between exchange rates and the imported input prices in each si is given by the estimated coefficient β_0. The long-run elasticity is given by the sum of the coefficients on the contemporaneous exchange rate and two lags of exchange rate terms $\sum_{t=0}^{-2}\beta_t$.[19]

Finally, the set of fixed effects $\theta_{p,i} + \lambda_{hs6}$ capture all other factors affecting intermediate input prices. In particular, $\theta_{p,i}$ capture aggregate changes in production costs (including

[18] These results are available upon request.

[19] Variable deletion F-tests confirmed that high sectoral long-run pass-through rates are mostly achieved within three quarters. In the benchmark specifications, we thus only used two lags for the long-run analysis.

commodity price changes) in source country i as well as the evolution of demand conditions in the importing country, Switzerland.[20] It is therefore assumed that the time- and supplier-varying fixed effects are homogeneous across all $hs8$ products of a given si sector, so that the k dimension can be neglected. Marginal costs and demand conditions are difficult to measure - especially at the product level. As a remedy, other researchers have used aggregate measures such as consumer-price- , producer-price- or labour-cost-indices as marginal cost proxies and GDP as proxies for demand conditions (see for example Campa and Goldberg, 2005 or Auer and Chaney, 2009). Given that our data includes the product dimension, we add fixed effects for each HS 6-digit product group, λ_{hs6}, to control for time and supplier invariant determinants of price adjustments within a $hs6$ product group.

In order to see to what extent I-O output sectors so face imported input price adjustments when exchange rates change, the estimated short- and long-run ERPT effects on imported input prices have to be re-weighted according to each si's share of each so's total imported inputs. These shares are calculated from the I-O table 2001 for Switzerland and are denoted as R_{so}^{si}, where $\sum_{si}\left[R_{so}^{si}\right] = R_{so}$. Average short-run ERPT effects on imported input prices per I-O output sector so are thus given as follows:[21]

$$\beta_0^{so} = \sum_{si}\left[R_{so}^{si} * \beta_0^{si}\right]; \tag{12}$$

and the long-run effects as follows:

$$\sum_{t=0}^{-2}\beta_t^{so} = \sum_{si}\left[R_{so}^{si} * \sum_{t=0}^{-2}\beta_t^{si}\right]. \tag{13}$$

After estimating (11), we calculated the standard errors of the linear combinations (12) and (13) that take into account the variance-covariance structure of the estimated coefficients β_t^{si}.

[20] The time component is pooled to phase p including four quarters. Each phase corresponds to a time period in which crude oil prices have on average either hiked, remained relatively constant or decreased during the 12 previous months (see Section 4 and Figure 1). Thus, the underlying assumption is that marginal costs of inputs, which are captured by the fixed effects and are likely to be driven by energy prices or crude oil prices, have changed in each of these phases but remained constant within a phase.

[21] As I-O tables are not updated each period, it is assumed that the import structure per so is not varying over time, which is a necessary but restrictive limitation of our analysis. Comparisons of Swiss I-0 tables between 2001 through 2008 show that the import content of outputs in fact remains relatively stable over time.

5.2 ERPT into export prices

Our export regressions estimate ERPT on export prices in line with our theoretical considerations and equation (9). Similar to the estimation strategy on the import side, first-difference equations, based on bilateral export data at the HS8-digit level with lagged exchange rate terms to allow for the possibility of gradual adjustment of export prices, are estimated separately for each I-O output sector level so, as follows:

$$dp^e_{t,j,f} = \theta_{p,j} + \lambda_{hs6} + \sum_{t=0}^{-2}(\gamma_{1,t} * de_{t,j}) + \sum_{t=0}^{-2}(\gamma_{2,t} * dp^m_t) + v_{t,j,f}, \tag{14}$$

where index j stands for export destination, f for export product at the $hs8$ level and so is omitted[22]. Letters or expressions already used in equation (9) have the same interpretation; lower case letters still designate logarithms. The fixed effects $\theta_{p,j}$ control for phase and destination dependent demand shifts, for instance, due to changes in general economic conditions. As in the import side equation (11), these fixed effects absorb all relative cost and demand changes between Switzerland and one specific destination country.[23] Fixed effects λ_{hs6} capture variations in domestic marginal costs for different export products at the *hs6*-level.

Short-run total exchange rate pass-through, TPT, (on foreign currency export prices) per so is in line with our theoretical framework defined as:

$$1 - \left[\gamma^{so}_{1,0} + \gamma^{so}_{2,0}\right]; \tag{15}$$

and for the long-run it is defined as:

$$1 - \left[\sum_{t=0}^{-2}\left[\gamma^{so}_{1,t} + \gamma^{so}_{2,t}\right]\right], \tag{16}$$

where the first terms within the brackets in (15) and (16) correspond to mark-up adjustments due to exchange rate changes, or PTM effects. The second terms show the exchange

[22]Note that $f = k$ if the input k is exported by Swiss exporters and $j = i$ if source country i is also a destination country for Swiss exports.

[23]As an example, if domestic sourcing becomes more expensive for whatever reason (e.g. domestic agricultural intermediates get more expensive for the food sector), this changes the relative demand and cost conditions for Swiss exporters vs. foreign producers and are hence captured by the $\theta_{p,j}$ dummies. In robustness checks, we also estimated models with *(non-time varying) destination country dummies* but *time-varying product dummies* instead. The ERPT coefficients turned out to be similar.

rate driven cost-adjustment effects through imported inputs, CAE.[24]

6 Results

Table 4 presents sectoral ERPT coefficients for imported input prices. The first two columns display average short- and long-run elasticities in each input sector, while the last two columns report the responses of imported input prices faced by each output/export sector. The latter figures are calculated as weighted averages of pass-through coefficients across input sectors according to their import weight in a respective output sector. The weights are taken from Swiss 2001 I-O-tables (see equation 12 and 13). To account for possible auto-correlation in the errors within trading partner countries, we report robust-clustered standard errors using the partner country as the clustering unit because nominal exchange rates are country-pair-specific and not product-specific.[25] This strategy is followed in all regressions reported in this paper.

<Insert Table 4 here>

Looking first at the results in column 1 and 2, while we find evidence of full pass-through in the majority of sectors, contrary to assumptions made in the recent empirical literature, we do not find evidence of full pass-through for all sectors (either in the short- or long-run). There is some sectoral heterogeneity in the short-run, but the estimated long-run coefficients are not statistically significantly different from one in 8 out of 14 sectors and above one in 2 sectors.[26] With regard to imported input prices faced by each output sector in the

[24]It should be noted that the theoretically derived CAE term is defined as follows: $\gamma_{2,t}^{so} * \beta_t^{so}$. These beta and gamma coefficients are however estimated in two different samples, the imported input price sample and the export price sample. As a result, obtaining the appropriate standard errors for these estimates (i.e. the product of the estimates) is a non-trivial task and cannot be accomplished with conventional bootstrapping methods. One possible remedy is to construct firstly all variables needed for the import regression within the export price sample, which does however substantially reduce variation in the data. Secondly, the new import regression and the export regression is estimated through seemingly unrelated equations (SUR) in order to apply new post-estimation simulations to calculate non-linear combinations and their standard errors. We estimated such models and came to the same conclusions as with the simpler and straightforward approach described in the main text. Not least, estimates from the two alternatives do not substantially differ as the $\gamma_{2,t}^{so}$ coefficients are not significantly different from zero for most sectors and/or the magnitude is close to zero. The combined effects $\gamma_{2,t}^{so} * \beta_t^{so}$ are thus also close to zero. We are grateful to Giovanni Mellace for important suggestions on these issues.

[25]Unless the pricing of products differs greatly in terms of which currency it is denominated in, partner country is the preferred clustering unit. However, our results are robust to estimations using (partner country)*(hs8-product) as the clustering unit. These results are available upon request.

[26]Iron & steel and Fabricated metal products.

third and fourth column, the picture remains unchanged with complete pass-through or exchange rate amplification (coefficients above one) being the appropriate characterisation of the input price reactions to exchange rate movements, especially in the long-run.[27] With regard to the marginal cost channel, these high pass-through rates imply a substantial input cost sensitivity to exchange rate changes, which is a precondition for being a valid explanation for incomplete ERPT.

The magnitudes of the pass-through coefficients into imported input prices may be surprisingly high, but they are in line with the existing evidence of high pass-through into Swiss import prices. For instance, Campa and Goldberg (2005) estimate a long-run pass-through rate of 0.94, which is not significantly different from one, for the Swiss manufacturing sector as a whole. Gaulier et al. (2008) estimate ERPT for each HS 4-digit product line separately and obtain an average ERPT of 0.7 for Switzerland. Only about 30 % of their estimated pass-through coefficients are statistically different from one. For countries in the euro area, Campa and Gonzalez Minguez (2006) conclude that industry-specific pass-through rates into import prices are on the order of 0.8 and that many industries within a country reach full pass-through after only four months. Furthermore, Campa and Gonzalez Minguez (2006) show that pass-through into producer price indices is more than double the size of transmission into consumer prices suggesting higher pass-through into imported input goods compared to consumer goods. However, our results somewhat contradict the study conducted by the State Secretariat for Economic Affairs (Seco, 2011) that estimated fairly low average ERPT into Swiss import price indices of 0.4 after three to four quarters.[28]

How can this high pass-through rate at the upper bound of prior estimates be explained? It is important to bear in mind that we only included input (intermediate) goods in the import regressions, while studies employing more aggregate price indices are likely to be biased towards consumer goods. In line with equation 5 in Section 3, high ERPT can be explained by an input demand elasticity that changes little with local prices (in CHF). This is reasonable for highly customised input goods tailored to specific needs of firms.

Recent theoretical advances complement the imperfect competition model of mark-up pricing from Section 3 with distribution costs in the local market in order to explain ERPT (see for example, Corsetti and Dedola, 2005 in a general-equilibrium framework or in Berman et al., 2012 in a Melitz-type model). According to Goldberg and Campa (2010) and Berman et al. (2012), 30-60 % of local consumer goods prices are made up by distribution costs as opposed to a much lower distribution cost share for intermediate goods. This is

[27]For instance, a coefficient of 1.45 for the Textiles sector in the long-run (column 4 of Table 4) indicates that foreign suppliers increase CHF prices by about 14.5 % when the CHF depreciates by 10 %.

[28]Stulz (2007) also obtains an ERPT of 0.4.

important because a lower share of distribution costs incurred in local currency lowers the incentive for pricing-to-market (PTM), and thus increases pass-through rates in all models emphasising distribution costs.[29] Our import side results support this class of models and suggest that prices of imported inputs faced by Swiss output/export industries are mainly invoiced in currencies of the foreign suppliers (PCP). As a consequence, Swiss industries highly benefit from exchange rate appreciations through cheaper imported inputs, in particular in those industries with a higher share of foreign inputs.[30] Hence, exporters can potentially benefit from "natural hedging" practices in times of currency appreciations if imported price changes are not transmitted to foreign consumers. Moreover, variable deletion F-tests confirmed that these high sectoral long-run pass-through rates are mostly achieved within three quarters.[31]

As a robustness check, we performed the same estimations adding interaction terms for each exchange rate variable with a dummy that equals one for all observations during the "strong Franc" period (Q1 2010 - Q3 2011, or since the nominal CHF/EUR exchange rate reached a level below 1.25 for the first time). This was done in order to study the pricing behaviour during this exceptional time. However, we could not find statistical evidence that the pricing strategies of foreign suppliers changed during the strong CHF period in the wake of the Eurozone crisis.

Table 5 displays the short-run PTM and pass-through coefficients as well as cost-adjustment effects due to imported input price changes on the export side. We find substantial sectoral heterogeneity indicating along the lines of Knetter (1993) that sectoral differences are important factors in explaining ERPT. The results for direct ERPT (DPT, column 4) show that 6 sectors out of 15 report partial ERPT[32], 4 sectors are characterised by full pass-through[33] and ERPT for 2 sectors is not statistically different from zero.[34] The cost-adjustment effects denoted by Indirect (CAE) in the second column of Table 5 are overwhelmingly insignificant meaning that exporters do not pass on imported input price changes to foreign consumers. Given full pass-through rates in a majority of sectors on the imported input side (see Table 4), these insignificant CAE coefficients imply that an appreciation of the exporter currency (CHF) leads to higher profit margins. This supports

[29] Previous empirical studies come to similar conclusions: Using French firm-level data, Berman et al. (2012) show that ERPT is substantially higher for intermediate goods than for consumer goods. Gaulier et al. (2006) reach the same conclusion using disaggregated trade data.

[30] see also Amiti et al. (2012) for similar findings.

[31] We also estimated equations with four lags which yielded similar results.

[32] Food & beverages, Textiles, Rubber & plastics products, Fabricated metal products, Mineral products and Electrical machinery.

[33] Paper products, Iron & steel, Machinery & equipment and Precision instruments.

[34] Wood products and Chemicals & pharmaceuticals.

the view of imported inputs as a natural means for hedging exchange rate risks.

<Insert Table 5 here>

Table 6 provides additional insights with regard to PTM and cost-adjustment behaviour at the sectoral level in the long run. Consistent with the short-run results and in line with Yang (1997), the Machinery & equipment and Precision instruments sectors are able to keep profit margins stable by passing on exchange rate shocks completely to foreign clients. Conversely, the average exporter in the Wood products, Textiles or the Food & beverages sectors engages at least partly in PTM (see column 1, Table 6), thereby stabilising local prices and absorbing some of the exchange rate movements in the mark-up.

<Insert Table 6 here>

The cost-adjustment coefficients CAE in the second column of Table 6 have no statistical significance and/or small magnitudes confirming the corresponding short-run CAE results described above. In sum, the cost-savings accrued on the inputs from the recent CHF appreciation period compensate for the partly squeezed profit margins on the export side. As with the import estimations, we also tested whether pricing behaviour on the export side differed during the "strong Franc" period and again found no convincing support for this hypothesis. Thus, our results also hold for the period of the recent CHF appreciation.

As robustness checks, we also ran export price regressions in which the constructed imported input prices were replaced with an imported input weighted exchange rate for the short- and long-run. These results, available upon request, corroborated the general finding about small or non-responsiveness of export and local prices to imported input price changes. While the magnitudes of the CAE coefficients were generally higher, these were found to be statistically insignificant except for four (mostly commodity intensive) sectors. Therefore, we can conclude that in the vast majority of the investigated goods sectors firms do not adjust export prices in response to exchange rate driven changes of production costs. As price adjustments are costly and a large bulk of the production costs is incurred in CHF (including compensation of employees, see Table 1), Swiss exporters optimally choose to absorb changes of the imported input prices in their mark-ups. Moreover, the relationship between import intensity and ERPT in these results, shown in Figure 2, also corroborates the main findings in Amiti et al. (2012): sectors that import a large share of their inputs pass on a much smaller share of the exchange rate shock to export prices.

<Insert Figure 2 here>

The negative relationship between the share of imported inputs and ERPT displayed in Figure 2 can also be easily depicted in a general model of international pricing, as done by Burstein and Gopinath (2013). Intuitively, it should be clear that the higher the share of imported inputs that are invoiced in the export currency, the less an exchange rate appreciation would really constitute a cost "shock" anymore, as also argued by Goldberg and Hellerstein (2008). As a result, sectors with higher shares of imported inputs do not require to pass on exchange rate movements in the same amount as sectors relying less on imported inputs.

Lastly, we exploit our multiple export destination data to check whether ERPT is also driven by destination-specific characteristics. Specifically, we interact the bilateral exchange rate and cost adjustment variable (CAE) with regional dummies corresponding to the Euro-zone, European non-Euro countries, the US, BRICS and the remaining OECD countries. This robustness check reveals that sectoral ERPT and export price adjustments due to input cost changes do not vary systematically across regions with the exception of the US. There are some significant differences in the US, with pass-through rates being on average lower and cost reactions being negative, which may be attributed to the US as a competitive destination market or the fact that most US import goods are invoiced in dollars (Gopinath et al., 2010). The lower ERPT in the US is already well-documented in the literature (see for example Campa and Goldberg, 2005). The negative CAE suggest that Swiss exporters may be responding to cheaper imports by sourcing higher quality inputs, allowing them to move up the value-chain and raise CHF export prices for US-destined products.

<Insert Tables 7>

7 Conclusions

This paper uses highly disaggregated trade data for Switzerland over 2004-2011 to examine at length whether Swiss exporters systematically respond to exchange rate changes by adjusting their prices. Given the high share of imported intermediates in total intermediate inputs in Swiss manufacturing, of underlying significance is the impact of exchange rate changes on the prices of these imported inputs as the latter may serve as a "natural" channel by which exporters can maintain their competitive advantage despite an appreciation of the CHF.

Our empirical results, that are impervious to various robustness checks, firstly indicate full ERPT into imported input prices in a majority of sectors.[35] On the export side, our results indicate strong sectoral ERPT heterogeneity in both the short- and long-run. Moreover, the cost-adjustment effects are found to be overwhelmingly insignificant implying that exporters do not pass on imported input price changes to foreign consumers. Together with high ERPT into imported input prices, this provides evidence for the effectiveness of natural hedging. Thus, an appreciation of the CHF leads to higher profit margins through the import channel and imported inputs act as a natural means for hedging exchange rate risks. The improved profit situation due to cheaper imported inputs partly compensates for mark-up reductions caused by incomplete ERPT when the currency appreciates. In contrast, a depreciating exchange rate makes imported inputs more expensive and these higher costs are not reflected in the export prices. As a result, natural hedging is likely to lead to a smoothing of profit margins in times of exchange rate volatility. Another contribution was to show this relationship empirically.

The evidence provided for the exchange rate sensitivity of input prices supports imported inputs as an explanation of incomplete ERPT. Without pass-through into input prices, imported inputs could not generate incomplete ERPT. In addition, our results indicate a negative relationship between sectoral import intensity and ERPT on the export side. This is consistent with previous literature. The last robustness check also suggests that, apart from the US, ERPT does not systematically differ across destinations using border prices that are arguably unaffected by local non-traded costs. Thus, export border prices available across destinations helped us to isolate the imported input channel from other destination-specific explanations of incomplete ERPT such as distribution or other non-traded costs denominated in local-currency.

The appreciation of the CHF began in 2009 and progressed steadily until the middle of 2010 after which it accelerated in response to the ensuing Eurozone crisis. During much of 2012, the Swiss National Bank (SNB) intervened to assuage Swiss exporters of the adverse effects of this appreciation. However, our final empirical result suggests that the pricing strategies of Swiss exporters may not have changed in response to the strong CHF in wake of the Eurozone crisis. Significantly, a similar result at the extensive margin would strongly question the SNB's intervention during this period.

[35] However, contrary to assumptions made in the recent empirical literature, we do not find evidence of full pass-through for all sectors either in the short- or long-run.

Future research could address the data limitations of our paper. While we could not identify changes in the pricing strategy of Swiss firms during the recent strong CHF period, such adjustment may be observed over a longer time period. We also did not directly investigate whether our results are partly driven by extensive margin adjustments, which being the case renders central bank intervention both appropriate and necessary to avoid irreversible structural damage of the exporting industry as emphasised by hysteresis theories (see for instance Baldwin and Krugman, 1989). Finally, it would be useful to extend our analysis to an enlarged country sample. To the extent that our results hold across countries and at the extensive margin, they would also have significant implications for monetary policy and for the policy debate on the impact of exchange rate misalignments on trade imbalances.

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Table 1: Descriptive statistics: Import price equation

	Dependent variable: Imported input price	Mean	Std. Dev.	Min.	Max.
1	Agriculture (3'378)	-0.00	0.62	-3.97	3.83
2	Mining & quarrying (279)	-0.02	1.51	-5.15	6.09
3	Food & beverages (17'918)	-0.00	0.60	-6.10	6.08
4	Textiles (53'111)	-0.00	0.74	-5.51	6.63
5	Wood products (4'572)	0.01	0.74	-4.52	5.41
6	Paper products (16'495)	0.00	0.78	-6.25	6.78
7	Chemicals & pharmaceuticals (104'450)	-0.00	1.19	-11.77	10.33
8	Rubber & plastics products (13'408)	-0.00	0.88	-7.36	6.75
9	Mineral products (6'895)	-0.00	1.03	-7.04	6.31
10	Iron & steel (50'285)	0.00	0.81	-8.78	8.44
11	Fabricated metal products (16'567)	0.00	0.97	-7.42	8.16
12	Machinery & equipment (2'754)	-0.01	0.99	-6.19	6.35
13	Electrical machinery (3'634)	0.00	0.99	-5.00	5.74
14	Communication equipment	..	..	..	..
15	Precision instruments (9'125)	0.01	1.09	-7.57	8.56
	Independent variable: Nominal exchange rate	Mean	Std. Dev.	Min.	Max.
	All sectors	-0.01	0.03	-0.24	0.19

Notes: Figures in parentheses correspond to the number of observations in the respective sectors; reported statistics for the nominal exchange rate variable are equal across different sectors and are therefore not reported separately; figures missing for input sector 14 as no *hs8* input product classified within sector 14.

Table 2: Descriptive statistics: Export price equation

	Dependent variable: Export product price	Mean	Std. Dev.	Min.	Max.
1	Agriculture (10'944)	0.00	0.97	-8.90	10.13
2	Mining & quarrying (9'403)	0.00	1.14	-10.95	10.83
3	Food & beverages (73'240)	0.00	0.57	-7.58	8.17
4	Textiles (185'355)	-0.00	0.84	-8.51	9.35
5	Wood products (10'457)	-0.01	0.95	7.11	8.11
6	Paper products (47'404)	-0.00	0.98	-11.42	8.80
7	Chemicals & pharmaceuticals (190'038)	0.00	0.98	-12.10	12.32
8	Rubber & plastics products (58'638)	0.00	0.90	-9.29	10.24
9	Mineral products (36'427)	-0.00	1.07	-9.93	9.82
10	Iron & steel (60'706)	0.01	0.96	-9.28	9.34
11	Fabricated metal products (133'608)	0.00	0.92	-8.74	9.14
12	Machinery & equipment (209'033)	-0.00	1.00	-10.91	11.87
13	Electrical machinery (97'780)	-0.00	0.98	-10.35	10.35
14	Communication equipment (27'876)	0.00	1.21	-11.67	12.51
15	Precision instruments (103'826)	0.00	0.93	-8.43	9.64

Notes: Figures in parentheses correspond to the number of observations in the respective sectors.

Table 3: Share of imported inputs of total production costs in Switzerland by sector

		(Imported inputs) / (Total inputs + Compensation of employees)	(Imported inputs) / (Total inputs)
1	Agriculture	0.18	0.22
2	Mining & quarrying	0.09	0.13
3	Food & beverages	0.14	0.17
4	Textiles	0.27	0.38
5	Wood products	0.11	0.18
6	Paper products	0.14	0.21
7	Chemicals & pharmaceuticals	0.24	0.29
8	Rubber & plastics products	0.19	0.27
9	Mineral products	0.18	0.27
10	Iron & steel	0.25	0.35
11	Fabricated metal products	0.21	0.35
12	Machinery & equipment	0.17	0.25
13	Electrical machinery	0.25	0.31
14	Communication equipment	0.21	0.32
15	Precision instruments	0.16	0.22

Source: OECD

Table 4: ERPT into imported input prices (in CHF)

		By input sector		By output sector*	
		Short-run	Long-run	Short-run	Long-run
1	Agriculture	0.49	0.71	$0.50^{a/b}$	1.34^{a}
		(0.35)	(0.63)	(0.20)	(0.51)
2	Mining & quarrying	2.78	6.54	1.09	3.09^{a}
		(3.78)	(4.04)	(1.05)	(1.21)
3	Food & beverages	0.72^{a}	1.51^{a}	0.61^{a}	1.18^{a}
		(0.24)	(0.49)	(0.20)	(0.43)
4	Textiles	0.79^{a}	1.33^{a}	$0.71^{a/b}$	1.45^{a}
		(0.12)	(0.32)	(0.12)	(0.38)
5	Wood products	1.13^{a}	1.71^{a}	0.97^{a}	1.79^{a}
		(0.20)	(0.37)	(0.15)	(0.40)
6	Paper products	$0.58^{a/b}$	1.37^{a}	$0.61^{a/b}$	1.60^{a}
		(0.11)	(0.38)	(0.15)	(0.41)
7	Chemicals & pharmaceuticals	0.18^{b}	1.79^{a}	0.75	$2.65^{a/b}$
		(0.45)	(0.81)	(0.72)	(0.90)
8	Rubber & plastics products	$0.72^{a/b}$	1.56^{a}	0.34^{b}	1.81^{a}
		(0.11)	(0.32)	(0.33)	(0.68)
9	Mineral products	0.86^{a}	1.62^{a}	1.46	3.48^{a}
		(0.326)	(0.38)	(1.36)	(1.48)
10	Iron & steel	1.12^{a}	$2.32^{a/b}$	1.18^{a}	$2.65^{a/b}$
		(0.28)	(0.57)	(0.43)	(0.63)
11	Fabricated metal products	$0.73^{a/b}$	$1.99^{a/b}$	1.03^{a}	$2.27^{a/b}$
		(0.12)	(0.45)	(0.22)	(0.52)
12	Machinery & equipment	0.55	1.85	0.68^{a}	$1.88^{a/b}$
		(0.98)	(1.13)	(0.30)	(0.41)
13	Electrical machinery	0.30	1.59^{a}	0.61^{a}	$1.84^{a/b}$
		(0.49)	(0.44)	(0.24)	(0.32)
14	Communication equipment	..	..	0.73^{a}	$1.89^{a/b}$
		..	..	(0.15)	(0.39)
15	Precision instruments	0.88^{a}	0.92	0.85^{a}	1.76^{a}
		(0.38)	(0.87)	(0.13)	(0.39)

Notes: *Weighted average ERPT faced by each output sector [weights from I-O table]; by input sector: short-run = β_0^{si}, long-run = $\sum_{t=0}^{-2} \beta_t^{si}$; by output sector: short-run = β_0^{so}, long-run = $\sum_{t=0}^{-2} \beta_t^{so}$; $^{a/b}$H0 of zero/full pass-through rejected at the 95%-level; estimated with WLS [weight = import value], robust-clustered standard errors in parentheses [cluster unit = source country]; phase-source varying fixed effects as well as *hs*6 varying fixed effects; coefficients missing for input sector 14 as no *hs8* input product classified within sector 14.

Table 5: ERPT into export prices (in CHF and in foreign currency units, FCU) - short-run

		In CHF			In FCU	
		Direct (PTM)	Indirect (CAE)	Total (1-TPT)	Direct (DPT)	Total (TPT)
1	Agriculture	0.59	-0.00^{b}	0.59	0.41	0.41
		(0.67)	(0.02)	(0.68)	(0.67)	(0.68)
2	Mining & quarrying	0.70	-0.01^{b}	0.69	0.30	0.31
		(0.47)	(0.01)	(0.47)	(0.47)	(0.47)
3	Food & beverages	0.33$^{a/b}$	-0.01$^{a/b}$	0.32$^{a/b}$	0.67$^{a/b}$	0.68$^{a/b}$
		(0.12)	(0.00)	(0.12)	(0.12)	(0.12)
4	Textiles	0.62$^{a/b}$	0.02$^{a/b}$	0.65^{a}	0.38$^{a/b}$	0.35^{b}
		(0.18)	(0.01)	(0.18)	(0.18)	(0.18)
5	Wood products	1.08^{a}	-0.00^{b}	1.08^{a}	-0.08^{b}	-0.08^{b}
		(0.34)	(0.01)	(0.35)	(0.33)	(0.35)
6	Paper products	0.18^{b}	0.01^{b}	0.19^{b}	0.82^{a}	0.81^{a}
		(0.22)	(0.01)	(0.22)	(0.22)	(0.23)
7	Chemicals & pharmaceuticals	0.69^{a}	-0.02^{b}	0.67^{a}	0.31^{b}	0.33^{b}
		(0.32)	(0.03)	(0.30)	(0.32)	(0.30)
8	Rubber & plastics products	0.44$^{a/b}$	0.00^{b}	0.44$^{a/b}$	0.56$^{a/b}$	0.56$^{a/b}$
		(0.10)	(0.00)	(0.10)	(0.10)	(0.10)
9	Mineral products	0.52$^{a/b}$	-0.02^{b}	0.49$^{a/b}$	0.48$^{a/b}$	0.51$^{a/b}$
		(0.21)	(0.01)	(0.22)	(0.21)	(0.22)
10	Iron & steel	-0.14^{b}	-0.03$^{a/b}$	-0.17	1.14^{a}	1.17
		(0.49)	(0.01)	(0.49)	(0.49)	(0.419)
11	Fabricated metal products	0.30$^{a/b}$	-0.01^{b}	0.29$^{a/b}$	0.70$^{a/b}$	0.71$^{a/b}$
		(0.12)	(0.00)	(0.12)	(0.12)	(0.12)
12	Machinery & equipment	0.27^{b}	-0.00^{b}	0.26^{b}	0.73^{a}	0.74^{a}
		(0.22)	(0.01)	(0.22)	(0.22)	(0.22)
13	Electrical machinery	0.62$^{a/b}$	-0.02^{b}	0.60$^{a/b}$	0.38$^{a/b}$	0.40$^{a/b}$
		(0.16)	(0.02)	(0.17)	(0.16)	(0.16)
14	Communication equipment	0.73	-0.03^{b}	0.70	0.27	0.30
		(0.40)	(0.02)	(0.40)	(0.40)	(0.40)
15	Precision instruments	0.16^{b}	-0.00^{b}	0.16^{b}	0.84^{a}	0.84^{a}
		(0.19)	(0.01)	(0.20)	(0.19)	(0.20)

Notes: PTM (pricing to market coefficient) = $\gamma^{so}_{1,0}$, CAE (cost-adjustment effect) = $\gamma^{so}_{2,0}$, 1-TPT = $\gamma^{so}_{1,0} + \gamma^{so}_{2,0}$, DPT = $1 - \gamma^{so}_{1,0}$, TPT (total pass-through coefficient) = $1 - (\gamma^{so}_{1,0} + \gamma^{so}_{2,0})$; both CHF (columns 1-3) and FCU (columns 4-5) price elasticities are reported as CAEs (cost-adjustment effects) are more intuitive from the local currency (here CHF) perspective, whereas ERPT discussions are generally done from a FCU perspective; $^{a/b}$H0 of zero/one PTM, CAE or pass-through (DPT and TPT) rejected at the 95%-level, respectively; estimated with weighted least squares [weight = import value], robust-clustered standard errors in parentheses [cluster unit = partner country]; phase-source varying fixed effects as well as *hs6* varying fixed effects.

Table 6: ERPT into export prices (in CHF and in foreign currency units, FCU) - long-run

		In CHF			In FCU	
		Direct (PTM)	Indirect (CAE)	Total (1-TPT)	Direct (DPT)	Total (TPT)
1	Agriculture	0.31	-0.05^{b}	0.26	0.69	0.74
		(0.83)	(0.06)	(0.85)	(0.83)	(0.85)
2	Mining & quarrying	0.99	-0.14$^{a/b}$	0.85	0.01	0.15
		(0.75)	(0.04)	(0.78)	(0.75)	(0.78)
3	Food & beverages	0.35^{b}	-0.02$^{a/b}$	0.33^{b}	0.65^{a}	0.67^{a}
		(0.19)	(0.01)	(0.19)	(0.19)	(0.12)
4	Textiles	0.71^{a}	0.05$^{a/b}$	0.76^{a}	0.29^{b}	0.24^{b}
		(0.23)	(0.01)	(0.23)	(0.23)	(0.23)
5	Wood products	1.40^{a}	0.01^{b}	1.41^{a}	-0.40^{b}	-0.41^{b}
		(0.41)	(0.03)	(0.43)	(0.41)	(0.43)
6	Paper products	0.33	0.04^{b}	0.37	0.67	0.63
		(0.44)	(0.03)	(0.46)	(0.44)	(0.46)
7	Chemicals & pharmaceuticals	0.49	-0.09^{b}	0.40	0.51	0.60
		(0.58)	(0.07)	(0.53)	(0.58)	(0.53)
8	Rubber & plastics products	0.85^{a}	-0.02^{b}	0.83^{a}	0.15^{b}	0.17^{b}
		(0.32)	(0.01)	(0.33)	(0.31)	(0.33)
9	Mineral products	0.55	-0.01^{b}	0.53	0.45	0.47
		(0.37)	(0.03)	(0.39)	(0.37)	(0.39)
10	Iron & steel	0.47	-0.04^{b}	0.43	0.53	0.57
		(0.63)	(0.02)	(0.63)	(0.63)	(0.63)
11	Fabricated metal products	0.55$^{a/b}$	-0.03^{b}	0.52$^{a/b}$	0.45$^{a/b}$	0.49$^{a/b}$
		(0.16)	(0.02)	(0.16)	(0.16)	(0.16)
12	Machinery & equipment	-0.04^{b}	0.01^{b}	-0.02^{b}	1.04^{a}	1.02^{a}
		(0.34)	(0.03)	(0.34)	(0.34)	(0.34)
13	Electrical machinery	0.94^{a}	-0.07^{b}	0.87^{a}	0.06^{b}	0.13^{b}
		(0.38)	(0.05)	(0.35)	(0.38)	(0.35)
14	Communication equipment	0.73	0.01^{b}	0.74	0.27	0.26
		(0.73)	(0.05)	(0.73)	(0.73)	(0.73)
15	Precision instruments	-0.09^{b}	-0.00^{b}	-0.09^{b}	1.09^{a}	1.09^{a}
		(0.29)	(0.02)	(0.30)	(0.29)	(0.30)

Notes: PTM (pricing to market coefficient) $=\sum_{t=0}^{-2}\gamma_{1,t}^{so}$, CAE (cost-adjustment effect) = $\sum_{t=0}^{-2}\gamma_{2,t}^{so}$, 1-TPT = $\sum_{t=0}^{-2}\left(\gamma_{1,t}^{so}+\gamma_{2,t}^{so}\right)$, DPT = $1-\sum_{t=0}^{-2}\gamma_{1,t}^{so}$, TPT (total pass-through coefficient) = $1-\sum_{t=0}^{-2}\left(\gamma_{1,t}^{so}+\gamma_{2,t}^{so}\right)$; both CHF (columns 1-3) and FCU (columns 4-5) price elasticities are reported as CAEs (cost-adjustment effects) are more intuitive from the local currency (here CHF) perspective, whereas ERPT discussions are generally done from a FCU perspective;$^{a/b}$H0 of zero/one PTM, CAE or pass-through (DPT and TPT) rejected at the 95%-level, respectively; estimated with weighted least squares [weight = import value], robust-clustered standard errors in parentheses [cluster unit = partner country]; phase-source varying fixed effects as well as *hs6* varying fixed effects.

Table 7: Sensitivity analysis by region - long-run

Sector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
EU PTM	0.555	4.563^{a}	0.294	0.714	3.023^{a}	1.394	-0.881	2.071^{a}	2.727^{a}	2.359^{a}	0.526	-0.296	1.851	2.203	-1.822
	(1.236)	(1.492)	(0.425)	(0.442)	(0.857)	(0.881)	(1.721)	(0.353)	(0.790)	(0.608)	(0.272)	(1.258)	(1.052)	(2.058)	(1.223)
Rest of EU/EFTA PTM	0.495	1.241	0.447	0.465	2.591^{a}	-0.114	0.756	0.898	-0.399	-2.932^{a}	1.364^{a}	-0.767	0.403	2.363	0.477
	(1.346)	(0.969)	(0.444)	(0.555)	(0.487)	(1.113)	(1.841)	(0.760)	(0.841)	(0.604)	(0.576)	(0.909)	(0.758)	(3.196)	(1.226)
US PTM	3.983^{a}	-1.257	1.300^{a}	1.532^{a}	6.362^{a}	-0.522	1.072	2.211^{a}	-0.133	4.734^{a}	0.078	-0.791	1.829^{a}	-0.001	0.681
	(1.257)	(1.241)	(0.426)	(0.577)	(0.593)	(1.919)	(1.716)	(0.297)	(1.244)	(0.705)	(0.321)	(1.016)	(0.900)	(2.071)	(1.266)
BRICS PTM	-0.001	-0.072	0.146	1.563^{a}	0.540	0.691	-0.531	0.024	0.373	-0.614	0.294	0.535	1.700	-1.081	-0.379
	(1.564)	(0.964)	(0.437)	(0.450)	(0.454)	(0.900)	(1.904)	(0.299)	(0.755)	(0.838)	(0.273)	(0.767)	(1.150)	(2.513)	(1.336)
Rest of OECD PTM	-2.616	1.578	0.078	0.137	0.531	-1.777	-0.396	0.121	0.666	-0.147	0.436	-0.718	0.165	0.762	0.002
	(2.334)	(1.025)	(0.899)	(0.500)	(0.461)	(1.064)	(2.003)	(0.675)	(1.024)	(1.048)	(0.648)	(0.742)	(0.762)	(2.356)	(1.255)
EU CAE	-0.0986	-0.00409	-0.0283	0.0635	0.101^{a}	0.0901	-0.236	0.00978	0.101^{a}	0.0374	-0.0410^{a}	-0.0814^{a}	-0.0963	0.186^{a}	-0.0653
	(0.124)	(0.0765)	(0.0255)	(0.0505)	(0.0463)	(0.0546)	(0.167)	(0.0111)	(0.0471)	(0.0256)	(0.0114)	(0.0184)	(0.0881)	(0.0915)	(0.0417)
Rest of EU/EFTA CAE	-0.033	-0.126	-0.028	0.002	0.038	-0.007	0.031	0.004	-0.102	-0.150	-0.009	0.074	0.113	-0.061	0.037
	(0.125)	(0.0670)	(0.0302)	(0.0216)	(0.0346)	(0.0625)	(0.158)	(0.0168)	(0.0763)	(0.0828)	(0.0315)	(0.0527)	(0.121)	(0.223)	(0.0811)
US CAE	-0.503^{a}	-0.018	-0.131^{a}	0.016	-0.606^{a}	0.159	-0.099	-0.202^{a}	0.081	-0.176^{a}	-0.025	0.170^{a}	-0.154	0.216^{a}	0.031
	(0.144)	(0.0726)	(0.0387)	(0.0136)	(0.0333)	(0.120)	(0.170)	(0.0211)	(0.0646)	(0.0359)	(0.0464)	(0.0640)	(0.157)	(0.0919)	(0.0381)
BRICS CAE	-0.074	-0.284^{a}	-0.008	0.015	-0.132^{a}	0.060	0.056	-0.033^{a}	0.148^{a}	0.031	0.029^{a}	-0.047^{a}	-0.171	-0.005	-0.088^{a}
	(0.187)	(0.0628)	(0.0525)	(0.0208)	(0.0313)	(0.0620)	(0.154)	(0.0112)	(0.0444)	(0.0269)	(0.0112)	(0.0185)	(0.112)	(0.157)	(0.0372)
Rest of OECD CAE	-0.104	-0.154^{a}	-0.003	0.038^{a}	-0.035	0.000	0.092	-0.011	-0.100	0.059	0.028	0.134	-0.036	-0.172	0.004
	(0.192)	(0.0612)	(0.0269)	(0.0135)	(0.167)	(0.0552)	(0.155)	(0.0411)	(0.0920)	(0.0389)	(0.0525)	(0.158)	(0.0883)	(0.116)	(0.0481)

Note: “a” denotes statistical significance at the 5% level

Figure 1: Development of imported input prices faced by output sectors: 2005-2011

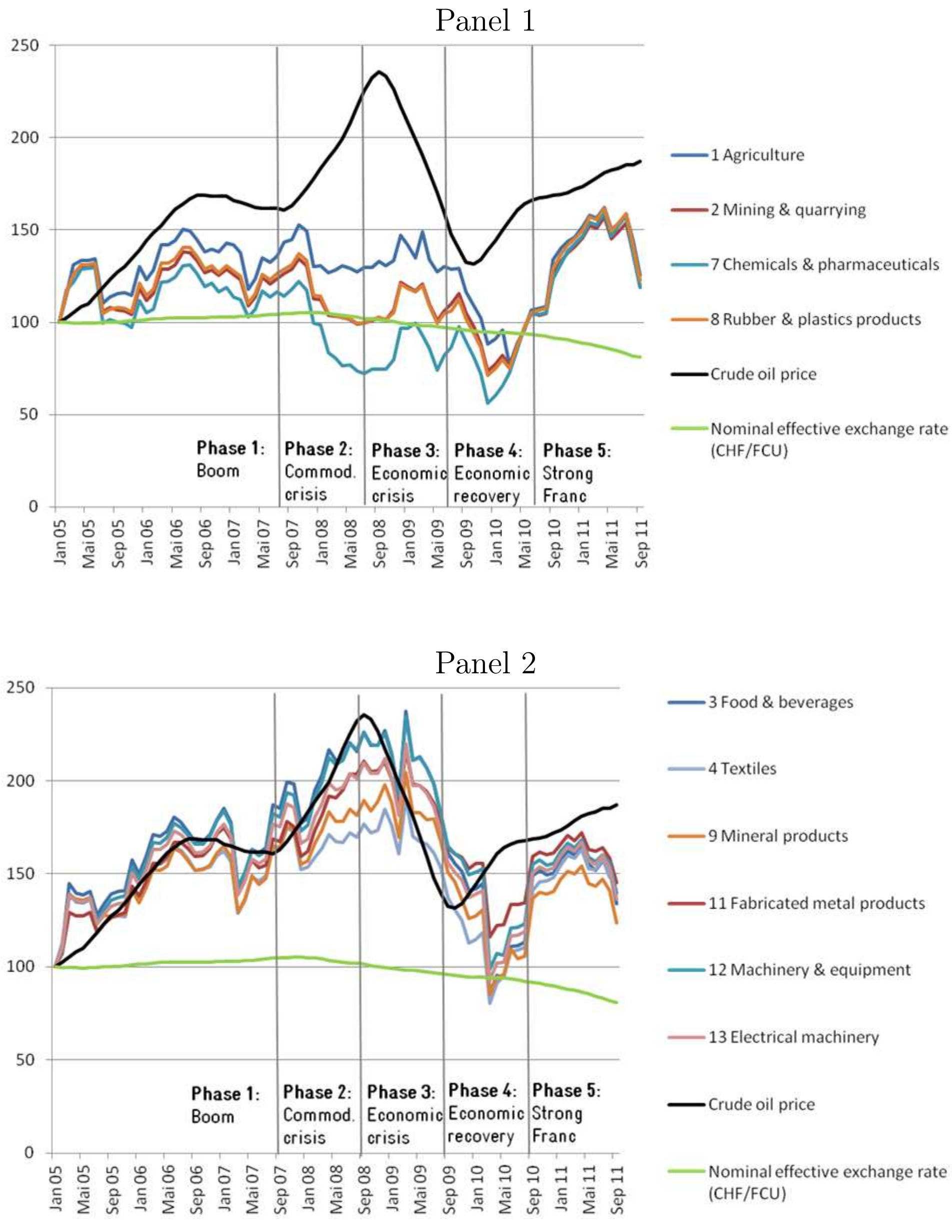
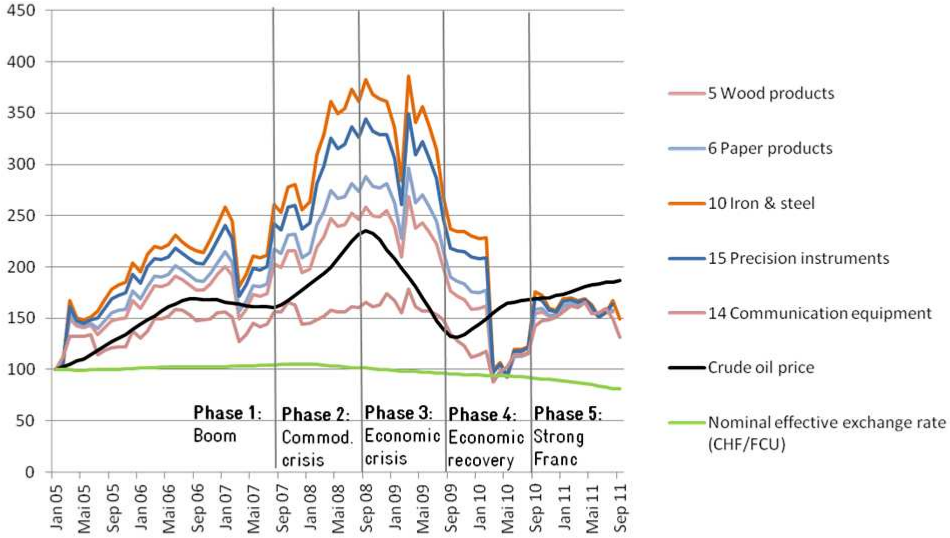


Figure 1: continued

Panel 3



Notes: Figures are averages of the last 12 months; all price indexes are based on prices in CHF; FCU denotes foreign currency units.
Source: Swiss Federal Customs Administration, Bank for International Settlements

Figure 2: Long-run sectoral ERPT is inversely related to sectoral import intensity