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Schwerpunktthema:
Die Schweiz in den globalen Wertschöpfungsketten

Study on behalf of the State Secretariat for Economic Affairs SECO

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Zusammenfassung

Für die Schweiz als kleine, offene Volkswirtschaft ist die Einbindung in globale Wertschöpfungsketten (Global Value-Added Chains, GVC) wichtig. Der Integrationsgrad der Schweiz liegt etwa im Mittelfeld der OECD und BRICS Länder (16. Platz gemäss OECD Daten), wobei der Anteil der ausländischen Wertschöpfung an den Schweizer Exporten im Jahr 2009 etwa 28% betrug (backward participation). In für die Schweiz bedeutenden Sektoren wie der chemischen, der Maschinen- und Elektronikindustrie lag der ausländische Wertschöpfungsanteil an den Exporten sogar deutlich über 30% und damit im internationalen Vergleich eher am oberen Ende. Da der Frankenkurs längerfristig eine Aufwertungstendenz aufweist und seit Beginn der jüngsten Wirtschaftskrise anhaltend hoch ist, stellt sich die Frage, ob der negative Zusammenhang zwischen Aufwertung und Exporten bei fortschreitender Integration in GVCs abgefedert wird. Theoretisch kann man davon ausgehen, dass die negativen Effekte einer Frankenaufwertung auf Profitmargen und Nachfrage in Branchen mit höherem Anteil an importierten Vorleistungen abgeschwächt werden: Ein stärkerer Franken sollte die Preise der importierten Vorleistungen senken und die Notwendigkeit von Exportpreiserhöhungen verringern. Die Folge wäre eine höhere Widerstandsfähigkeit der Exportnachfrage gegenüber Wechselkursschwankungen. Dieser Mechanismus wird als *natural hedging* bezeichnet.

In der nachfolgenden Studie untersuchen wir die folgenden Fragestellungen. In welchem Ausmass beeinflussen Wechselkursschwankungen die Exporte (intensive margin) sowie die Wahrscheinlichkeit, dass eine Firma überhaupt exportiert oder dass ein Produkt exportiert wird (extensive margin)? Hängt dies von der Integration in GVCs ab? Besteht die Gefahr, dass temporäre Wechselkurseffekte permanente Auswirkungen auf die Exporte haben können (Exporthysterese)? Diese Fragestellungen werden mit zwei ergänzenden Datensätzen mittels einer Regressionsanalyse untersucht. Einerseits finden jährliche Daten auf Produktebene der Eidgenössischen Zollverwaltung zwischen 2004 und 2013 Eingang in die Analyse. Zusätzlich verwenden wir firmenbezogene Daten aus dem Innovationspanel der KOF, die für 7 verschiedene Zeitperioden zwischen 1996 und 2013 zur Verfügung stehen.

Die mit den beiden Datensätzen erhaltenen Resultate sind qualitativ ähnlich. Mit den Produktdaten wird der negative Effekt einer Aufwertung auf die Exporte auf etwa -0.7 geschätzt. Auch reduziert diese die Wahrscheinlichkeit, dass ein Produkt exportiert wird um etwa 0.75 bis 1 Prozentpunkte. Wir untersuchen dann den Einfluss der importierten Vorleistungen auf den Wechselkurseffekt, der natural hedging mitberücksichtigt. Die Analyse zeigte auf, dass eine 10%-Aufwertung des mit den importierten Vorleistungen gewichteten Wechselkurses die Ex-

portwahrscheinlichkeit um etwas mehr als einen Prozentpunkt erhöht und den nachteiligen direkten Wechselkurseffekt wieder kompensiert. Allerdings kann kein kompensierender Effekt des importgewichteten Wechselkurses auf die Exporte nachgewiesen werden. In weiteren Schätzungen verwenden wir das Verhältnis zwischen importierten Vorleistungen aus einem Exportland und Gesamtimporten als Approximation für die natürliche Absicherung von Wechselkursrisiken innerhalb einer Branche. Diese Schätzungen zeigen auf, dass sich die negativen Aufwertungseffekte auf die Exporte und die Exportwahrscheinlichkeit mit steigendem Anteil an importierten Vorleistungen aus dem Exportland signifikant reduzieren.

Die Analyse auf Basis einer Stichprobe aus Industriefirmen ergibt qualitativ ähnliche Ergebnisse. Ein Zuwachs des Wechselkursindex um 1% reduziert das Exportvolumen demnach um 0.3%. Wird der internationale Verflechtungsgrad der Firma - approximiert durch den Gesamtanteil der Vorleistungen am Umsatz - berücksichtigt, zeigt sich, dass dieser Effekt mit zunehmendem Vorleistungsanteil an Stärke verliert. Dasselbe qualitative Muster trifft für die Exportwahrscheinlichkeit zu. Jedoch ist der Exportstatus in der ersten Beobachtungsperiode die bedeutendste Determinante der Exportwahrscheinlichkeit. Dies spricht für die Existenz von erheblichen Markteintrittskosten und impliziert, dass die aufgrund der Frankenaufwertung nicht mehr exportierenden Firmen eine vergleichsweise überproportionale Abwertung benötigen, um wieder profitabel exportieren zu können. Es besteht also die Möglichkeit, dass temporäre Wechselkursschwankungen permanente Auswirkungen auf die Exportstruktur der Schweiz haben (*Exporthysterese*).

Die mit beiden Datensätzen gewonnenen Resultate offenbaren insgesamt ein bedeutendes Ausmass an natural hedging von Wechselkursschwankungen. Dies gilt sowohl für die Exporte als auch für die Exportwahrscheinlichkeit. Eine Betrachtung der Integration in GVCs nach Branchen lässt grobe Rückschlüsse auf die Branchenexposition zu. Gemäss OECD verzeichnen wichtige Exportsektoren wie die Chemie- oder die Maschinenindustrie hohe ausländische Wertschöpfungsanteile an den Exporten von 42% (Chemie) und 33% (Maschinen) und dürften die jüngste Frankenaufwertung somit am ehesten abfedern können. Demgegenüber dürften die Nahrungsmittel- und die Papierindustrie (24%) stärker exponiert sein. Insgesamt implizieren unsere Resultate, dass Firmen und Branchen mit höherem internationalem Integrationsgrad weniger von den negativen Effekten einer Frankenaufwertung betroffen sind.

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1 Introduction

The sharp appreciation of the Swiss Franc and its ongoing strength despite the currency cap that the Swiss National Bank has put on the Swiss France have raised fears about negative export growth and resulting losses for Swiss exporters. From an economic perspective, a temporary currency appreciation may even have permanent adverse impact on exports. However, a high level of integration into global value chains (GVCs) could potentially mitigate these negative effects by simultaneously rendering imported intermediate inputs cheaper.

An indicator of a country's integration in GVCs is the extent to which its exports rely on the share of imported intermediate inputs in foreign value added (backward participation) and the extent to which its exports serve as inputs in value added in the exports of other countries (forward participation). Switzerland was ranked 16th in GVC participation amongst OECD and BRICS economies in the year 2009, with a higher share of backward participation (28% versus 23%, OECD 2013). This was especially true of manufacturing industries such as chemicals, machinery and electrical equipment. In fact, 35% of the final demand for manufactured goods and market services in Switzerland in 2009 represented value added created abroad, with foreign value added shares for textiles and transport equipment being close to 100%.

This significant use of intermediate inputs by Swiss manufacturing industries has implications for their economic resilience to short and long-term changes in macroeconomic fundamentals, in particular exchange rates. Thus, adverse effects on Swiss manufacturing exporters resulting from an appreciation of the Swiss Franc would be expected to be mitigated at both margins of trade by decreasing the relative prices of imported intermediate inputs, thereby reducing the need for export price increases or losses due to reduced profit margins. This would result in a higher resilience of export demand to exchange rate fluctuations. This mechanism is referred to as "natural hedging", the extent of which would depend on the extent to which exchange rate changes are transmitted to traded prices (exchange rate pass-through). The objective of this study is to examine exchange rate-driven adjustments of the Swiss manufacturing industry given the latter's pronounced reliance on the use of imported inputs. Another related objective of this study is to examine the extent to which export propensities in the current period depend on those in the preceding period to examine the "export hysteresis" hypothesis (for instance see Baldwin and Krugman, 1989).

Specifically, we examine the following research questions concerning extensive and intensive export margin adjustments to exchange rate changes:

- How do the volume/value of exports (intensive margin) and the probability of exporting

(extensive margin) react to exchange rate movements given the Swiss manufacturing industry's significant reliance on the use of imported inputs?

- To what extent does the exchange rate sensitivity of exports depend on backward participation in global value chains?
- How does export participation in a previous time period affect current export participation, given exchange rate fluctuations and backward participation?

This last question addresses the possibility of export hysteresis. If past export status has a positive effect on the export probability, then this is an indication that temporary exchange rate fluctuations can have a lasting effect on the export structure. We employ two different yet complimentary datasets to examine our research questions: HS 6-digit product-level data from the Swiss Federal Customs Administration (Eidgenössische Zollverwaltung) from 2004-2013 and firm-level data from the KOF innovation survey covering a sample of manufacturing firms in 7 different years in time beween 1996 and 2013. Our twofold approach offers the unique possibility to study heterogeneous patterns in firm reactions to exchange rate changes while providing the ability to control for a rich number of characteristics that are unobserved in aggregate data over a largely overlapping time period.

Our results find qualitative validity in both product- and firm-level analyses and are robust to the use of different estimation strategies. They suggest that an appreciation of the Swiss Franc has a negative impact on both the propensity and the value of Swiss exports, but that this negative effect is mitigated in sectors where the Swiss import share of intermediate inputs is high.

Using product-level data, the negative effect of an appreciation on exports was estimated to be about -0.7, i.e. a 1% appreciation of the Swiss Franc was associated with a 0.7% fall in exports, ceteris paribus and on average. An increase of the Franc by 1% also reduced the likelihood that the product was exported by approximately 0.075 to 0.1 percentage points. We then investigated the effect of imported inputs on the overall exchange rate effect, taking "natural hedging" into account. Our analyses revealed that a 1% appreciation of the imported-inputs-weighted exchange rate increased the probability of exporting by just over one tenth of a percentage point, thereby offsetting the adverse direct exchange rate effect. However, no compensating effect of the import-weighted exchange rate could be detected on the value of exports. In further estimates, the ratio between sectoral imported inputs from an export country and total imports was used as an approximation for the natural hedge against exchange rate risks within an industry. These estimates also showed that an increasing proportion of imported inputs from the export

country significantly reduced the negative effects of currency appreciation on both export value and export probability.

Firm-level results suggest that a 1% increase in the exchange rate index is associated with a 0.3% reduction in the volume of exports, ceteris paribus and on average. However, once the degree of international integration approximated by the overall share of intermediate inputs in sales is considered, this negative effect is found to be considerably mitigated and – with increasing intermediate input shares – even offset in various empirical specifications.

Furthermore, we find strong evidence for export hysteresis. This suggests that products that are not exported in the previous year require larger exchange rate depreciations to achieve positive export profits and to be exported in the following year than products that are already present in an export market. The previous export experience is found to be the most important determinant of export probability with the magnitude of the effect ranging from 0.10 (10 percentage points) in the product-level results to 0.38 (38 percentage points) in our firm-level results. This suggests the existence of significant entry costs and implies that companies no longer exporting due to the strong Swiss Franc require a comparatively disproportionate devaluation to export again profitably. It is therefore possible that temporary exchange rate fluctuations have permanent negative effects on the export structure of Switzerland.

To summarize, the qualitatively similar results obtained from the two data sets reveal a significant overall extent of "natural hedging" of exchange rate fluctuations. This applies both to the probability of exporting and the value of exports. Sectoral integration into GVCs is a rough indicator of a given industry's exposure. Going by our results, major Swiss export sectors such as chemicals and engineering that have high foreign share of value added in exports of 42% and 33%, respectively, are most likely to be less adversely affected by a strong Franc. In contrast, the food and paper industry (backward participation of 24%) are likely to be more exposed to the vagaries of exchange rate fluctuations. Overall, our results imply that firms and sectors with a higher degree of international integration are likely to be less affected by the negative effects of a stronger Swiss Franc.

The remainder of the study is structured as follows. We provide a brief review of relevant literature in Section 2. Section 3 outlines the theoretical framework underlying our empirical analyses. Section 4 describes the measures of natural hedging. Section 5 presents the product-level analysis, while Section 6 discusses the firm-level analysis. Section 7 concludes.

2 Literature Review

The purpose of this section is to describe the main studies and results related to our paper. We do not aim to give a complete overview of the overwhelming exchange rate literature. Auboin and Ruta (2011) provide a good survey of the relationship between exchange rates and international trade.

Greenaway et al. (2010) is the study most closely related to this paper. They examine a panel of UK manufacturing firms and show that the negative effect of an exchange rate appreciation on the probability to export is lower in industries that import a greater share of inputs. Interestingly, a similar cushioning effect of imported inputs on the adverse effect of a currency appreciation is not found in export sales regressions (the intensive export margin). In contrast, Berman et al. (2012) show with French firm-level data that the the export volume reacts less to exchange rate movements for firms that employ a larger fraction of imported inputs. Similarly, Amiti et al. (2012) find that French firms that source more foreign inputs display a lower exchange rate pass-through rate, which implies a lower sensitivity of export volume to currency fluctuations.

In the Swiss context, Auer and Saure (2011) estimate a considerable negative effect of an exchange rate appreciation on export value of around -0.42, implying a 4.2% reduction in export value when the CHF appreciates against the foreign destination currency by 10%. Using Swiss firm-level and customs transaction-level data, Lassmann (2013) and Fauceglia et al. (2012) show that a CHF appreciation results in substantially cheaper imported inputs. A high pass-through rate into imported input prices is an important precondition for finding a compensating effect of foreign inputs on exchange-rate driven export performance.

This paper is also related to the literature examining export hysteresis, namely the persistence in exporting depending on export history. From a policy point of view this matters because, as shown theoretically by Baldwin and Krugman (1989), a large exchange rate shock – like the Swiss franc appreciation in the wake of the Eurozone crisis – can lead to exporters' exit decisions that are not reversed after the currency approaches its pre-crisis level. Their theoretical result relies on the existence of entry sunk costs into export markets. Empirically, the existence of sunk costs is well supported (see Roberts and Tybout, 1997, Bernard and Wagner, 2001, Bernard and Jensen, 2004 and Das et al., 2007). For instance, the results by Bernard and Wagner, 2001 and Bernard and Jensen, 2004 for Germany and the US, respectively, imply a large increase in the export probability of about 30 to 60 percentage points. In addition, these studies reveal that the sunk cost investment related to foreign market entry depreciates quickly over time: The effect of having exported in the previous two years is usually much smaller than having exported in the

previous year. Roberts and Tybout, 1997 also show that the impact of an exchange rate shock on predicted export probabilities is larger for firms that are already exporting. As a result, an average non-exporter requires a greater currency depreciation than an average exporter to generate positive export profits. These results are in line with the export hysteresis theory outlined in Baldwin and Krugman (1989). Campa (2004) confirms the importance of sunk exporting costs for the extensive export margin using Spanish firm-level data. However, he also finds that the aggregate response of export volume to exchange rate changes is mainly driven by quantity adjustments (the intensive export margin) and not by entry and exit decisions of firms.

3 Theoretical Framework

3.1 Intensive export margin and imported inputs

To derive the implications of exchange rate changes moderated by backward participation in global value chains on export quantities and revenues, we rely on a theoretical extension of the general pass-through framework presented in Burstein and Gopinath (2013).

A Swiss firm i that supplies a segmented foreign market j can charge an optimal export price that can be described as the sum of the log marginal cost and a mark-up:

$$p_{ij} = \mu_{ij}(p_{ij} - p_j) + mc_{ij}(q_{ij}, w_{ch}, e_j, \alpha_{ij}), \tag{1}$$

where the mark-up μ_{ij} depends on the Swiss export price expressed in the destination currency p_{ij} relative to an industry price index p_j in the export market j. The foreign currency marginal cost mc_{ij} is a function of the produced quantity q_{ij}, the factors w_{ch} that influence the costs denominated in Swiss francs such as Swiss wages and the bilateral exchange rates e_j - defined as foreign currency per unit of Swiss franc - that affect the costs of imported inputs denominated in the destination currency. The importance of this cost component depends on the expenditure share of imported inputs priced in the destination currency α_{ij}. Note that lower-case letters denote variables measured in logs. Taking the log-differential of (1), the price changes in the export market can be proxied as follows:

$$\Delta p_{ij} = -\Gamma_{ij}(\Delta p_{ij} - \Delta p_j) + mc_q \Delta q_{ij} + \Delta w_{ch} + (1 - \alpha_{ij})\Delta e_{ij}, \tag{2}$$

where $\Gamma_{ij} \equiv -\frac{\partial \mu_{ij}}{\partial (p_{ij} - p_j)}$ is the markup elasticity with respect to the relative price, $mc_q \equiv \frac{\partial mc_{ij}}{\partial q_{ij}}$ is

the marginal cost elasticity with regard to export output. Implicitly, we assumed full-pass through into imported input prices, $\frac{\partial mc_{ij}}{\partial e_j} = 1$.[1] When demand is CES constant mark-up pricing implies $\Gamma_{ij} = 0$. Constant returns to scale (CRS) technology of production translates into $mc_q = 0$, while decreasing return to scale (DRS) leads to $mc_q > 0$. Log demand is denoted by $q_{ij} = q(p_{ij} - p_j) + q_j$ where q_j is the aggregate demand in market j. Log-differentiating demand, we obtain changes in firm demand:

$$\Delta q_{ij} = -\varepsilon(\Delta p_{ij} - \Delta p_j) + \Delta q_j \tag{3}$$

, where $\varepsilon_j \equiv -\frac{\partial q}{\partial p_{ij}}$ corresponds to the price elasticity of foreign demand. Inserting (3) into (2) and assuming that exchange rate movements have no effect on aggregate variables (i.e $\Delta p_j = \Delta q_j = 0$) and on production costs denominated in Swiss francs ($\Delta w_{ch} = 0$), the exchange rate pass-through (ERPT) can be expressed as:

$$\eta_{ij} = \frac{\Delta p_{ij}}{\Delta e_j} = \frac{1 - \alpha_{ij}}{1 + \Gamma_{ij} + \Phi_{ij}}, \tag{4}$$

where $\Phi_{ij} = mc_q \varepsilon_j$ is the partial price elasticity of marginal costs. Combining (4) and (3), we obtain the response of the firm export quantity to changes in exchange rates:

$$\Delta q_{ij} = -\varepsilon \eta_{ij} \Delta e_j = -\varepsilon_j \left(\frac{1 - \alpha_{ij}}{1 + \Gamma_{ij} + \Phi_{ij}} \right) \Delta e_j. \tag{5}$$

From (5) we see that the change in the export quantity consequent upon a change in the exchange rate equals ERPT times the foreign demand elasticity. With constant mark-up pricing ($\Gamma_{ij} = 0$), CRS production technology ($\Phi_{ij} = 0$) and no imported inputs ($\alpha_{ij} = 0$) ERPT is complete ($\eta_{ij} = 1$). In contrast, when some inputs are sourced internationally and priced in the export price currency ($1 \geq \alpha_{ij} > 0$), then ERPT is incomplete ($\eta_{ij} < 1$). The imported input cost share α_{ij} measures the sensitivity of marginal costs to exchange rate fluctuations. The higher α_{ij} the less an exchange rate change affects marginal costs in the foreign currency, the less firms adjust export prices. This results in lower ERPT and a weaker quantity response.

Proposition 1: *The higher the share of imported inputs α_{ij} in total cost, the less export quantities react to exchange rate fluctuations. Specifically, a higher α_{ij} dampens the positive (negative) quantity response Δq_{ij} to Swiss franc depreciations (appreciations), all else equal.*

[1] It is assumed that $\frac{\partial mc_{ij}}{\partial wi} = 1$.

This proposition also holds when desired mark-ups decrease with the relative price, $\Gamma_{ij} > 0$. In this case Swiss exporters choose the absorb an appreciation of the Swiss franc partly in the mark-up instead of passing on the exchange rate shock fully to consumers. Similarly, if marginal costs increase with output $mc_q > 0$ because of DRS, then a price increase as a result of currency appreciation and a lower sold quantity will reduce marginal costs. In turn, this diminishes the initial incentive to raise prices, $\Phi_{ij} = mc_q \varepsilon_j > 0$. Therefore, apart from imported inputs, variable mark-ups and decreasing return to scale (DRS) further reduce price and quantity reactions to exchange rates.

Log export revenues measured in Swiss francs are denoted by r_{ij} can be expressed as

$$\Delta r_{ij} = \Delta p_{ij} + \Delta q_{ij} - \Delta e_j. \tag{6}$$

Using (5) we obtain the export revenues as a function of ERPT and the foreign demand elasticity:

$$\Delta r_{ij} = \big((1-\varepsilon_j)\eta_{ij} - 1\big)\,\Delta e_j. \tag{7}$$

Given that firms with market power set prices in the elastic part of the demand curve $\varepsilon_j > 1$ and ERPT is $\eta_{ij} \leq 1$, the reactions of export revenues to exchange rate movements are qualitatively the same as in the case of export quantities described in proposition 1. In addition, from (7) we see that revenues increase even when there is no quantity response due to local currency pricing $(\eta_{ij} = 0)$ because a depreciation induces a positive export valuation effect. This could happen for instance because all costs are incurred in the export price currency $(\alpha_{ij} = 1)$. Proposition 2 summarizes the theoretical predictions following from the revenue equation (7) in combination with the pass-through equation (4) :

Proposition 2: *A Swiss franc appreciation (depreciation) reduces (increases) export revenues. The response of export revenues to exchange rate fluctuations becomes smaller the higher the cost share of imported inputs α_{ij} is.*

Proposition 1 will be tested with product-level data, while we use the product- and firm-level data for testing Proposition 2 with regard to export revenues (value of exports).

3.2 Export extensive margin and imported inputs

The extensive margin analysis studies the entry and exit behavior of firms and products in and out of export markets. This theoretical section borrows from Baldwin and Krugman (1989),

Roberts and Tybout (1997) and Campa (2004). Exchange rate changes affect export participation decisions through its effect on operating profits. As we saw in the previous section, export revenues rise when a currency depreciates. From this, it directly follows that whenever variable costs of exporting are proportional to export revenues, a Swiss franc depreciation would raise operating profits, while an appreciation would lower them. However, backward participation in global value chains may weaken the relationship between exchange rate fluctuations and operating profits. To see this, assume that the operating or gross export profits for a Swiss exporter i to country j are denoted as follows:

$$\pi_{ij}(E_j) = \frac{P_{ij}^* Q_{ij}^*}{E_j} - \underbrace{A_{ij} W_{ch}^{1-\alpha} \left(\frac{W_j}{E_j}\right)^{\alpha_{ij}} Q_{ij}^*}_{=C_{ij}}, \quad A_{ij} = \alpha_{ij}^{-\alpha_{ij}} \cdot (1-\alpha_{ij})^{\alpha_{ij}-1}, \tag{8}$$

where P_{ij}^* and Q_{ij}^* are the optimal foreign currency price and quantity, E_j is the bilateral exchange rate, W_{ch} and W_j are the prices of domestic and imported inputs respectively. C_{ij} is the cost function net of fixed costs dual to the the following Cobb-Douglas production function $Q_{ij} = \left(K_j\right)^{\alpha_{ij}} \cdot \left(K_{ch}\right)^{1-\alpha_{ij}}$ with α_{ij} being the share of imported inputs K_j and $1-\alpha_{ij}$ the share of domestic inputs K_{ch}. Then, taking the derivative with respect to exchange rate E_j and using the envelope theorem, we obtain

$$\frac{\partial \pi_{ij}(E_j, \alpha_{ij})}{\partial E_j} = -\frac{P_{ij}^* Q_{ij}^*}{E_j^2} + \alpha_{ij} A_{ij} W_{ch}^{1-\alpha_{ij}} W_j^{\alpha_{ij}} \frac{Q_{ij}^*}{E_j^{1+\alpha}}. \tag{9}$$

From (9) it should also become clear that firm gross profits in the producer currency respond more strongly to exchange rates when production costs only arise in the producer currency $(\alpha_{ij} = 0)$. Intuitively, when the exchange rate increases or, equivalently, depreciates by one unit, the gross profits rise by export revenues $\frac{P_{ij}^* Q_{ij}^*}{E_j^2}$. On the other hand, when total costs and revenues are incurred in the same foreign currency $(\alpha_{ij} = 1)$, the depreciation raises profits only by $(P_{ij}^* - A_{ij} W_j) \frac{Q_{ij}^*}{E_j^2}$. More generally, it is unequivocal that a depreciation has a positive and an appreciation a negative impact on firm profits even when exporters do not adjust the price P_{ij}^* and quantity Q_{ij}^*.

Proposition 3: *A higher cost share of imported inputs α_{ij} dampens the positive impact of a depreciation and the negative impact of a appreciation on gross profits.*

We can extend the profit function (8) by allowing for sunk entry costs F and exit costs G that have been shown to be empirically important. Then, the export profits can be written as

$$\widetilde{\pi}_{ijt}(E_{jt},\alpha_{ij}) = Y_t\left[\pi_{ijt}(E_{jt},\alpha_{ij}) - F_j(1-Y_{ijt-1})\right] - G_jY_{ijt-1}(1-Y_{ijt}), \tag{10}$$

where t denotes a time period. Profits (10) depend on whether a firm exported in the last period or not, i.e. whether Y_{ijt-1} is 1 or 0. If a firm exported last period $(Y_{ijt-1}=1)$ and still exports $(Y_{ijt}=1)$, then sunk entry and exit costs do not a play a role and (10) collapses to profit function (8) $\widetilde{\pi}_{ijt} = \pi_{ijt}$. If a firm did not export in the last period but starts to export in the current period, profits become $\widetilde{\pi}_{ijt} = \pi_{ijt} - F_j$. Finally, if a firm decides to exit an export market, profit is $\widetilde{\pi}_{ijt} = -G_j$. In a dynamic setting a firm's objective is to maximize the expected present value of profit streams by choosing whether to export or not in every period given the profit-maximizing price P^*_{ij} quantity Q^*_{ij} and the resulting profits π_{ijt} (see also 8). Formally, the goal is to maximize

$$\Pi_{ijt} = \max_{Y_{ijt}} \mathbb{E}_t\left[\sum_{s=t}^{\infty}\delta^{s-t}\widetilde{\pi}_{ijs}(E_{js},\alpha_{ij})\right], \tag{11}$$

where $\mathbb{E}_t$ denotes expected value, δ is the one-period discount factor and $\widetilde{\pi}_{ijs}$ are the period-by-period profits given by (10). Using the Bellman equation to solve (11) the firm chooses a sequence of Y_{ijt} that satisfies:

$$V_{ijt}(.) = \max_{Y_{ijt}}\left(\widetilde{\pi}(E_{jt},\alpha_{ij}) + \delta\mathbb{E}_t\left[V_{ijt+1}(.) \mid Y_{ijt}\right]\right) \tag{12}$$

A firm will then decide to export to in period t whenever the following first-order condition holds:

$$\pi_{ijt}(E_{jt},\alpha_{ij}) + \delta\left(\mathbb{E}\left[V_{ijt+1}(.) \mid Y_{ijt}=1\right] - \mathbb{E}_t\left[V_{ijt+1}(.) \mid Y_{ijt}=0\right]\right) \geq F_j - (F_j+G_j)Y_{ijt-1}. \tag{13}$$

Equation (13) provides the theoretical basis for the following binary export decision that will be estimated in Section 5.4:

$$Y_{ijt} = \begin{cases} 1 & \pi_{ijt}(E_{jt},\alpha_{ij}) + \delta\left(\mathbb{E}_t\left[V_{ijt+1}(.) \mid Y_{ijt}=1\right] - \mathbb{E}_t\left[V_{ijt+1}(.) \mid Y_{ijt}=0\right]\right) \geq F_j - (F_j+G_j)Y_{ijt-1} \\ 0 & otherwise \end{cases} \tag{14}$$

These equations have implications worth discussing. First, when sunk costs are present, the exporting history matters for the current exporting decision. On the one hand, this is captured on the right-hand side of (13) that corresponds to entry costs F_j or the avoidance of exit cost $-G_j$

depending on the exporting status of a firm in the previous period, Y_{ijt-1}. $F_j + G_j$ is sometimes called the "hysteresis band". The left-hand side of (13) displays the benefits from supplying an export market, namely the sum of gross profits and the discounted future value of being already an exporter in period t. This second dynamic term on left-hand side is only non-zero when there are sunk costs. Otherwise, condition (13) reduces to $\pi_{ijt}(E_{jt}, \alpha_{ij}) > 0$. Hence the presence of sunk-costs can be identified by testing whether a firm's export participation in the previous period helps predict its current exporting status after controlling for a firm's current export profitability. As shown in equation (8), realizations of the exchange rate affect the entry decision through its effect on current gross profits. The gross profits of firms that rely more on backward participation in global value chains react less to exchange rate fluctuations than an average firm. In addition, exchange rate movements influence the decision to export also because of its effect on the discounted future value of being an exporter now. For instance, this implies that exchange rate movements that firms regard as transitory should impact less the export probability. As a result, the width of the hysteresis band, sometimes also referred to as the band of inaction, becomes wider not only due to higher sunk costs but also because of greater use of imported inputs. The option value of not reacting in order to avoid sunk entry or exit costs becomes more attractive when firms source more inputs internationally. In other words, larger permanent changes in the exchange rate are required to induce firms to enter or exit an export market.

Proposition 4: *The impact of exchange rate movements on the export probability is lower for firms that rely more on imported inputs (higher α_{ij}).*

Proposition 3 cannot be directly tested since export profits are not observed in the data. Put differently, export profits are a latent variable that must be inferred from export behavior. If currency movements exert a lower effect on export probability (Proposition 4) in firms or sectors with higher imported input shares, then this would be interpreted as a natural hedging effect of foreign sourcing on export profits. Therefore, export profits are predicted to be less affected by exchange rate fluctuations when integration in GVCs rises. Finally, the importance of sunk costs will be tested in both available datasets.

4 Measures of natural hedging and GVC integration

We use three different indicators to estimate the potential natural hedging effect of exchange rate risks through imported inputs. The first two measures will be used in the product-level

estimations, while the last measure will be employed in the firm-level regressions. We have seen in Section 3 that theoretically a higher share of imported inputs reduces the need to adjust export prices and quantities (intensive margin). Furthermore, a higher share of imported inputs lowers the effect of exchange rate movements on export profits, thereby reducing the impact of exchange rates on the export probability (extensive margin).

4.1 Imported input weighted real exchange rate index

To account for the sensitivity of imported input prices to exchange rates in our regression framework, time-varying sectoral imported input weighted exchange rates are calculated based on supplier-specific imported input values similarly to Greenaway et al. (2010) and Fauceglia et al. (2012).[2] These real exchange rate indices are then reweighted according to the import share of each input sector in the respective output/export sector. These import shares are calculated from the 2001 I-O table for Switzerland stemming from OECD (2012).[3]

More formally, these imported input weighted real exchange rates are constructed as follows:

$$Import\_RER_{so,t} = \sum_{si} \left\{ \left[\sum_{j} \left(\left(W_{si}^{j} \right)_t \cdot \left(\frac{e_{j,t} \cdot p_j}{e_{j,o} \cdot p_{ch}} \right) \right) \right]_{t,si} \cdot \left(R_{so}^{si} \right) \right\}, \tag{15}$$

where t is the time period, j is the source country of imported inputs, si is the input-output (I-O) imported input sector and so is the I-O output sector. e_{jt} and e_{jo} are the supplier-specific bilateral nominal exchange rates in time t and in the base period (1.2004) and $\frac{p_j}{p_{ch}}$ measures the inflation differential between import origin j and Switzerland ch. Therefore, $\frac{e_{j,t} \cdot p_j}{e_{j,o} \cdot p_{ch}}$ corresponds to a real exchange rate index. $(W_{si}^{j})_t$ is the value of imported inputs (in CHF expenses) from source country j relative to the total value of imported inputs in sector si during year t. This term is included to obtain an average imported input weighted exchange rate for each input sector si. Ultimately, these exchange rates are multiplied by R_{so}^{si}, corresponding to the share of imported inputs from sector si to total imported inputs in output/export sector so. The weights R_{so}^{si} do not vary over time so that the index reflects primarily changes in the bilateral exchange rates.[4]

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

[3] 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.

[4] R_{so}^{si} is based on the 2001 I-O table for Switzerland taken from OECD (2012). From the OECD, an I-O table for 2005 is also available. Comparisons of Swiss I-O tables between 2001 and 2005 show that the sectoral import

On the one hand, exchange rate movements may affect the prices of imported inputs from a given origin. In addition, equation (15) also captures changing import patterns across countries over time through $(W^i_{si})_t$ that are also related to exchange rate changes. Thus, *Import_RER* is the imported input weighted real exchange rate faced by each (output) sector *so* in each period t. Finally, we will employ the log version of this index, *ln(Import_RER)*. This measure takes into account the geographic dispersion of import origins and how changes in the exchange rate between the CHF and the currencies of those importer countries affect costs of imported inputs.[5]

4.2 Ratio between imported inputs from the export destination and total imported inputs

As a second more restrictive measure of natural hedging, which is a variant of *Import_RER*, we construct the following measure called *Alpha*:

$$Alpha_{j,so,t} = \sum_{si} \left(\left(W^j_{si} \right)_t \cdot R^{si}_{so} \right), \tag{16}$$

$Alpha_{j,so,t}$ can be interpreted as the ratio of imported inputs stemming from the export destination j within an export/output-sector *so* in year t to total imported inputs. This measure can then be interacted with the bilateral real exchange rate against the export destination currency. From an econometric point of view, this interaction exploits best the information on export destinations included in the product-level data. On the other hand, one drawback is that it restricts the effect of natural hedging to imported inputs coming from the export destination only. However, together with *Import_RER, Alpha* should provide a fuller picture on the relationship between integration in GVCs and the effect of exchange rate changes on exports.

4.3 Ratio of total firm inputs to firm sales

Finally, in the firm-level dataset, we use the ratio between total intermediate inputs stemming from outside the firm and firm sales as an approximation for the integration in GVCs. This measure has the advantage to vary at the firm-level. It should capture international integration

shares in total imports in an output sector in fact remain relatively stable over time and are likely to be driven by sector-specific technological factors.

[5] We do not differentiate between input and output-sector in the following sections and use the *k* subscript for a specific sector.

whenever firms that have higher total input to sales ratios also exhibit higher imported inputs over sales ratios. This is not testable in our data but we think that the assumption of a positive correlation between the total and the imported input ratio is reasonable and should hold on average, at least.[6]

5 Product-level analysis

5.1 Product-level empirical strategy

Our empirical analysis of the product-level data is conducted in the framework of the gravity model, which following Melitz (2003) additionally exploits the fact that not all countries trade with each other in all products and if they do, those trade flows are not necessarily symmetric. These considerations give rise to a two-stage estimation procedure, as in Helpman et al. (2008). In addition to correcting for the Heckman (1979) selection bias, Helpman et al. (2008) use Melitz (2003) to argue that a correction for biases arising from asymmetries in trade flows is also necessary to obtain consistent results.

We therefore use the Heckman (1979) two-step estimator to control for the large number of zero trade flows between trading partners. Zero trade flows become increasingly probable as the level of disaggregation of products increase, which is also true for our data. The Heckman estimation also allows us to distinguish between the effects of exchange rate changes at both the intensive and extensive margins of trade.

The Heckman two-step estimation involves running a first stage Probit in (17) that estimates the effect of explanatory variables on the probability of exporting. The second step corrects for sample selection by including the inverse Mills ratio in the equation (18). Equation (18) comprises a OLS estimation of the natural logarithm of positive exports as the dependent variable on the same set of control variables as in step one with the exclusion of at least one variable that should ideally affect trade only at the extensive margin (17). We use the time taken to import by the destination country from Switzerland as the selection variable as this variable has a relatively great bearing on the probability of exporting. Furthermore, from a theoretical viewpoint the time to import should mainly affect the fixed cost of exporting and thus the extensive margin only.

Formally, we have the following baseline specifications:

[6] As large firms that are overrepresented in our sample tend to import more (see e.g., Bernard et al., 2007), this assumption may be plausible.

Step one: Selection equation (export participation)

$$Pr(X_{jpt} > 0) = \beta_0 + \beta_1 E_{jt} + \beta_2 \alpha_{jkt} + \beta_3 E_{jt}\alpha_{jkt} + \beta_4 ln(1+\tau_{jpt}) + \beta_5 PTA_{jt} + \beta_6 ln(Dist_j) + \beta_7 Contig_j + \beta_8 Lang_j + \beta_9 Time2Import_{jt} + \beta_{10} MR_{jt} + \lambda_k + \varepsilon_{jkt}, \tag{17}$$

Step two: Outcome equation (export sales)

$$ln(X_{jpt}|X_{jpt} > 0) = \beta_0 + \beta_1 E_{jt} + \beta_2 \alpha_{jkt} + \beta_3 E_{jt}\alpha_{jkt} + \beta_4 ln(1+\tau_{jpt}) + \beta_5 PTA_{jt} + \beta_6 ln(Dist_j) + \beta_7 Contig_j + \beta_8 Lang_j + \beta_{10} MR_{jt} + \rho InvMillsRatio + \lambda_k + \varepsilon_{jkt} \tag{18}$$

where X_{jpt} is the nominal export value of HS-6 product p in destination j at time t, τ is the preferential tariff rate on Swiss exports of HS-6 product p in destination j, PTA is an indicator variable for the existence of a preferential trade agreement between Switzerland and the destination country and MR denotes the "Bonus-vetus-OLS" multilateral resistance term from Baier and Bergstrand (2009). Bilateral trade costs are typically proxied by bilateral distance between capitals of the two countries ($Dist_{ij}$), and indicators for common international borders ($Contig_{ij}$) and language ($Lang_{ij}$); Equation (18) also includes the time taken to import ($Time2Import_{jt}$) by the destination country j from Switzerland. Moreover, we also control for sector-specific fixed effects (λ_k) at the ISIC two-digit level.

The dependent variable in the selection equation (17) is a dummy variable that takes the value one if a HS 6-digit product was exported to a specific export destination in a given time period and zero otherwise. We consider only HS 6-digit products that are exported at least to one country in the sample period to ensure that the specific products are manufactured in Switzerland. This dependent variable is best interpreted as the probability of a HS 6-digit product being exported to a particular destination. The dependent variable in the outcome equation (18) is the log of positive exports.

Our main explanatory variable of interest E_{jt} is the log bilateral real exchange rate ($ln(RER)$) between Switzerland and the destination country j at time t. We would expect an appreciation of the Swiss franc against an importer's currency to diminish the propensity to export a HS 6-digit product to this destination, $\beta_1 > 0$. However, in line with Proposition 1, 2 and 4, we also test how the relationship between exchange rates and export propensity is altered by the degree of sectoral (k) backward participation, measured by the α_{jkt} term, in cross-border supply chains. α_{jkt} is approximated in some specifications by the imported input weighted exchange rate, $ln(Import\_RER)_{k,t}$, which varies along the k and t dimension (see 15), and in others with

$Alpha_{jkt}$ (see 16). Specifically, we expect a mitigating effect of backward integration in GVCs, $\beta_2 < 0$.

Finally, to incorporate "hysteresis" into the empirical framework, the RHS of the selection equation (17) is augmented by X_{jpt-1}, which is an indicator variable for export participation in destination j at time $t-1$.

5.2 Estimation issues

The panel structure of our data can be exploited to control for product-specific determinants of the export probability by including time-invariant fixed effects at the HS-6-digit level. However, adding fixed effects to a probit model may yield inconsistent estimates due to incidental parameter problem (Wooldridge, 2002). We thus also estimate equation (17) using a linear probability model (LPM) which allows for the inclusion of HS6-specific fixed effects.[7] In some specifications for the extensive and intensive margin, we replace *Contiguity*, *Common language* and *ln(Distance)* by country-fixed effects to control more thoroughly to time-invariant factors at the country-level. The standard errors are clustered by HS6 $\times$ partner-country and time in most specifications (see also Baldwin and Harrigan, 2011).

We also estimate equation (18) using the Poisson-PML (PPML) estimator proposed by Silva and Tenreyro (2006) due to the likely presence of heteroskedastic errors that bias OLS estimates.

Finally, the "hysteresis" equation is estimated using the random effects dynamic probit model that incorporates HS6-specific fixed effects and the initial export status using the Mundlak-Chamberlain-Wooldridge device (Mundlak, 1978; Chamberlain, 1982; Wooldridge, 2005). Given its ease of interpretation, we also use the dynamic LPM model as a robustness check despite the fact that the past export status is almost surely downward biased. However, the coefficient of the past export status from an LPM with fixed effects may provide a lower-bound estimate for the importance of export hysteresis according to Bernard and Jensen, 2004.

5.3 Product-level data and explanatory variables

Product-level bilateral trade data, obtained from the Swiss Federal Customs Administration (Eidgenössische Zollverwaltung), covers traded HS 6-digit product 2004 and 2013. The dataset

[7] The estimates from LPM usually constitute reasonable approximations of average partial effects according to Wooldridge (2002).

Table 1: SUMMARY STATISTICS OF PRODUCT-LEVEL DATA

Variable	Obs	Mean	Std.Dev.	Min	Max
Export value (CHF mn)	2042770	0.8	18.5	0	4950
Export volume ('000 kg)	2042770	74.2	2781.6	0	1380000
Export probability	2042770	0.4	0.5	0	1
RER (index)	2042770	98.11837	13.5	56.3	152.2
Import_RER	1972840	102.3	7.4	90.1	117.2
Imported input share (Alpha)	1972840	0	0.1	0	0.6
Distance (km)	2042770	4085	4746.2	436.1	19006.7
RGDP_partner (USD bn)	1838493	1180	2300	15.2	14200
PCRGDP_partner (USD)	1838493	27787.5	18468.4	687.3	87716.7
Simple avg tariffs	1299282	1	3.9	0	495
Weighted avg tariffs	1299281	1	3.9	0	495
PTA	2042770	0.8	0.4	0	1
Time to import (days)	1832972	13.1	6.8	5	41
Contiguity	2042770	0.1	0.3	0	1
Common language	2042770	0.2	0.4	0	1

is reduced to the 37 most important trading parters for Switzerland, including all OECD countries and the BRICS, accounting for more than 90 percent of Swiss exports. We also collapse the monthly recorded transactions to annual data. These data allow us to control for destination, time and product-specific factors of export adjustments that might otherwise confound the estimation of the effect of exchange rate changes.

Data on exchange rates are taken from the Swiss National Bank. Sectoral-level indicators of backward participation in global value chains come from the OECD TiVA database and from Input-Output tables (see Fauceglia et al., 2012).

The bilateral trade cost variables are taken from the CEPII gravity dataset. Since these variables are time-invariant, they are excluded from our estimations that include destination-specific fixed effects. Data on time taken to import come from the World Bank's Doing Business Indicators. Data on real GDP are taken from the World Bank's World Development Indicators while tariff data are sourced from WTO IDB using WITS. The WTO's RTA-IS database provides information that is used to construct the PTA variable. Finally, the MR terms are constructed a la Baier and Bergstrand (2009).

All these data are summarized in Table 1. We have close to 2 million observations on our variables of interest. The average export value to the OECD and BRICS countries over 2004-2013

was CHF 0.8 million while the average export propensity was 0.4.

5.4 Results

5.4.1 Estimations with the imported input weighted exchange rate

Table 2 presents the results of the gravity estimations of (17) and (18). We estimate first a Heckman selection model in columns 1 and 2. The highly significant inverse Mill's ratio in column 2 indicates that the concern of a non-randomly selected export sample and the use of the Heckman model is justified. In the first-step probit regression explaining the extensive margin (see column 1), the time required (recorded in days) to enter a destination country acts as an exclusion variable and exerts a significantly negative effect on the exporting probability. Importantly, column 1 shows that a 1% appreciation of the exchange rate reduces the probability of exporting by about 0.1 percentage point, ceteris paribus and on average. However, the estimate of the imported-inputs-weighted exchange rate, *ln(Import_RER)*, reveals that the adverse effect of a currency appreciation is almost reversed, with a 1% appreciation of the import-weighted exchange rate leading to a more than 0.1 percentage point higher export probability (extensive margin). In contrast, we do not observe this mitigating effect at the intensive margin in either the Heckman or the PPML results. There is a counterintuitive negative estimate of the coefficient of *ln(Import_RER)* in column 2, but it is not confirmed with the PPML estimations in column 3. As a result, we cannot conclude that there is a significant alleviating effect of imported inputs at the intensive margin in this specification. The elasticity of exports (in CHF) to an exchange rate change ranges from -0.631 in the Heckman selection model (column 2) to -0.865 in the Poisson model (column 3). This suggests that export value reduces by about 0.7%, ceteris paribus and on average, from a 1% appreciation of the exchange rate. However, the effect of the import-weighted exchange rate is unable to arrest this fall in export value in any specification.

Column 4 shows that the export status in the previous period is a strong determinant of the export probability in the following period. This is indicative of export hysteresis, namely that temporary exchange rate shocks may have permanent negative effects on the export structure. For instance, a firm that dropped out of the export market because of a currency appreciation requires a much lower exchange rate to profitably serve a foreign market than a current exporter. This empirical persistence in export status is usually explained by substantial market entry sunk costs. In our linear probability model with fixed effects (column 4), the magnitude of the compensating effect of the import-weighted exchange rate on export probability displays a similar magnitude to its

Table 2: DIRECT EXCHANGE RATE EFFECT AND IMPORTED INPUT WEIGHTED EXCHANGE RATE

Dependent variable	Prob(Exp) (1)	Export value (2)	Export value (3)	Prob(Exp) (4)
Exp(t-1)				0.102***
				(0.002)
ln(RER)	-0.096***	-0.865***	-0.631***	-0.055***
	(0.011)	(0.075)	(0.133)	(0.007)
ln(Import_RER)	0.120**	-1.354***	-0.032	0.116**
	(0.060)	(0.440)	(2.937)	(0.046)
ln(Real GDP)	0.086***	0.786***	8.427e+08***	0.157***
	(0.001)	(0.029)	(22261878.376)	(0.008)
Tariffs	0.039***	0.018	-0.311***	-0.005**
	(0.002)	(0.017)	(0.034)	(0.002)
PTA	-0.011**	-0.053*	-0.292***	-0.002
	(0.005)	(0.032)	(0.066)	(0.003)
Contiguity	0.178***	1.216***	-0.100	
	(0.008)	(0.084)	(0.190)	
Common language	0.010	0.118**	0.520***	
	(0.006)	(0.054)	(0.091)	
ln(Distance)	0.023***	-0.052***	-0.023	
	(0.002)	(0.015)	(0.028)	
Time2import	-0.001***			
	(0.000)			
Mill's ratio		2.054***		
		(0.196)		
Observations	1,028,631	531,649	1,161,399	1,033,963
Estimation		Heckman	PPML	LPM FE
R-squared		0.151		

Notes: Significance levels: *** p< 0.01, ** p< 0.05, * p< 0.1, robust standard errors in parentheses, error correction for clustering at the hs6 x partner country level (except for PPML in column (4) in which standard errors are clustered by partner country and year). All columns include industry (ISIC 2-digit) and year dummies. Column (5) includes hs6 x partner country fixed effects. Marginal effects at means are reported in the probit specification in column (1).

counterpart in column 1. Altogether, the results of Table 2 suggest that sourcing inputs abroad leads to natural hedging of exchange rate risks, albeit only at the extensive margin.

Next, we estimate a specification that exploits more thoroughly the bilateral dimension of the product-level data. Specifically, we employ the $Alpha_{jkt}$ approximation of natural hedging working through imported inputs stemming from the export destination (see 16) and therefore likely to be traded in the same currency as the exported good. Furthermore, we replace *Contiguity*, *Common language* and *ln(Distance)* by country-fixed effects to control more carefully to time-invariant factors at the country-level. Therefore, the following specification, whose results are presented in 5.4.2, is more restrictive and serves to provide further evidence on the natural hedging mechanism through imported inputs.

5.4.2 Estimations with the sectoral and destination-specific foreign input share

Table 3 reports the set of results using disaggregated product-level data at the HS6-digit level from the Swiss customs. In columns 1 to 4, we estimate Heckman selection models that take into account the non-randomness of the HS6-digit products that are exported. The results of the probit regressions in columns 1 and 3 are consistent with our theoretical predictions. To begin with, an exchange rate appreciation- an increase in *ln(RER)*-reduces the probability to export (see columns 1 and 3). Our theoretical model suggests that this works through a reduction in operating profits of exporting firms. However, the importance of the exchange rate decreases with backward participation in global value chains, as one can see from the positive coefficient of the interaction term *Alpha x ln(RER)* in columns 1 and 3. The Alpha estimates in columns 1 and 3 also show that an increasing sector-specific share of imported inputs from a destination country raises strongly the likelihood that a product within that specific sector is exported to that destination. One likely explanation is that part of the fixed costs involved with exporting have already been incurred for the importing activities. For instance, firms that import from a country may already have a knowledge of the regulatory and legal environment and are likely to have established relationships with local logistic and other producer service providers that can be shared for exporting activities. The demand situation in the foreign country approximated by *ln(Real GDP)* also has a strong positive and significant effect on the export propensity. Having a preferential trade agreement (PTA) with a foreign country also promotes export entry. Counter-intuitively, higher tariffs also increase the exporting probability. However, we explain later that this might occur due to a remaining correlation with the residual term. Reassuringly, the probit regressions in columns 1 and 3 display similar results.

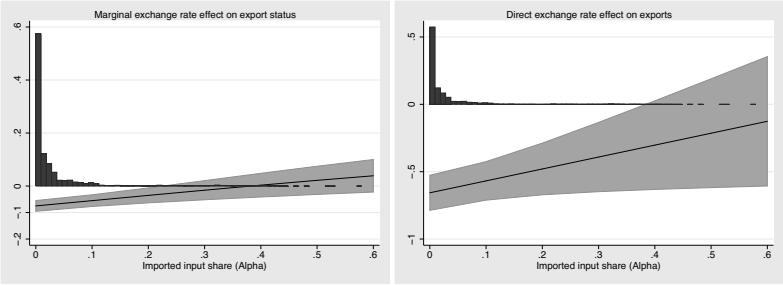
Table 3: DIRECT EXCHANGE RATE EFFECT AND IMPORTED INPUT SHARE FROM DESTINATION

Dependent variable	Pr(Exp)	Exp value	Pr(Exp)	Exp vol	Exp value	Pr(Exp)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exp(t-1)						0.13***	0.670***	0.707***	0.102***
						(0.001)	(0.001)	(0.001)	(0.002)
Exp(t-2)								0.232***	
								(0.002)	
ln(RER)	-0.075***	-0.657***	-0.074***	-0.487***	-0.371**	-0.003***	-0.042***	-0.049***	-0.056***
	(0.010)	(0.066)	(0.010)	(0.073)	(0.154)	(0.006)	(0.008)	(0.008)	(0.007)
Alpha x ln(RER)	0.196***	0.885**	0.146***	1.379***	2.178**	0.11***	0.067***	0.067***	0.078***
	(0.056)	(0.409)	(0.056)	(0.461)	(0.890)	(0.03)	(0.020)	(0.021)	(0.028)
Alpha	0.388***	3.420***	0.371***	3.246***	4.918***	0.21***	0.086***	0.092***	0.115**
	(0.058)	(0.398)	(0.058)	(0.437)	(0.714)	(0.05)	(0.016)	(0.016)	(0.051)
ln(Real GDP)	0.253***	2.049***	0.254***	1.945***	1.039e09***	0.14***	0.047***	0.037***	0.154***
	(0.012)	(0.110)	(0.012)	(0.128)	(1.568e08)	(0.008)	(0.008)	(0.010)	(0.008)
Tariffs	0.012***	-0.043**	0.014***	0.050***	-0.367***	-0.003*	0.003***	0.002***	-0.005**
	(0.002)	(0.017)	(0.002)	(0.018)	(0.040)	(0.002)	(0.001)	(0.001)	(0.002)
PTA	0.030***	0.130***	0.028***	0.113***	-0.139***	0.003	0.000	-0.004	-0.002
	(0.005)	(0.027)	(0.004)	(0.029)	(0.039)	(0.003)	(0.003)	(0.003)	(0.003)
Time2import	-0.001***		-0.001***						
	(0.000)		(0.000)						
Mill's ratio		2.167***		2.325***					
		(0.193)		(0.235)					
Obs. (in Mio.)	1.029	0.532	1.029	0.516	1,161	1.034	1.034	0.903	1.034
Estimation		Heckman			PPML	Probit	LPM	LPM	LPM FE
R-squared		0.1607		0.1973			0.571	0.581	
Pseudo-R-squared	0.174		0.1696						

Notes: Significance levels: *** p<0.01, ** p<0.05, * p<0.1, robust standard errors in parentheses, error correction for clustering at the hs6 x partner country level (except for PPML in column (5) in which standard errors are clustered by partner country and year). Columns (1) to (8) include country, industry (ISIC 2-digit) and year dummies, column (6) includes Mundlak-terms and the initial export condition to approximate firm fixed effects, column (9) includes hs6 x partner country fixed effects. Marginal effects at means are reported in the probit specifications in columns (1), (3) and (6). Bonus-Vetus terms to approximate multilateral resistance terms are included but not reported.

To clarify the relationship between exchange rates and global value chains, based on the results of column 1 of Table 3, the left panel of Figure 1 depicts the marginal effect of the exchange rate on the export probability as a function of Alpha. When the Alpha term is zero, implying that no imported inputs stem from the destination country for a specific output sector, a 1% increase in the exchange rate reduces the export probability by 0.075 percentage points. In contrast, the importance of the exchange rate for the decision to supply an export market declines when the share of imported inputs from that export market for a given output sector rises. When the imported input share reaches a value of about 0.2 (20%), the exchange rate does not have a statistically significant effect anymore. This is the case for exports to Germany that have an average Alpha of 0.33, which range from 0.23 to 0.58 depending on the sector. In other words, whether or not a product is exported to Germany is not affected by currency movements because of natural hedging through imported input costs. However, in the area where *Alpha* is below 0.2 exchange rate fluctuations still matter for the exporting decision. For instance, for the US Alpha equals 0.06 and for China Alpha has a value of 0.03. In both cases, the role of exchange rate fluctuations on Swiss export propensities matters.

Figure 1: EXCHANGE RATE EFFECT AS A FUNCTION OF IMPORTED INPUT SHARE



Notes: Marginal effects at percentiles and the maximum of the distribution of Alpha. LHS: First-step pooled probit regression with a binary variable for export participation at time t in country j as the dependent variable. RHS: Second-step OLS regressions in a Heckman selection model with log export value as the dependent variable, results are based on column 1 and 2 of Table 3.

Columns 2, 4 and 5 report the results related to the intensive export margin; while columns 2 and 4 report the results of the second-stage Heckman, column 5 reports the results from the PPML estimation. A similar picture to the extensive export margin emerges. According to the second-step OLS regression in column 2, an exchange rate appreciation exerts a substantial negative effect on the exported value, but this effect is cushioned when more inputs are sourced from the destination country. We control in column 2, as in the quantity regression shown in

column 3, for a selection bias due to a large number of zero export flows. The right panel of Figure 1 shows graphically the impact of the exchange rate and its interaction with imported inputs *(Alpha)* based on column 2. The main effect (i.e. the effect of the constituting term) of *ln(RER)* is -0.657. This means that a 1% appreciation of the CHF against the destination country currency reduces the export value by 0.66% when Alpha equals zero. When Alpha is above 0.4, an exchange rate appreciation does not significantly reduce the export value. In this case, natural hedging reduces the need to raise prices in the local currency, implying a lower exchange rate pass-through and buoyant exports. The main effect of Alpha in column 2 also displays a strong positive effect on the export value. Therefore, being integrated in backward supply chains in the destination country does not only increase the entry probability but also promotes export revenues. Furthermore, a stronger demand in the foreign country *(ln(real GDP))* and membership of PTAs boost exports, while higher tariffs dampen exports. All these results also hold in column 4 where the export value is replaced by export quantity measured in kilos. The compensating effect of imported inputs turns out to be larger, in column 4 compared to column 2, as the estimate of *Alpha x ln(RER)* reveals. As a robustness check, we run the export value regression using the state-of-the-art Poisson-PML estimator suggested by Silva and Tenreyro (2006) in column 5. However, the results remain qualitatively unchanged.

In columns 6 to 9, we test for the presence of sunk costs by including the one year lag of the exporting status. The estimated effects of the lagged exporting status are highly significant in all four columns and an are the strongest determinant of the export propensity. The size of the effect ranges from 0.1 using the random effects dynamic probit (column 6) and the linear probability model (LPM) with hs6 x partner-country fixed effects (see column 9) to about 0.7 using the LPM models (see columns 6 to 8). This range of estimates is in line with the firm-level literature (see for instance Bernard and Jensen, 2004; Bernard and Wagner, 2001; Roberts and Tybout, 1997). The large effect of the lagged export indicator implies that products that are not exported in the previous year require larger exchange rate depreciations to achieve positive export profits and to be exported in the following year than products that are already present in an export market. This is a clear evidence for export hysteresis, namely that a currency appreciation may reduce the number of exported goods and exporting firms permanently. Furthermore, the sunk cost investment depreciates very quickly over time, as the much lower coefficient of having been an exporter lastly two years before *(Exp(t-2))* shows.[8] This result implies that once a product is out of an export market, the investments done in the foreign market lose value rapidly, increasing the

[8] Including a variable *(Exp(t-3))*, which equals one if a product has been exported in $t-3$ the last time, does have a negligible effect on the estimates (results are available upon request). This robustness check confirms that past exporting experience quickly depreciates over time.

necessary export revenues required to overcome sunk export costs and generate positive export profits. Overall, the large magnitudes of the past export coefficients imply that factors such as a higher foreign demand or a depreciated currency do not easily compensate for the lack of presence in a foreign market.[9]

6 Firm-level analysis

6.1 Firm-level data and empirical strategy

6.1.1 Firm-level Data

For firm-level data analysis, we use a revolving panel in three-year intervals. These data stem from the KOF innovation survey and cover 7 time periods (1996, 1999, 2002, 2005, 2008, 2011, and 2013). This leaves us with 3 business cycles over more than the past decade. The panel is based on a nonrandom sample of 6500 firms that are drawn from the universe of Swiss firms with at least 5 full-time equivalent employees in the manufacturing sector, the construction, and the service sector.[10] As participation is voluntary – the response rate is about 35% – the panel is naturally unbalanced. However, it is rotating in the sense that firms may leave and are replaced or, alternatively, re-enter, such that the number of firms observed per period is approximately constant. We observe a total of 6,576 firms, and the average number of firms per year amounts to 2,284 of which 1,126 firms are exporters. The total number of observations is 15,837. The number of time periods covered by firms ranges from 1 to 7, and the median in the sample is 3. The data include information on the export volume and the main destination market. In addition, information on firm-level employment, turnover, and investment (among other firm characteristics) as well as answers to qualitative questions (e.g., price-related and non-price-related competition) are obtained. These variables allow us to control for firm-level determinants of exporting that are unobserved in aggregate data and to take the potential heterogeneity across firms into account.

[9] A further robustness check available upon request indicates that our results are robust to the exclusion of the chemicals & pharmaceutical sector.

[10] More specifically, multi-stage sampling is applied based on 34 industries such that the sample size is non-random. Within industries, the population is further stratified disproportionately based on 3 industry-specific size classes in such a way that large firms are oversampled. The sampling method is variable probability sampling, with the probability differing by size class and equalling 1 for the largest size class. According to the Federal Statistical Office, the average number of employees per firm was about 11.2 in 2008 (a total of 3,494,071 employees and 312,861 firms was reported), compared to the average of 285 for all firms in the same year in the sample. Source: Betriebszählung 2008.

We clean the panel by assigning NOGA 2008 codes (equivalent to NACE Rev. 2) and HS 2-digit codes to firms in all years, using correspondence tables to previous industry and trade classifications. We keep firms that are active in the agricultural, mining & quarrying, and manufacturing sectors only.[11] Next, we match the innovation panel dataset on the real exchange rate as constructed and described in the previous section, and on variables about economic fundamentals.

Panel a. of Table 4 indicates the export entry and exit behavior of firms as well as the total number of firms and the number of exporters according to year. This information sheds light on firm-level dynamics that are analyzed by way of a two-step selection approach in the following sections. First of all, the number of firms by year ranges from 714 (in 1999) to 989 (in 2002) compared to the overall number of distinct firms that amounts to 2,611 over the entire period, hence the panel exhibits substantial velocity. A substantial fraction of those export as figures reported by year show. Second, the number of firms that change their export status (switchers) varies across time. Furthermore, there is variation in entry and exit dynamics. The distinction between firms that enter and exit illustrates that the pattern of firms that enter into exporting corresponds to the business cycle. The number of firms that enter increased between 1999 and 2005, then decreased over the following two periods, before increasing again in the last period of observation. Firms that exit follow by and large the pattern of the business cycle too (.i.e., the number of exiting firms tends to increase during economic downturns or crises), with the exception of a drop in exiting firms in 2011. At first glance, this may indicate lagged effects or a lack of an effect of the exchange rate on export participation. In any case, these unconditional figures are not informative of a significant relationship between the exchange rate and export participation. Finally, the comparatively high share of exporters and the given velocity suggest that sample selection, including sample attrition, is present and may be taken into account empirically later on.

Panel b. of Table 4 summarizes descriptive statistics about variables used for analysis. The figures are unweighted, i.e., they do not take the stratification into account. They include sample characteristics as well as the following firm-level variables: number of employees and skill-level specific shares thereof; expenditures on intermediate inputs, investment, and R&D; turnover; value added per employee; the export share; and the main export market. Overall, the Table shows that the coverage is good regarding the variables included in regressions later on. Of the 2,611 remaining firms in the sample, 1,983 firms report positive exports. We calculate the export volume by multiplying the export share by turnover.[12] The average export volume amounts to

[11] Specifically, this includes firms in ISIC Rev.3.1 codes 1 and 14-36. Excluding the agricultural and the mining&quarrying sectors left our results unchanged

[12] Note that all variables indicated in shares exhibit mass points at integer values resulting from the tendency of firms to round such figures up or down. However, histograms show that the variables are roughly continuously

43 million Swiss Francs. The latter is of course driven by the substantial fraction of zeros in the data: the average of strictly positive exports is 58 million Swiss Francs. Since firms with at least 5 employees have been sampled beforehand solely, and large firms have been oversampled, the average number of employees is large (amounting to 183) as is the standard deviation. Nevertheless, the data are highly right-skewed as expected, with the median amounting to 70 employees.[13] Firms pay on average a total wage sum of 17 million Swiss Francs and report average intermediate input costs of 39 million and average value added of 34 million Swiss Francs. The average intermediate input share amounts to 42%.

6.1.2 Empirical strategy for firm-level data

The empirical strategy can be outlined as follows. We aim at testing Proposition 2 with the data at hand. For this, let us denote by R_{it} the real export volume R of firm i in time period t; by r_{it} the log thereof; and by e_t the aggregate log real effective exchange rate index (REER_t) at time t. To construct this index, we used annual 6-digit export data from the Swiss Customs Administration as well as currency-specific exchange rates from the SNB.[14] Alternatively, we use an industry-specific exchange rate $\text{REER}_{f(t)}$ for which we match firm-level NOGA codes to HS 2-digit product lines, and the real effective exchange rate based on 24 countries and with base year 1999 = 100 from the Swiss National Bank (SNB). By α_{it} we denote the i-specific intermediate input share in turnover at t; and by gdp_t the log weighted foreign real GDP, which refers to real foreign activity weighted by export region based on Europe, the US, and Japan as obtained from KOF Swiss Economic Institute. Other firm-specific variables are collected in the vector z_{it}. These include log total factor productivity (TFP), log employees in full-time equivalents as a proxy for firm size, and a binary variable indicating R&D activity. These are described in the previous subsection.[15] All variables except shares are deflated using the Swiss

distributed such that they are not interval coded. This response bias concerns wages, intermediate inputs, and export volumes as well. We calculated these variables by multiplying the respective share by turnover.

[13] Note that we observe firms with < 5 employees in the sample. This is solely due to firms that reduced employment in later periods.

[14] Proposition 1 cannot be tested due to the lack of data on export quantities. Note that Proposition 3 would require a test of the joint impact of α_{it} and an import-weighted real effective exchange rate in industry f, $\text{II REER}_{f(t)}$. Because the inclusion of both variables may lead to identification issues, we assume that the export-weighted REER_t equals the $\text{II REER}_{f(t)}$. Furthermore, we tested the sensitivity of results to a lag choice at $t-1$.

[15] TFP is obtained as the residual from a regression of the log value added on log wage (the unit labor costs times the number of full-time equivalent employees) and log material costs, with standard errors clustered at the firm level. We use material costs because information on investment is sparse and information about capital is not available. In addition, we checked the sensitivity of the regression results to the inclusion of other firm-level variables which did not improve the explanatory power of our model (e.g., foreign ownership status, unit labor costs, skill shares).

Table 4: SUMMARY STATISTICS

Panel a.

Year	Switch_{t^*}	Entry_{t^*}	Exit_{t^*}	Firms	Export
1996	0	0	0	871	647
1999	23	14	9	714	548
2002	41	14	21	989	732
2005	58	28	18	965	730
2008	61	15	25	830	624
2011	54	17	11	907	677
2013	56	13	23	767	569

Panel b.

Variable	Obs	Mean	Std.Dev.	Min	Max	Total
Number of firms	6043	-	-	-	-	2611
Exporter	4528	-	-	-	-	1983
Initial exporter	4407	-	-	-	-	-
Export volume	6043	4.34e+07	3.59e+08	0	1.86e+10	-
Export volume (>0)	4528	5.79e+07	4.14e+08	4910	1.86e+10	-
Log TFP	6043	5.12e-5	0.358	-0.993	3.4	-
Value added	6050	3.40e+07	1.61e+08	67922	6.86e+09	-
Wage	6050	1.73e+07	6.89e+07	14289	1.96e+09	-
Material costs	6050	3.87e+07	2.56e+08	8473	1.27e+10	-
Number of empl.	6043	183	595	1	20180	-
R&D	6043	0.599	0.490	0	1	-
Interm. input share	6043	0.42	0.169	0.01	0.95	-
REER (SNB)	-	103.061	6.786	93.770	115.050	-
REER (own)	-	96.064	6.258	85.724	106.070	-
REER (own, HS 2-digit)	-	95.475	6.455	80.586	124.180	-
Foreign GDP	-	16628.090	1705.950	13686	18502.300	-

Notes: (Panel a.) Switch denotes firms that changed export status over the panel period; t^* denotes a change (switch, entry, exit) with respect to the previous period; Firms and Export refers to the number of firms and exporters by year. (Panel b.) Employees: total number of employees in full-time equivalents; Exports, wages, intermediate inputs, turnover and value added per employee in Swiss Francs; TFP is the (Solow) residual from a regression of log value added on log wages and log material costs. Source for REER: SNB real effective exchange rate index, base=1999, 24 countries; own calculations using annual HS 6-digit export data from Swiss Customs Administration EZV; foreign GDP refers to real foreign activity weighted by export region based on Europe, the US, and Japan as obtained from KOF Swiss Economic Institute; real variables are deflated using the manufacturing PPI (base=1994, BFS).

manufacturing producer price index from the Swiss Federal Statistical Office (BFS) with base year $1994 = 100$.

We model the equation of interest by way of a the following regression model for the intensive margin of exports as a baseline model:

$$r_{it} = \beta_0 + \beta_1 e_t + \beta_2 \alpha_{it} + \beta_3 e_t \times \alpha_{it} + \beta_4 gdp_t + \gamma z_{it} + u_{it} \tag{19}$$

We employ the fixed effects estimator to account for time-invariant unobserved effects that are arbitrarily correlated with the variables we observe.

In order to link estimation to the theory outlined in Section 3, we account for endogenous selection into exporting by applying a two-step procedure (see also Campa, 2004; Helpman et al., 2008).[16] Selection into exporting may imply that sample selection issues arise when estimating (19). Specifically, according to (14), the outcomes along the extensive and intensive margins are generated by different data processes, respectively, resulting in error terms that are correlated between the equation for selection into exporting and the export volume equation. The binary participation equation is specified by way of the following pooled Probit model with correlated random effects:

$$P(\text{Export}_{it} = 1 | \text{Export}_{it_0}, e_t, \alpha_{it}, e_t \times \alpha_{it}, gdp_t, z_{it}, \bar{z}_i) \tag{20}$$

where the coefficient on the initial conditions Export_{it_0}, the export status at the time the firm enters the sample, provides a direct test of the potential importance of export hysteresis in trade and satisfies the exclusion restriction, and $\bar{z}_i$ are time averages of the explanatory variables (Mundlak, 1978).[17] As we seek to infer whether the impact of exchange rate movements on the export probability is lower for firms that rely more on intermediate inputs, interaction terms are again included in (20). In order to take the initial conditions problem into account, we use an approximate reduced-form specification for selection in the first period.

[16] This also accounts for the fact that exports are generated by a limited dependent variable process including a large fraction of zeros. Alternatively, the benchmark equation could be modeled by way of a Poisson model of the following form with parameter vectors defined as row vectors: $E(R_{it}|e_t, \alpha_{it}, x_{it}) = exp(\beta_0 + \beta_1 e_t + \beta_1 \alpha_{it} + \beta_3 e_t \times \alpha_{it} + \beta_4 gdp_t + \gamma z_{it})$.

[17] Note that the data at hand do not allow us to estimate a dynamic model including the export status in the previous period. The inclusion of $\text{Export}_{i,t-1}$ reduces the number of observations by more than one half as firms drop out and may re-enter over time. As a consequence, we are no longer able to obtain sufficiently precise estimates. However, the inclusion of the initial condition should be able to provide an adequate approximation of the selection process that we intend to model. As we include the initial condition rather than past export status, we are interested in effects on the extensive margin of trade in general rather than in a direct test of the hysteresis hypothesis.

The outcome equation in log-linear form with correlated random effects is given by:

$$E(r_{it}|\text{Export}_{it}=1)=\delta_0+\delta_1 e_t+\delta_2\alpha_{it}+\delta_3 e_t\times\alpha_{it}+\delta_4 gdp_t+\theta_1 z_{it}+\theta_2\bar{z}_i+\rho\hat{\lambda}_{it} \qquad (21)$$

where $\hat{\lambda}_{it}$ the inverse Mills ratio obtained from estimating (20) included in the RE estimation of (21) that accounts for selection.

Stratified sampling and sample selection.

Recall that firms that are larger in terms of employment have been oversampled by applying variable probability sampling. Furthermore, the response rate of firms is roughly 35% in all periods. There is good reason to believe that larger, more productive firms are possibly more likely to respond simply because they have higher labor endowments, and that firm response depends on firm-specific conditions in t, i.e., the response selection is probably endogenous. Exploiting the panel nature by conditioning on a set of time averages of the explanatory variables as in (21) allows us to account for a general form of sample selection that is evident from the non-response in period t_0.[18]

Sampling issues lead to weighted estimators that allow for the stratification, where observations are weighted by the inverse of the sampling probability. Weighting can be applied to the models specified above.

For simplicity, we define the weighted estimator $\widehat{\theta}_w$ that is a solution to the general minimization problem as follows:

$$\min_{\theta\in\Theta}\sum_{i=1}^{N_0} p_{\ell_i}^{-1} q(w_i,\theta), \qquad (22)$$

where $p_{\ell_i}, \quad \ell=1,...,L$ is the weight that is attached to i, with $i=1,...,N_0$ the stratum for observation i; and $q(w_i,\theta)$ the objective function chosen to identify the population parameters using random draw w_i.[19]

[18] Note that this cannot take a potential correlation of non-response with the business cycle into account.

[19] Standard errors have to be corrected accordingly. The weights have been adjusted for the response probability of the firm such that $p_{\ell_i}=p_{\ell_i^0}/E(\hat{r}_i)$, where $E(\hat{r}_i)$ was obtained from a binary response model for the response probability on firm characteristics (language and geographic region, industry and size class); see Ley (2013).

6.2 Firm-level results

The results from estimating (19) as shown in Table 5 reveal a number of findings. First, they suggest that the effect of an increase in the real effective exchange rate index by 1% decreases exports by 0.3% (column 1). The choice of different exchange rate indices does not affect the robustness of this results (columns 3 and 5). Second, while the exchange rate effect is considerable in magnitude, TFP, firm size, the intermediate input share, and GDP seem to be more important in magnitude. In contrast, R&D activity has a smaller impact on firm-level exports. Third, the interaction between the exchange rate and the firm-level intermediate input share reported in even columns shows that as the intermediate input share increases, the negative effect of the real effective exchange rate becomes less and less important. Using the results in column 2 for instance, at the mean intermediate input share of 41.8%, the effect of the REER would be -0.368. At a share of 53% (the 75-th percentile), the effect would become positive, amounting to 0.012. To provide an interpretation of the interaction effect, we summarize the direct partial effect of the exchange rate evaluated along the distribution of α_{it} visually in the left-hand side panel of Figure 2. Overall, if one may assume that a large fraction of intermediate input shares are imported from abroad, our findings provide evidence of a natural hedging mechanism through increased firm-level integration. With oversampling of large firms, this may be a plausible assumption since it has been shown empirically that exporting and importing firms are larger in size (Bernard et al., 2007). However, in the absence of precise measures of the imported intermediate input share, the results should be generally interpreted with care.

Next, we estimate equations 20 and 21 to account for selection into exporting. We show the results in Table 6. The table suggests the following. Conditional on firm's export participation, the effect of the exchange rate becomes insignificant whereas other fundamentals (GDP) as well as exporter size and the intermediate input share still matter. This is shown in Panel A. However, we find evidence for a significant and negative effect of the REER on export activity once we interact the variable with the intermediate input share and thus take firm heterogeneity into account. As the computation of marginal interaction effects in nonlinear models is complicated, we report the marginal effect evaluated at the mean intermediate input share. It amounts to about -0.2 and remains robust across different choices of the REER as shown in even columns of Table 6. In addition, the effect of REER evaluated along the distribution of α_{it} is reported in the right-hand side panel of Figure 2.[20] In line with the results for the intensive margins presented without accounting for selection bias, the marginal effects are increasing in firm-level interme-

[20] The correct interaction effects (see Norton et al., 2004) are reported in the Appendix.

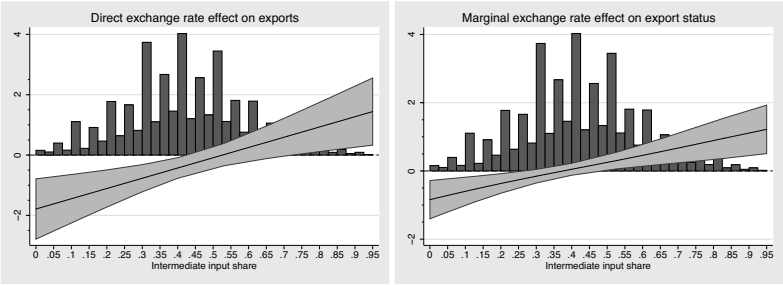
Table 5: EXCHANGE RATES AND FIRM-LEVEL EXPORTS

	(1)	(2)	(3)	(4)	(5)	(6)
A. Fixed effects regressions						
TFP	0.555***	0.565***	0.554***	0.562***	0.555***	0.560***
	(0.098)	(0.096)	(0.098)	(0.097)	(0.098)	(0.098)
Employees	1.002***	1.000***	1.002***	1.000***	1.001***	1.001***
	(0.056)	(0.055)	(0.056)	(0.056)	(0.056)	(0.056)
R&D	0.081**	0.076**	0.081**	0.079**	0.081**	0.079**
	(0.034)	(0.033)	(0.034)	(0.033)	(0.034)	(0.034)
REER	-0.300*	-1.789***	-0.334*	-1.402***	-0.336**	-1.208**
	(0.168)	(0.510)	(0.178)	(0.493)	(0.170)	(0.470)
α_{it}	1.660***	-14.052***	1.658***	-9.536**	1.659***	-7.496
	(0.240)	(5.014)	(0.240)	(4.736)	(0.240)	(4.587)
REER$\times\alpha_{it}$		3.399***		2.459**		2.014**
		(1.079)		(1.037)		(1.006)
Foreign GDP	1.051***	1.031***	0.974***	0.950***	0.962***	0.941***
	(0.141)	(0.140)	(0.152)	(0.152)	(0.153)	(0.154)
Obs.	4,528	4,528	4,528	4,528	4,528	4,528
No. groups	1,983	1,983	1,983	1,983	1,983	1,983
B. Weighted Regressions (using sampling weights)						
TFP	0.496***	0.507***	0.496***	0.510***	0.496***	0.509***
	(0.107)	(0.105)	(0.107)	(0.105)	(0.107)	(0.106)
Employees	0.894***	0.889***	0.894***	0.890***	0.894***	0.892***
	(0.081)	(0.081)	(0.081)	(0.081)	(0.081)	(0.082)
R&D	0.103*	0.096*	0.103*	0.098*	0.103*	0.098*
	(0.054)	(0.054)	(0.055)	(0.055)	(0.055)	(0.055)
REER	0.054	-1.586**	0.065	-1.655*	0.062	-1.521*
	(0.310)	(0.797)	(0.336)	(0.899)	(0.324)	(0.870)
α_{it}	1.503***	-16.559**	1.504***	-17.103*	1.503***	-15.592*
	(0.302)	(7.956)	(0.302)	(9.041)	(0.302)	(8.959)
REER$\times\alpha_{it}$		3.910**		4.094**		3.766*
		(1.719)		(1.985)		(1.970)
Foreign GDP	0.622**	0.657**	0.635**	0.651**	0.637**	0.653**
	(0.267)	(0.264)	(0.266)	(0.264)	(0.268)	(0.265)
Obs.	4,528	4,528	4,528	4,528	4,528	4,528
No. groups	1,983	1,983	1,983	1,983	1,983	1,983

Notes: ***, **, *, $^{\#}$ denote statistical significance at the 1%, 5%, 10% and 15% level, respectively. Fixed effects regressions (firm fixed effects) with robust standard errors. The sample covers the years 1996, 1999, 2002, 2005, 2008, 2011, and 2013. Dependent variable: log real exports. Independent variables except R&D in logs. Columns (1) and (2) use the log REER from SNB; columns (3) and (4) use log REER calculated from HS8-digit export data (Eidgenössische Zollverwaltung EZV); columns (5) and (6) use log REER calculated at the 2-digit level (matched NOGA industry and HS8 trade classification). Each specification is reported without (in uneven columns) and with (in even columns) interaction effects of REER and firm-level intermediate goods shares in turnover. Sampling weights in Panel B are response-probability adjusted.

diate input share. This may indicate that increased integration would allow firms to benefit from exchange rate appreciations of home currency and thus provides further evidence for the relevance of natural hedging. In line with previous literature (e.g., Campa, 2004), the strong effect of export participation in the initial period also points to sunk costs that may produce hysteresis in exports. This implies that firms that exit export markets due to an exchange rate appreciation need a disproportionately strong depreciation to re-enter the export market. In contrast to the results obtained in Table 5, the results suggests that the REER affects the extensive rather than the intensive margin of exports, where we are not able to confirm a significant relationship between the two after correcting for selection into exporting (Panel B).[21]

Figure 2: REER EFFECTS EVALUATED AT PERCENTILES OF INTERMEDIATE INPUT SHARE



Notes: Partial and marginal effects at percentiles and the maximum of the distribution of α_{it} (intermediate input share in turnover). LHS: Fixed effects regressions with log export volume as the dependent variable. RHS: Pooled probit regressions with a binary variable for firm export participation at time t as the dependent variable. 90% confidence intervals shown. A histogram of the distribution of firm-level intermediate input shares is shown in both figures.

6.3 Discussion

The results shown in Tables 5 and 6 are informative regarding the heterogeneity of the exchange rate effect across different types of firms. More specifically, we have analyzed – conditional on important firm-level export determinants – how differences in intermediate input shares affect

[21] In addition to the above analysis we have checked the sensitivity of the results to using firm-level sales as the dependent variable. Specifically, we used real firm-level turnover. This variable is not adjusted by profits due to data availability. The exchange rate effect amounts to about -0.2 across all REER measures, but including an interaction term of the REER and the intermediate input share leads to insignificant results for both the constituting as well as the interaction term. In line with the results for exports, there is no significant REER effect on the intensive margin once we control for selection at the extensive margin (export status).

Table 6: EXCHANGE RATES AND FIRM-LEVEL EXPORTS

	(1)	(2)	(3)	(4)	(5)	(6)
A. Participation equation (Probit AME)						
Initial export	0.378***	0.378***	0.381***	0.380***	0.380***	0.379***
	(0.013)	(0.013)	(0.011)	(0.010)	(0.011)	(0.010)
TFP	0.063*	0.060*	0.059*	0.057*	0.058*	0.056
	(0.033)	(0.033)	(0.035)	(0.034)	(0.035)	(0.035)
Employees	0.051*	0.048	0.064**	0.056**	0.063**	0.057**
	(0.031)	(0.030)	(0.027)	(0.025)	(0.027)	(0.025)
R&D	0.004	0.004	0.003	0.0004v	0.002	-0.0001
	(0.019)	(0.019)	(0.019)	(0.019)	(0.020)	(0.019)
REER	0.026	n.r.	0.095	n.r.	0.040	n.r.
	(0.127)		(0.105)		(0.096)	
α_{it}	0.108	n.r.	0.158	n.r.	0.154	n.r.
	(0.100)		(0.101)		(0.101)	
REER$\times\alpha_{it}$		-0.206***		-0.216***		-0.232***
		(0.059)		(0.026)		(0.028)
Foreign GDP	-0.106	-0.099	-0.095	-0.079	-0.086	-0.073
	(0.076)	(0.075)	(0.070)	(0.069)	(0.070)	(0.069)
B. Outcome equation						
TFP	0.145	0.150	0.146	0.150	0.143	0.147
	(0.203)	(0.212)	(0.196)	(0.208)	(0.200)	(0.208)
Employees	0.755***	0.760***	0.755***	0.761***	0.754***	0.756***
	(0.142)	(0.143)	(0.141)	(0.139)	(0.143)	(0.146)
R&D	0.122	0.121	0.123	0.122	0.121	0.118
	(0.109)	(0.113)	(0.115)	(0.118)	(0.118)	(0.121)
REER	-0.044	0.623	-0.004	0.869	-0.081	0.333
	(0.538)	(1.668)	(0.578)	(1.805)	(0.580)	(1.799)
α_{it}	1.142**	8.709	1.145**	10.854	1.139**	5.892
	(0.558)	(16.274)	(0.554)	(17.966)	(0.579)	(17.633)
REER$\times\alpha_{it}$		-1.637		-2.134		-1.048
		(3.524)		(3.973)		(3.901)
Foreign GDP	1.676***	1.678***	1.662***	1.659***	1.663***	1.659***
	(0.387)	(0.400)	(0.382)	(0.353)	(0.368)	(0.382)
Obs.	6,043	6,043	6,043	6,043	6,043	6,043

Notes: ***, **, *, # denote statistical significance at the 1%, 5%, 10% and 15% level, respectively. Two-step Heckman regressions with bootstrapped standard errors in Panel B. All regressions include means of the firm-level explanatory variables over time and are weighted by the sampling weights (adjusted for response probability). The sample covers the years 1996, 1999, 2002, 2005, 2008, 2011, and 2013. Independent variables except R&D and initial export status (binary) in logs. Dependent variables: export status (0=non-exporter, 1=exporter) at time t in Panel A, log export volume in Panel B. Columns (1) and (2) use the log REER from SNB; columns (3) and (4) use log REER calculated from HS8-digit export data (Eidgenössische Zollverwaltung EZV); columns (5) and (6) use log REER calculated at the 2-digit level (matched NOGA industry and HS8 trade classification). Each specification is reported without (in uneven columns) and with (in even columns) interaction effects of REER and firm-level intermediate goods shares in turnover. Panel A reports average marginal effects from pooled probit regressions (marginal effects of REER at the mean of α_{it} in uneven columns). Constituting terms are included in the probit regressions but not reported (n.r.).

the exposure to exchange rate shocks by way of natural hedging. The conclusions obtained from the analysis may also be viewed in light of the heterogeneity across industries rather than firms. For this purpose, we may compare average intermediate input shares indicated in the survey at question to integration in GVCs as reported by the OECD and used in the previous sections.[22] It is evident from Table 7 that total intermediate input shares are slightly higher than the foreign value added content of gross exports with the exception of the chemical and the textile sectors. This is due to home-country sourcing as well as oversampling of large firms. Accounting for the latter would allow us to assume that the shares in Column 2 versus Column 3 are closely correlated. Then, we may hypothesize that exporters in highly integrated sectors such as textiles, chemicals, and transport equipment are on average able to naturally hedge against exchange rate appreciations. The reverse is true for exporters in industries that are on average integrated to a lesser degree, for instance, in the agricultural, the mining and quarrying, the food products, and the wood products sectors. Of course, these figures have to be interpreted with care as precisely comparable figures are missing.

Table 7: INTERMEDIATE INPUT SHARES

Industry	Exports	Foreign VA	I-share
Agriculture, hunting, forestry and fishing	780.2	19.79	0.31
Mining and quarrying	97.8	16.97	0.25
Food products, beverages and tobacco	11894.4	24.23	0.53
Textiles, textile products, leather and footwear	2582.9	42.85	0.41
Wood, paper, paper products, printing and publishing	8048.0	23.77	0.39
Chemicals and non-metallic mineral products	54365.1	42.12	0.43
Basic metals and fabricated metal products	13274.5	31.42	0.37
Machinery and equipment, nec	26832.4	33.09	0.44
Electrical and optical equipment	41040.9	32.43	0.40
Transport equipment	3378.6	40.14	0.45
Manufacturing nec; recycling	4973.7	33.00	0.40

Notes: Source: OECD TiVA (2013), figures for 2009; Foreign value added content shares (Column 1) of gross exports in USD (Column 1). I-share: total inputs/turnover (α_{it}), source: KOF innovation panel (1996-2011). Figures are averages over time. We have roughly allocated ISIC sectors to IO industries.

[22] It would be preferable to pursue the previous empirical analysis by industry, however, this would restrict the sample size such that we are no longer able to obtain sufficiently precise results. Note that they are given for the year 2009 (cross section) by the OECD and calculated over time for the firm sample, however, the intermediate input shares prove to be stable over time.

7 Conclusion

In this study, we asked whether changes in the exchange rate affect both the intensive and extensive margins of trade. To do so, we analyzed Swiss HS 6-digit product panel data and a panel data set of manufacturing firms from the KOF innovation survey. The Swiss franc has sharply appreciated after the recent economic crisis and is still strong, despite the cap that the Swiss National Bank has put on the exchange rate in 2011. We hypothesized that sectors that are highly (backward) integrated in global value chains may naturally hedge against such a development. The decrease in relative prices of imported intermediate inputs may mitigate or even offset the negative effects of an appreciation on profit margins. Furthermore, we studied export hysteresis, i.e., the question whether fluctuations in the exchange rate have a permanent effect on exports. The results obtained from both aggregate and firm-level data are qualitatively robust. Our results suggest that the exchange rate effect is decreasing in firm-level and industry-level integration. We also find evidence for substantial market entry costs as past exports are shown to be important determinants of the extensive margin of trade. This points to the possibility that temporary appreciations may affect the export structure in Switzerland permanently.

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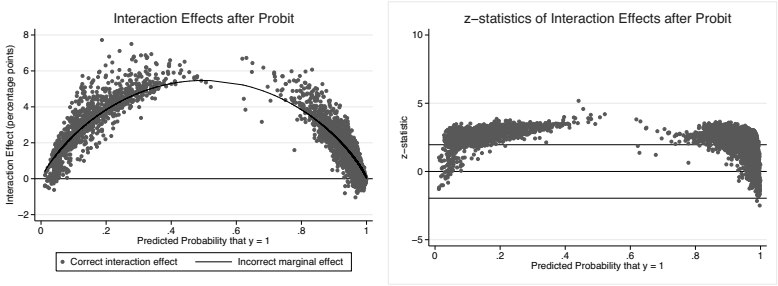
A Appendix

Table A1: PROBIT INTERACTION EFFECTS OF EXCHANGE RATE AND INTERMEDIATE INPUT SHARE

Export status	(1)	(2)	(3)
Interaction effect	1.722	1.828	1.642
Standard error	0.723	0.824	0.740
Z-statistic	2.187	2.035	2.085
Obs.	5875	5875	5875

Notes: Column (1) uses the log REER from SNB; column (2) uses log REER calculated from HS8-digit export data (Eidgenössische Zollverwaltung EZV); column (3) uses log REER calculated at the 2-digit level (matched NOGA industry and HS8 trade classification). Marginal interaction effect of two continuous variables, the log exchange rate index and the firm-level intermediate input share in turnover. Dependent variable: export status at time t (0=no exports, 1=exports). Marginal effects of other variables suppressed.

Figure A1: PROBIT INTERACTION EFFECTS OF EXCHANGE RATE AND INTERMEDIATE INPUT SHARE



Notes: Marginal interaction effect of two continuous variables, the log REER index (SNB) and the firm-level intermediate input share in turnover on export status. Left-hand side panel plots the interaction effect for non-linear models calculated as the cross-partial derivative of the expected value of the dependent variable (see Norton et al., 2004), and the interaction effect calculated by the conventional linear method) against predicted probabilities. Right-hand side panel plots z-statistics of the interaction effect against predicted probabilities.

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www.seco.admin.ch, wp-sekretariat@seco.admin.ch
ISBN 978-3-905967-23-4