The Skill-Biased Effects of Exchange Rate Fluctuations

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Abstract

This paper examines the linkages between real exchange rate movements and firms' skill demand. Real exchange rate movements may affect unskilled workers differently than skilled workers because of skill-specific adjustment costs, or because exchange rates lead to changes in relative factor prices and firms' competition intensity. Using panel data on Swiss manufacturers, we find that an appreciation increases high-skilled and reduces low-skilled employment in most firms, while total employment remains roughly unchanged. We find evidence that exchange rates influence firms' skill intensity because they affect outsourcing activities, innovation efforts, and firms' compensation schemes.

Keywords: Labor Demand; Skill Intensity; Employment; Real Exchange Rates; Firms' Foreign Exposure

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1 Introduction

A growing literature demonstrates that the effects of movements in real exchange rates on overall employment and wages are very heterogeneous across *industries* and *firms* (Campa and Goldberg, 2001; Revenga, 1992; Alexandre et al., 2011; Nucci and Pozzolo, 2010; Moser et al., 2010). However, much less is known about the heterogeneity of the exchange rate effects on employment and wages of *workers with different skill levels* within firms. Are high-skilled workers less exposed to exchange rate shocks than low-skilled workers? Does the low responsiveness of total employment to real exchange rate movements established in previous firm-level studies hide that firms change their skill content of production when affected by real exchange rate movements? To understand if and to what extent such distributional effects exist is relevant for the individual worker, but also in at least two further respects. First, if an exchange rate appreciation mainly lowers employment of low-skilled workers with poor prospects of finding new jobs, the welfare consequences and the associated costs for social security systems may be more substantial than if high-skilled workers are dismissed. Second, studying the effects of exchange rates on skill groups sheds light on how greater trade integration affects the skill intensity of production. The reason lies in the symmetry as to how tariffs and exchange rates affect domestic prices (Feenstra, 1989). Our results therefore complement recent papers studying the impact of trade liberalization on skill demand, most notably Bustos (2011).

From a theoretical perspective, there are three main reasons why exchange rate movements may have asymmetric effects on workers with different skills. First, in a flexible labor market, higher hiring and firing costs for skilled employees relative to unskilled employees may lead to a comparatively lower responsiveness of skilled employment when firms face an exchange rate shock (Hamermesh and Pfann, 1996; Blatter et al., 2012; Oi, 1962) (*adjustment costs channel*). Second, exchange rate movements alter relative factor prices. The impact on the individual worker is thus likely to depend on the elasticity of substitution between his labor input, remunerated in home currency, and other imported inputs to production remunerated in foreign currencies. Since other input factors such as (foreign) capital and (imported) intermediate inputs are generally thought to complement high-skilled labor while potentially substituting low-skilled labor (Krusell et al., 2000; Parro, 2013; Burstein et al., 2013), exchange-rate-induced factor price changes may lead to adjustments in the skill mix of firms (*relative factor price channel*). Third, changes in real exchange rates affect the firms' price competitiveness on the export market and the domestic market. In recent years, a large literature has emerged documenting that the intensity of competition that firms face affects their production methods, productivity, and employment relationships (Berman et al., 2012; Ekholm et al., 2012; Bertrand, 2004; Guadalupe, 2007; Lu and Ng, 2013). These responses to changes in competition, in turn, may lead to shifts in the skill intensity of production (*indirect competition channel*).[1]

This paper empirically examines the linkages between movements in the real exchange rate and skill-specific employment in Swiss manufacturing firms. To this end, we rely on panel data based on the KOF innovation survey covering the period 1998–2012. The main advantage of this data set is that it not only allows us to estimate the elasticities of skill-specific employment to exchange rate movements, but also to analyze how the potential skill-bias in the effect of exchange rate fluctuations emerges. We examine several potential sources: outsourcing of tasks with different complexity, innovation choices, overall investment as well as investment in information and communication technologies (ICT). The motivation for investigating the mechanisms is that the three channels highlighted above have different medium-term consequences for the demand for skills. For instance, if in the case of an appreciation, low-skilled jobs are more strongly shed than high-skilled jobs only because of differences in adjustment costs across skill groups, low-skilled jobs lost during the appreciation might reappear if the currency devaluates. If, by contrast, firms respond to a real appreciation by adjusting their mode of production or their input mix, exchange rate movements might have longer-term impacts on firms' relative skill demand, as these changes may be costly to reverse.

Analyzing the case of Switzerland appears particularly interesting for two reasons. First, Switzerland is a small open economy with exports amounting to 52.3% of GDP in 2012. The average Swiss manufacturing firm therefore

[1] An important implication of these theoretical considerations is that they question the validity of the empirical strategy of a set of earlier papers which examine the nexus between competition and relative skill demand or offshoring. The strategy generally employed in this literature amounts to instrumenting the extent of (import) competition that a firm or an industry faces using import exchange rates as an instrument. Yet, if exchange rates exert a direct effect on relative skill demand through the adjustment cost and the relative factor price channel highlighted above, the exclusion restriction of this identification strategy—i.e. that exchange rates affect outcomes only through (import) competition—may be violated.

depends quite heavily on exports, and hence, is prone to movements in real exchange rates. Second, the Swiss franc acts as a safe haven currency. In periods of economic turmoil and increased uncertainty in financial markets, this special status of the Swiss currency can generate substantial movements in exchange rates which can be regarded as exogenous shocks to Swiss manufacturing firms. The implications of such currency movements on the competitive position of Swiss firms are illustrated in Figure 1, which depicts the evolution of competitiveness-weighted real unit labor costs in selected OECD countries.[2] The figure shows the relative loss in competitiveness resulting from the strong appreciation of the Swiss franc relative to the Euro and the U.S. Dollar in the course of the sovereign debt crisis from 2009 onward. The vertical line marks the ceiling on the EUR/CHF exchange rate that was subsequently introduced by the Swiss National Bank (SNB) in September 2011 among others to ease the competitive pressure put on Swiss exporters.

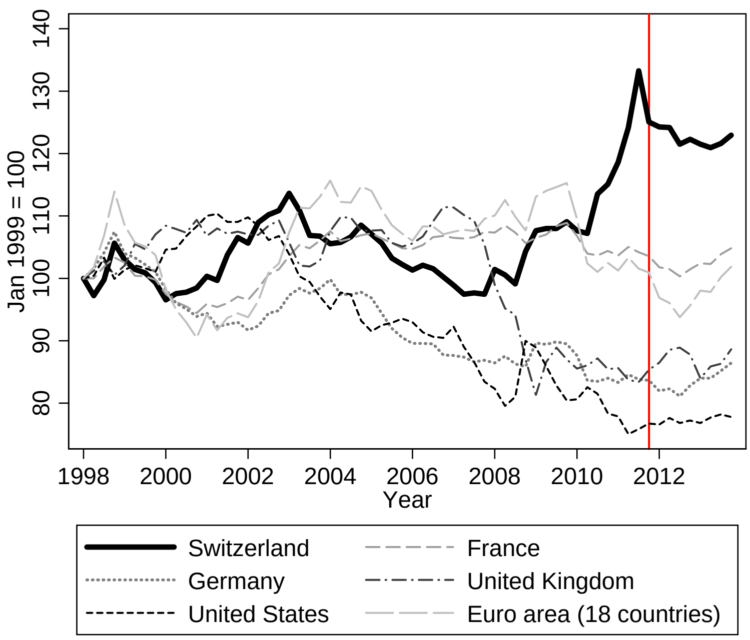

Figure 1: Competition-weighted relative unit labor costs 1998–2013 for selected developed countries (*Source: OECD*)

Our empirical results imply that overall full-time equivalent employment in the average surviving exporting firm is *not* reduced if the Swiss franc appreciates. One explanation for this finding is that the negative effects arising from

[2]To be precise, the figure shows the evolution of a country's unit labor costs translated into U.S. dollars at the current exchange rate in comparison to a weighted average of the unit labor costs of a country's main competitors on its domestic market and its export markets.

reductions in revenues are offset by the positive effects arising from the reduced costs of imported intermediate inputs, as firms rely heavily on imported inputs and their labor demand responds more strongly to changes in costs than to changes in revenues. Another explanation is that Swiss exporters absorb the impact of currency appreciations through reducing profitability instead of shedding labor.

Yet, the exchange rate impacts on employment are heterogeneous across skill groups. Specifically, we find that high-skilled workers suffer less than low-skilled workers from reduced export revenues if the currency appreciates while, at the same time, they seem to benefit more from cheaper imported intermediate inputs. These skill-specific exchange rate elasticities seem to be partly the result of exchange-rate-induced adjustments in firms' production. In particular, our findings suggest that an appreciation leads to outsourcing of production-related tasks and induces firms to increase their R&D activities and upgrade the quality of their products. Moreover, we find evidence that an appreciation increases the importance of performance-oriented remuneration schemes at the expense of rule-based schemes, in line with Bertrand's (2004) hypothesis on the effects of competition on employment relationships. Overall, low-skilled workers appear to be more strongly exposed to firm-level adjustments triggered by an appreciation of the real exchange rate than high-skilled workers.

The remainder of this paper is organized as follows. Section 2 briefly summarizes the related literature dealing with the effects of exchange rate movements on labor market outcomes. In Section 3, we discuss important theoretical considerations with regard to the transmission of exchange rate movements on overall labor demand and skill-specific demand. Section 4 describes our econometric framework. Section 5 explains the data and presents descriptive statistics and Section 6 contains the results of our empirical analysis. Finally, Section 7 contains some concluding remarks.

2 Related literature

The earlier strand of the literature used industry-level data to study the wage and employment effects of real exchange rate movements. The most prominent paper is Campa and Goldberg (2001)[3], who analyze the effects of real exchange

[3]Other important earlier contributions on the relationship between exchange rates and employment are Revenga (1992), Burgess and Knetter (1998), and Gourinchas (1999).

rates on changes in net employment and wages in the U.S. manufacturing sector using panel data on 20 two-digit industries from 1972 to 1995. They find an average real wage elasticity to a permanent depreciation of the U.S. Dollar of 0.06, while employment elasticities are close to zero. Overtime wage payments and overtime hours worked are more sensitive to exchange rate fluctuations than overall wages and hours worked because the adjustment costs are lower for overtime labor. In addition, industries with higher export orientation respond more strongly to exchange rate movements because a higher share of foreign sales intensifies the exposure to exchange rates.

As opposed to Campa and Goldberg (2001) who analyze *net* job flows, Klein et al. (2003) emphasize the importance of studying *gross* job flows to measure the adjustment costs of labor re-allocation due to exchange rate movements. Even within narrowly defined industries, there exists a large degree of variation in openness, such that the analysis of net job flows might mask important allocative effects. Using industry data on the 4-digit SIC level on U.S. manufacturing for 1973-1993, the trend component of the real effective exchange rate (REER) is found to have a significant positive effect on job re-allocation within industries (job destruction plus job creation), while the cyclical component only affects job destruction.

In the more recent literature, a small number of papers have employed firm-level (i.e. micro) data to study the impact of exchange rate swings on labor market outcomes.[4] Moser et al. (2010) examine establishment-level data to investigate the effect of competitiveness on net job flows in Germany. They find that fluctuations in competitiveness (real wage costs) have a small but significant impact on net job flows of German manufacturing establishments. The main transmission channel of an exchange rate appreciation runs through lower job creation rather than higher job destruction. This is partly attributed to the tight regulation of the labor market in Germany (e.g., costly dismissals), but also to the fact that job destruction caused by bankruptcies are not taken

[4]Another related strand of literature examines the effects on the *overall* effect of real exchange rate movements on workers on the labor market using household survey data. That is, these papers do not study the implications of exchange rate movements on workers through labor demand of firms, but consider the general equilibrium effects of exchange rate fluctuations on workers. Assessing the overall impact is complex, as exchange rates not only directly affect employment and wages through labor demand (and potentially supply), but also job transition probabilities and consumption prices. The number of papers that attempts to assess these effects is relatively small and focuses on the U.S (Goldberg et al., 1999; Goldberg and Tracy, 2003) and Mexico (Robertson, 2003).

into account (attrition bias).

Similar results based on Italian firm-level data are reported by Nucci and Pozzolo (2010) who find a considerable impact of exchange rate swings on both employment and hours worked. In Nucci and Pozzolo (2014), using the same data set and the same empirical strategy, they also document a sizable impact of real exchange rate movements on firms' average wages. These authors also provide evidence that a firm's employment sensitivity to exchange rate movements depends, for a given level of external exposure, on its market power. In particular, they show that the impact of exchange rate movements is more pronounced the lower its mark-up power. These results are in line with a broad recent trade literature stressing the importance of the firms' mark-up power in mediating the impacts of exchange rate movements on individual firms. A firm's price-setting power, in turn, is determined among other things by the price elasticity of demand, the degree of price competition on its selling market, product differentiation and productivity (cf., Berman et al., 2012; Chatterjee et al., 2013).

Overall, the existing literature has focused on how the characteristics of firms determine the impact of real exchange rate shocks on net job flows and has emphasized the substantial job reallocation on the micro level caused by exchange rate shocks. However, to the best of our knowledge, there exists no study focusing on how these induced firm-level re-allocations affect workers of different skills, i.e., there is not study how exchange rates affect the skill intensity of production.[5]

3 Theoretical considerations

3.1 Exchange rates and the transmission to domestic firms

From a theoretical perspective, real exchange rates may affect the labor demand of domestic producers in several ways. In the model of Campa and Goldberg

[5]The studies of Campa and Goldberg (2001) and Nucci and Pozzolo (2010) both present regressions in which they interact the employment elasticity of the exchange rate with the initial share of non-college or blue-collar workers, respectively. Both studies show that these worker characteristics have a quantitatively meaningful influence on the magnitude of the employment response to exchange rate movements in the unit of observation. Yet, both studies abstain from examining the sources for this impact in more detail.

(2001), there exist three different transmission channels related to the trade exposure of firms. First, if the REER appreciates, domestic production becomes relatively more expensive compared to foreign production, thus lowering price competitiveness. The REER therefore affects firms through their degree of *export orientation*. A more export-oriented firm is more adversely affected by an appreciation than a firm mainly selling to the domestic market, ceteris paribus. Second, an appreciation in the REER leads to higher *import competition* because foreign producers become more price competitive in the domestic market. Taken together, these two channels suggest that an appreciation of the domestic currency forces firms to make adjustments which are potentially carried out through a reduction of labor inputs. The third channel through which REER exert an influence on firms runs in the opposite direction: an appreciation reduces production costs through cheaper *imported inputs*. If a firm relies heavily on imported intermediate inputs, but at the same time mainly sells to the domestic market, the "natural hedging" due to the fall in production costs may be substantial and offset the other negative effects.

As Nucci and Pozzolo (2010) show, the firm's mark-up power is another important dimension that shapes the intensity by which firms are exposed to the competitive pressure of REER movements. If there is imperfect competition such that firms can exert market power, there tends to be a positive pass-through in the foreign market, meaning that firms adjust their foreign-currency prices as a response to currency movements. These authors show that more market power (and thus higher pass-through into prices in foreign currency) attenuates the reduction in labor demand if the exchange rate appreciates. Nucci and Pozzolo (2010) also note that the importance of the effect of exchange rates on imported input costs depends crucially on the substitutability between imported and domestic inputs as governed by firms' production technology. In the extreme case of no possibility to substitute, exchange rate swings will have the most pronounced impact on profitability, and thus on labor demand.

3.2 Transmission to skill composition

There are three main ways as to how movements in the exchange rate can affect the skill mix of firms' labor demand. First, if hiring and firing costs vary with the skill-level of workers, firms may be more reluctant to dismiss workers with certain skills when faced with an exchange rate shock. In flexible labor markets, adjustment costs (i.e., hiring and firing costs) are likely to increase with skill-level for two reasons.[6] On the one hand, skilled workers generally possess more firm-specific human capital, rendering them more costly to replace. On the other hand, expected search costs are generally higher for more demanding positions, particularly in a labor market characterized by shortages of skilled workers, as in Switzerland (Hamermesh and Pfann, 1996; Blatter et al., 2012; Oi, 1962).

Second, movements in the exchange rate alter the relative factor prices of domestic inputs vs. foreign inputs, giving rise to a direct channel through which exchange rate fluctuations can affect the demand for different skills (*relative factor price channel*). In general, changes in the *input mix* caused by an exchange rate appreciation are likely to lower the relative demand for unskilled work in the domestic labor market. The reason is that the two most important production inputs other than domestic labor, intermediate inputs and capital, are thought to complement high-skilled labor while potentially substituting low-skilled labor. Consider the case of intermediate inputs. If, for instance, the home currency appreciates in real terms, imported intermediate inputs become relatively cheaper for domestic firms. This can cause the production of low-skilled and routinized material inputs and services to be moved abroad, as offshoring is most likely to happen for intermediate inputs that are standardized and require little coordination. At the same time, more offshoring activities might require more managerial resources, thus raising the demand for skilled work (Biscourp and Kramarz, 2007; Crinò, 2009; Hijzen et al., 2005; Becker et al., 2013). Similar arguments apply to capital goods if they are entirely or partially produced abroad. An appreciation of the exchange rate lowers their price relative to the price of domestic labor, incentivizing firms to acquire capital goods, as pointed out by Eaton and Kortum (2001). In the presence of capital-skill complementarity, i.e., if capital goods are complementary to high-skilled workers in production while substituting low-skilled workers (Krusell et al., 2000), an appreciation of the currency might increase the relative demand for high-skilled at the expense of low-skilled workers.[7]

As a third channel, exchange rates affect the firms' price competitiveness

[6] This may be different in countries where legal protection from lay-offs is more extensive for low-skilled workers.

[7] This exchange rate effect on skill demand is equivalent to the effect of lower *trade costs* on the skill-intensity of production through capital accumulation studied in two recent theoretical papers by Burstein et al. (2013) and Parro (2013).

on the export markets and the domestic market (Campa and Goldberg, 2001; Ekholm et al., 2012; Guadalupe, 2007; Lu and Ng, 2013). Changes in the intensity of price competition, in turn, may have asymmetric effects on workers with different skill levels (*indirect competition channel*). This is the link studied in the literature examining the effects of (import) competition on the demand for different skills. There are several mechanisms how competition may affect skill demand. Competition may incentivize firms to increase their innovation efforts,which raises the demand for skilled labor (Aghion et al., 2005; Lu and Ng, 2013). In a similar vein, Lu and Ng (2013) argue that if firms produce a range of products that are differentiated by quality, they will tend to shift production towards higher-quality products when import competition increases. The reason is that low-quality, mass-production goods are typically more strongly affected by import competition. This adjustment in the output mix is likely to increase the skill intensity of production. Similarly, competition may increase relative skill demand because higher import competition from abroad induces firms to update their capital faster and/or leads to a re-allocation of activities within industries towards more capital-intensive firms (Guadalupe, 2007; Ekholm et al., 2012; Lu and Ng, 2013).[8] Taken together, these mechanisms suggest that exchange-rate-induced increases in competition can generate shifts in labor demand favoring skilled labor at the expense of unskilled labor, thus reinforcing the effects operating through the relative price and the adjustment cost channel.

The effects of exchange rates on the skill intensity of production highlighted here are very similar to the effects studied in the literature that relates trade integration and changes in trade costs to the skill intensity of production. The similarity arises because tariffs and exchange rates have an equivalent effect on domestic prices (the symmetry hypothesis, cf. Feenstra, 1989). In line with our argument, recent work in this literature typically suggests that greater trade integration increases the skill intensity of production. For instance, an empirical paper by Bustos (2011) finds that a strong reduction in tariffs shifted the

[8]The model of Guadalupe (2007) establishes a direct link from competition to the demand for skills. If firms have heterogeneous cost functions and high-skilled labor is in limited supply, increased competition implies a rise in the relative profits of efficient firms. This reallocation effect within industries makes productive workers more valuable, thus increasing the demand for skilled workers. Ekholm et al. (2012) show that the strong real appreciation of the Norwegian Krone between 2000 and 2002 increased productivity growth in exporting firms which were strongly exposed to exchange rate movements due to a high export share relative to their share of imported inputs.

relative demand for skills in Argentinean firms upward, especially because exporting firms upgrade their technology. Other papers in this literature postulate that trade affects the skill intensity of production by increasing incentives for quality upgrading (Verhoogen, 2008) or innovation (cf., e.g., Acemoglu, 2003; Thoenig and Verdier, 2003; Bloom et al., 2011).

4 Econometric approach

Our empirical framework is organized in a panel structure where firm $i = 1, ..., N$ is the cross-section unit which belongs to some (three-digit) industry $j \in J$. Firm i is observed repeatedly during T_i time periods, where subscript i indicates that the panel is unbalanced. Following the approach taken by Nucci and Pozzolo (2010), we specify the following equation for the labor demand of firms:

$$\begin{aligned} \Delta y_{ijt} = \alpha_0 &+ \alpha_1 \Delta R^X_{jt} XS_{ij,t-1} + \alpha_2 XS_{ij,t-1} + \alpha_3 \Delta R^X_{jt} \\ &+ \alpha_4 \Delta R^I_{jt} IS_{ij,t-1} + \alpha_5 IS_{ij,t-1} + \alpha_6 \Delta R^I_{jt} \\ &+ X_{ijt}\beta + \theta_j + \theta_t + u_{ijt}. \end{aligned} \tag{1}$$

The model in (1) is specified in first differences, such that firm fixed effects in the *level* of the outcome are accounted for. Thus, we can allow unobserved time-constant heterogeneity to be arbitrarily correlated with the covariates.

The dependent variable of interest, Δy_{ijt}, refers to the change in the firm's (log) employment, or a component thereof. The explanatory variable of main interest is the (log) change in the *real effective exchange rate* (REER), denoted by ΔR_{jt}. As indicated by subscript j, we allow REER to be *industry-specific*. This takes into account the important fact that exporting industries can differ substantially in their mix of trading partner countries such that movements in a specific bilateral exchange rate have an asymmetric impact on domestic firms located in different industries. We use two different exchange rates. First, R^X_{jt} is an export-weighted REER and takes into account the composition of destination countries of industry exports plus the importance of competitor countries in these export markets. Second, R^I_{jt} is an imported-inputs-weighted exchange rate that accounts for the mix of source countries of intermediate inputs specific to domestic industry j.[9] The variable $XS_{ij,t-1} \in [0, 1]$ is the

[9] More details on the construction of these exchange rates are provided in the next section and in Appendix A. In contrast to previous papers, we do not decompose exchange rates into permanent and transitory components and only use the permanent component of the

share of annual revenues attributable to exports and indicates the degree to which a firm is exposed to the export REER on the revenue side. As in Moser et al. (2010), this variable is lagged one period to mitigate issues of simultaneity in the specification. Similarly, $IS_{ij,t-1}$ is the share of imported intermediate input costs in overall variable input costs and is also lagged one period. The vector θ_j contains industry fixed effects that account for industry-specific trends in employment, following Nucci and Pozzolo (2010). In the regressions on skill-specific employment, these trends account for constant industry-specific differences in the speed at which changes in the industry's skill structure of employment take place. Similarly, θ_t represents a set of time period dummies to capture aggregate macroeconomic shocks common to all firms, such as changes in aggregate prices, demand, interest rates, or fiscal policies. Finally, u_{ijt} is the usual idiosyncratic error term which we assume to be strictly exogenous with respect to the covariates.

In the baseline specification, the vector of controls, X_{ijt}, comprises four variables: two predetermined variables accounting for the firm's past and expected demand in period $t-1$ meant to capture past trends in the outcome and the firm's expected demand development at the start of the period, the beginning-of-period price-over-cost margin, accounting for firms' initial profitability, and a variable representing the trade-weighted change in real GDP in industry j's export markets ($\Delta FGDP_{jt}$). The reason why we include the last covariate is that the Swiss franc is, as mentioned in the introduction, a safe haven currency. Movements in the Swiss franc could therefore be related to changes in international demand. To the extent that these movements are industry-specific and hence not absorbed by period fixed effects, controlling for foreign demand is necessary to account for the potential correlation between the industry-specific exchange rates and industry-specific changes in foreign demand.

The elasticity of the outcome with respect to the export REER depends on the firm's (lagged) export share and equals:

$$\varepsilon_{R^X} = \alpha_1 \cdot XS_{ij,t-1} + \alpha_3. \tag{2}$$

exchange rate in the estimation. The reason is that our exchange rates are constructed as changes in annual averages of monthly data, which we view as approximating changes in permanent exchange rates. The results are, however, qualitatively similar if we use changes in the annual average of monthly permanent exchange rates as determined by moving averages over three months.

A priori, we would expect that α_3 is close to zero because, ceteris paribus, there should be no first-order impact of the export REER on a non-exporting firm ($XS_{ij,t-1} = 0$). Assuming that Δy_{ijt} is negatively affected by a rise in REER, α_1 will be negative, which implies that ε_{R^X} decreases with the firm's export share. Similarly, for the imported inputs REER, we have the elasticity

$$\varepsilon_{R^I} = \alpha_4 \cdot IS_{ij,t-1} + \alpha_6. \tag{3}$$

where again we expect that α_6 is close to zero and $\alpha_4 > 0$ because an appreciation has a larger positive effect for firms that rely heavily on imported inputs.

The model in eq. (1) exploits both cross-sectional variation and time variation to estimate the effect of exchange rates on employment. First, the effect is identified by changes in the export and imported input shares (i.e., $XS_{ij,t-1}$ and $IS_{ij,t-1}$), and changes in the movements of the industry-specific real exchange rates (R^X_{jt} and R^I_{jt}). The latter arise because of the heterogeneity in the geographic location of the industries' trading partners as well as its main competitors.[10] This is illustrated in Figure 2, which shows the growth rates of the export REER for three selected industries in our 6 sample periods. While the overall movements in the export REER are similar, the intensity of the exchange rate shocks differ throughout the sample period. For example, the Swiss printing industry was more heavily exposed to the appreciation of the Euro from 2007 to 2010 than the two other industries as more than 80% of its exports flow to the Euro area.

Second, we also identify the exchange rate effect due to firm-level differences in the exposure to exchange rate fluctuations on the revenue side and cost side of their income statements. More specifically, the two interaction terms in our main specification represent two of the three transmission channels that shape firms' exposure to exchange rate movements highlighted by Campa and Goldberg (2001) and discussed above. Thus, we generally abstract from the third transmission channel, the import competition channel, analogous to Campa and Goldberg (2001) and Nucci and Pozzolo (2010). One reason is that it is con-

[10] A potential limitation of our identification strategy is that we do not observe firms' use of financial derivatives to hedge currency risks. However, we believe that this does not lead to a substantial bias in our results, since evidence suggests that hedging against movements in real exchange rates over a three-year horizon is relatively uncommon (see also Ekholm et al., 2012, for a similar argument).

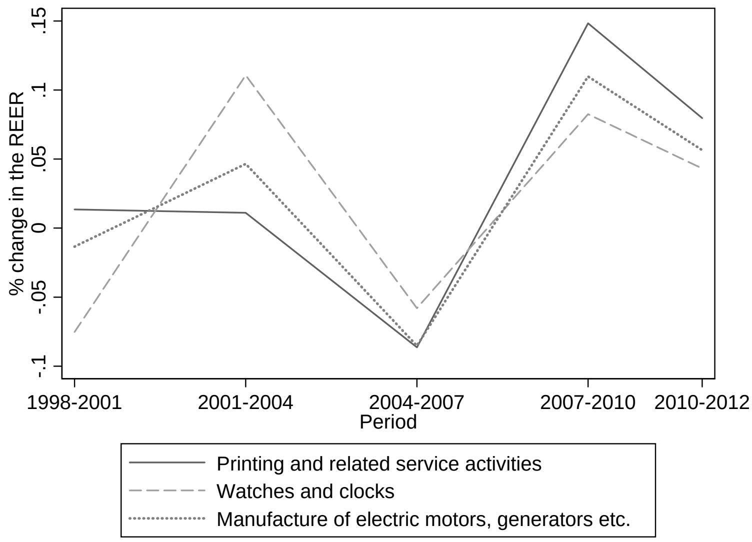

Figure 2: Export-weighted real effective exchange rate for three Swiss industries 1998–2012

ceptually difficult to separate the effect of import competition from the effect of export orientation, since both effects operate through changes in firms' price competitiveness. Another reason is the high intra-industry correlation between between import penetration and imported input use (Campa and Goldberg, 2001). We pursue two strategies to try to control for changes in import competition. First, we constructed two firm-specific proxies that measure changes in the extent of price competition that firms face on the domestic market.[11] Including these variables had not qualitative impact on the results presented in this paper[12], even when including interaction terms between these indicators and the log change in the industry-specific import exchange rate that reflects the geographic composition of an industry's imports. Second, we test a specification with a full set of industry-time fixed effects. Since import competition is generally measured on the industry-level using a Herfindahl index (cf., e.g., Ekholm et al., 2012), industry-level changes in competition are then accounted for.

[11]The first proxy is constructed using the period-to-period growth in the number of competitors that firms report to have in their main selling market. This growth rate was then multiplied with the firms' initial share of domestic sales in total sales (i.e. $1 - XS_{ij,t-1}$). Following the same logic, we also use an interaction between $1 - XS_{ij,t-1}$ and the period-to-period change in a standardized, 5-point Likert scale variable revealing the firms' perceived intensity of price competition.

[12]The results when adding these controls to the regressions models are available from the authors upon request.

5 Data

5.1 Data sources and variable definitions

We draw on a range of sources to construct the data set for our empirical analysis. The main source is the innovation surveys of the KOF Swiss Economic Institute. These surveys were conducted among Swiss companies between 1999 and 2013 in six waves (1999, 2002, 2005, 2008, 2011, and 2013). All surveys are based on a representative sample of the manufacturing industry, construction and business services sector in Switzerland and are disproportionately stratified with respect to firm size and two-digit industry affiliation.[13] Since there is a substantial time lag between the surveys, only about 50% of the firms responded to two successive surveys such that the panel is highly unbalanced. Because industry-specific exchange rates can only be constructed for tradable industries, the empirical analysis is restricted to within-firm changes in the *manufacturing* sector. In our baseline specification, we have 2,259 period-to-period within-firm changes that belong to 1,194 firms.

The firm-level micro-data provide information on the main outcome variables considered in this paper, i.e., overall employment and the skill structure of the firm's labor force. Most of these outcomes refer to the year before the survey took place, or, as in the case of full-time equivalent (FTE) employment, to the headcount at the end of the year prior to the survey. A disadvantage of the data set is that we do not directly observe the share of *imported* intermediate inputs in total intermediate inputs.[14] On the other hand, an important advantage of the survey data set for our analysis is that it also contains information on firms' outsourcing, investment, R&D choices, motives for innovation, wage-setting behavior, external orientation and perceived competition. These survey data allow us to study in more detail the potential channels that lead to a skill-biased effect of exchange rate fluctuations.

The export real effective exchange rate (REER) of the Swiss franc used in

[13]The raw data contain answers for 2172, 2586, 2555, 2141, 2363, and 2034 firms, respectively, representing an average response rate of 34.7%. The survey questionnaires can be downloaded from www.kof.ethz.ch/en/surveys.

[14]We multiply the import share in intermediate inputs on the *industry-level* with the *firm-level* share of intermediate inputs in total variable costs to obtain a measure of IS_{ijt}. The industry-level data is based on the Swiss input-output table from 2001. This approach is also used in Nucci and Pozzolo (2010), Nucci and Pozzolo (2014) and Fauceglia et al. (2014), the latter of which applied this procedure to study the natural hedging of Swiss firms against exchange rate fluctuations.

the analysis is specific to each NACE three-digit industry. The imported inputs REER is less disaggregated and is specific to ten different composite two-digit industries.[15] Both exchange rates are weighted averages of the nine most important bilateral real exchange rates for Switzerland.[16] For the imported inputs REER, the currencies are weighted according to the industry-specific geographic composition of Swiss imported inputs as derived from the OECD TiVA database. The export REER is 'double-weighted', i.e., the weights not only reflect the fraction of an industry's exports to the nine currency regions, but also the fact that movements in the bilateral exchange rate affect the competitiveness of Swiss exporters relative to those from the trading partners in the (eight) other export markets in which they compete. We refer to Section A in the Appendix for more details on the construction of the industry-specific REER and the sources of the trade data required for these calculations, and to Section C in the Appendix for detailed information on data sources and the construction of all the variables used in the analysis.

5.2 Descriptive statistics

Table 1 provides summary statistics on outcomes and covariates in our firm-level dataset. The average number of full-time equivalent workers is around 180, but there is a large amount of variability. The firm size distribution is heavily skewed to the right, with many small firms and few very large firms. When breaking down employment into education groups, we notice a large amount of heterogeneity, especially for highly educated workers. This variability in the skill composition of firms is also reflected in the distribution of average firm-level wages.

[15] Exchange rates are specified on the industry level because we do not have firm level data on the destination countries of firms' exports and the source countries of firms' imports. Thus, we cannot construct firm-specific exchange rate measures.

[16] The real exchange rates are provided by the Swiss National Bank (SNB) and are constructed using consumer price indices. Using producer price (PPI) or wholesale price indices (WPI) would be conceptually preferable, since they reflect prices of traded goods more appropriately. However, different countries have different methods and baskets to construct PPIs and WPIs, thus strongly limiting comparability across countries. Countries differ less in their methodology to compute CPIs, such that using CPIs to construct trade-weigted exchange rates remains standard. Moreover, movements in real exchange rates are strongly driven by nominal exchange rate fluctuations. In fact, robustness tests reveal that the results are similar when using nominal instead of real exchange rates in the regressions. The choice of the price deflator to construct real exchange rates is hence of second-order importance for the results presented in the paper.

Table 1: Descriptive Statistics

	mean	s.d.	Q25	Median	Q75
FTE employees	179.3	428.1	26.0	81.0	175.0
Tertiary education	40.5	186.8	3.0	9.6	30.8
Secondary education	72.2	172.6	10.0	29.7	73.7
Primary education	52.8	97.4	6.6	23.5	60.8
Annual av. wage (in 1000 CHF)	88.9	31.2	72.2	86.2	101.3
Sales (in mil. CHF)	73.7	249.9	6.0	21.0	57.3
Labor share	0.603	0.173	0.493	0.611	0.725
Double-export-weighted REER (growth)	0.023	0.073	-0.024	0.033	0.074
Imported inputs-weighted REER (growth)	0.025	0.078	0.005	0.036	0.068
Export share in turnover	0.395	0.376	0.010	0.300	0.800
Share of imported inputs in total var. costs	0.143	0.055	0.107	0.138	0.177
Foreign GDP (growth)	0.068	0.037	0.038	0.069	0.098
Price-cost margin	0.222	0.133	0.130	0.200	0.290
Number of competitors	15.8	19.5	2.5	8.0	13.0
Past demand	3.2	1.1	2.0	3.0	4.0

Notes: The sample contains all observations of the firms in the estimation sample. Growth rates refer to changes between cross-section periods.

The average growth rates in the exchange rates are around 2.5% for both the export REER and the imported inputs REER, but they exhibit a substantial amount of variation. A decomposition of the overall variance into components due to *between* variation and *within* variation shows that the between-firm variation in the export and imported inputs REER accounts for 27% and 26% of total variation, respectively. These numbers suggest that most of the variation occurs across time.

It is especially noteworthy that manufacturing firms are very heterogeneous with respect to their export orientation. The average export share is 39.3%. The 1st and 3rd quartiles imply that at the lower tail, almost 25% of firms are non-exporters, while at the upper tail, 25% of firms earn more than 80% of their revenue in exports. By contrast, firms are much more homogeneous in their share of imported input costs in total variable costs: this variable has a mean of 14.3% and a standard deviation of 5.5.

6 Empirical results

6.1 Effects on total employment and wages

The first column of Table 2 presents the results when estimating our baseline regression model on the log change in the number of full-time equivalent (FTE) employees in the firms. As detailed in Section 4, the OLS regression includes period dummies (θ_t) and industry fixed effects (θ_j).[17] The standard errors are cluster-robust to take into account potential serial correlation at the firm level. At the bottom of the table, we present for the average firm in the estimation sample the "export-side elasticity" ($\bar{\varepsilon}_{R^X}$) and "import-side elasticity" ($\bar{\varepsilon}_{R^I}$), i.e., the elasticity of the outcome variable with respect to the export and imported inputs REER, respectively, evaluated at the sample mean of the corresponding share variable. Throughout the paper, we restrict the baseline effects of both REER (the coefficients on ΔR^X_{jt} and ΔR^I_{jt}) to be zero, as we expect that firms with zero exports and zero imported inputs experience no first-order impact of real exchange rate movements. The bottom of the regression tables therefore contain the p-value of a F-test on the joint hypothesis that the baseline effects are zero (i.e., $H_0 : \alpha_3 = \alpha_6 = 0$). The tests indicate that the parameter restriction is supported by the data on the 5% significance level in all cases but one, in which we thus include these baseline effects.

The baseline regression in the first column shows that the higher the firms' initial export share, the more negative is the effect of an appreciation of the export REER on employment. The coefficient in the first column implies that a 1% appreciation of the export REER reduces FTE employment by 0.3% due to reductions in revenues for the average firm in the sample (with $XS_{ij,t-1}$=39%). However, employment is substantially shielded from the exchange rate shock because of reductions in the costs of intermediate inputs. The estimate on the interaction between the change in the industry's imported inputs exchange rate ΔR_{jt} and the firm's lagged imported input share $IS_{ij,t-1}$ is statistically significantly positive. The estimated export and import elasticities in fact imply that the appreciation of the Swiss franc in the course of the crisis in the Euro area from 2007 to 2010, during which the export exchange rate appreciated by $\Delta R^{EX}_{jt} = 12.3\%$, had no statistically significant negative effect on FTE employment in the average *surviving* manufacturing firm in the sample.[18]

The average effect, however, masks considerable heterogeneity in the effects for different firms. Figure 3 illustrates this. It shows the percentage change in

[17] The industry trends as well as the industry-period effects included in one of the extensions are on NACE 3-digit level. The inclusion of these trends has no qualitative effects on the results but the coefficients tend to be more precisely estimated.

[18] This conclusion, however, does not incorporate a possible negative impact of the appreciation on employment through increasing import competition for domestically oriented firms.

FTE employment for a firm which is hit by a 1% appreciation of both REER (i.e., $\Delta R^I_{jt} = \Delta R^X_{jt} = 1\%$), depending on its combination of imported inputs share $IS_{ij,t-1}$ and export share $XS_{ij,t-1}$. The straight line marks the combinations of $XS_{ij,t-1}$ and $IS_{ij,t-1}$ for which the appreciation does not lead to a change in FTE employment. Our baseline results imply that a 1% appreciation increases FTE employment by +1% in some firms in the estimation sample, while other firms reduce FTE employment by −0.9%.

The estimated export and import elasticities in Column 1 of the table are remarkably similar to those estimated by Nucci and Pozzolo (2010) for Italian manufacturing firms. They are, however, substantially larger than the employment elasticities reported by Campa and Goldberg (2001), who use data on four-digit U.S. manufacturing industries. One possible explanation for the higher employment elasticity in our compared to the U.S. case is that average wage paid in the firm does not statistically significantly react to the export and the imported inputs REER, as Column 6 of Table 2 indicates.[19] The limited responsiveness of wages to exchange rates is likely to give rise to higher employment elasticities to exchange rates, and is consistent with previous studies showing that wages in Switzerland are surprisingly rigid despite the relatively flexible labor market (cf., e.g., Fehr and Goette, 2005).

Columns 2–5 of the table illustrate the robustness of our baseline results concerning FTE employment. The regression in the second column shows that the estimated exchange rate elasticities do not depend on the inclusion of the covariates meant to capture industry-specific and firm-specific demand-side effects. This suggests that real exchange rate shocks are orthogonal to firm-level demand shocks (conditional on the period fixed effects). The regression in Column 3 augments the baseline model with industry-time fixed effects. The addition of the dummies does not affect the coefficients of the variables of interest.[20]

In Column 4, we estimate the previous model in levels rather than first differences by shifting the lagged dependent variable from the left- to the right-hand-side of the estimation equation. Since OLS is necessarily inconsistent in

[19]Another potential reason for the different employment and wage elasticities between our study and the study of Campa and Goldberg (2001) is that industry-level data may mask substantial within-industry reallocation of employees across firms (Nucci and Pozzolo, 2010; Klein et al., 2003; Gourinchas, 1999). Hence, estimated elasticities at the firm level tend to be larger than estimated elasticities at the industry level.

[20]Note that the two baseline effects of the exchange rates (ΔR^X_{jt} and ΔR^I_{jt}) are absorbed in this specification since the industry-time effects account for the variation on the jt-level.

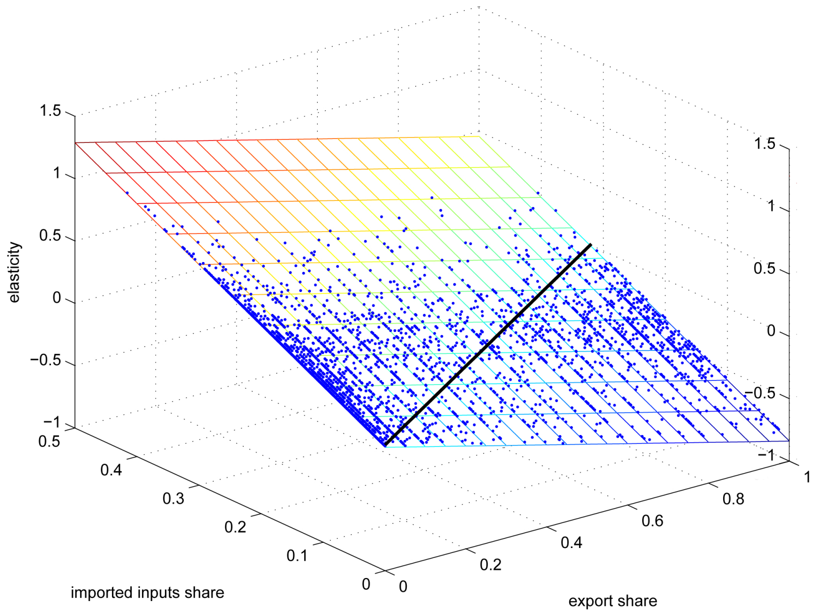

Figure 3: Winners and losers: elasticity of FTE employment to a 1% appreciation of the real exchange rates depending on firms' export share in revenues ($XS_{ij,t-1}$) and imported inputs share in variable costs ($IS_{ij,t-1}$)

this case because the lagged dependent variable $y_{ij,t-1}$ is correlated with the error term, we estimate the resulting dynamic employment model by employing the System GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998).[21] The lagged mark-up variable is also treated as potentially endogenous as it may be correlated with the firm-specific effect in the level equation. We thus use GMM-type instruments for the mark-up variable to ensure consistency of the parameter estimates. In the bottom of the table, we examine the validity of the specification by conducting a Hansen test of the overidentifying restrictions (which assesses the orthogonality between instrumental variables and the disturbance terms), and the Arellano-Bond test for second-order serial correlation of residuals in the first-differenced equation, which examines the assumption of serial independence in the difference equation.[22]

The results when applying the System GMM estimator shown in Column

[21]Incidentally, the resulting regression model is very similar to the employment regressions estimated in the original contributions by Arellano and Bover (1995) and Blundell and Bond (1998) to illustrate the usefulness of their estimator. See also Bond and Reenen (2007) for further discussions on the issues arising when estimating dynamic labor demand models.

[22]A significant AR(2) test statistic would also question the validity of using second lags of endogenous variables as instruments for the current values. The estimations are performed using the one-step GMM estimator. The coefficients and the estimated standard errors are, however, very similar when applying the two-step estimator.

4 are very similar to the corresponding OLS results in first differences. In Column 5, we augment the specification with the second lag of the dependent variable to assess whether the adjustment lags that usually characterize changes in employment in firms extend over a period of six rather than three years.[23] While the second lag of the dependent variable turns out to be not statistically significant, it also does not influence the estimated employment elasticities, as they are very comparable to the OLS results in first differences for the same subsample (not shown).

Overall, although the natural-hedging effect of cheaper intermediate inputs appears to be relevant, there are a number of other reasons why an appreciation does not lead to a reduction in FTE employment in the average manufacturing firm. First, the *responsiveness* to real exchange rates operating through the cost side is stronger than the responsiveness through the revenues side. Second, Swiss manufacturer may have comparatively large scope in setting prices owing to their favorable market position (cf. Siegenthaler, forthcoming), which may allow them to pass through the exchange rate shocks to their selling prices. Indeed, as in earlier studies (Campa and Goldberg, 2001; Nucci and Pozzolo, 2010; Alexandre et al., 2011), we find that the firms' competitive environment shapes the elasticity of employment to exchange rate movements.[24] Third, the relatively high initial mark-ups also provide some leeway to Swiss manufacturers to absorb exchange rate shocks by lowering their profit margins rather than by dismissing workers or cutting wages, as further regressions indicate.[25]

[23]This re-specification obviously leads to a drop in the sample size since only firms which are observed during four consecutive survey periods can be used for estimation.

[24]In particular, Table A.3 in the Appendix shows that the export-side elasticity exceeds the import-side elasticity in firms which perceive price competition to be relatively fierce or which have comparatively high initial mark-ups. The table presents separate regressions for firms with low and high initial price-cost margins (Columns 1 and 2), and for firms with low and high perceived initial price competition relative to the average firm in their industry (Columns 3 and 4). Firms are asked to assess on a 5-point Likert scale the intensity of price competition they face. We use the firms answer to this question in $t-1$ in order to split the sample.

[25]In particular, the last column of Table A.3 in the Appendix reveals that an appreciation of the Swiss franc decreases the firms' price-cost margins (i.e., revenues minus labor costs and intermediate input costs divided by revenues), which is a common proxy for the firms' mark-up. The regression illustrates that costs of Swiss manufacturers decline by less than their revenues, which suggests that firms absorb part of the exchange rate shock in profit margins. Burgess and Knetter (1998) document similar patterns after exchange rate movements in German and Japanese industries.

Table 2: Effect of exchange rate movements on total FTE employment and wages

VARIABLES	(1) Δ E Baseline	(2) Δ E Basic	(3) Δ E Extended	(4) E Sys GMM	(5) E Sys GMM	(6) Δ w
$\Delta R^X_{jt} \times XS_{ij,t-1}$	-0.770***	-0.847***	-0.879***	-0.656***	-0.459*	0.328
	(0.217)	(0.222)	(0.302)	(0.217)	(0.269)	(0.276)
$\Delta R^I_{jt} \times IS_{ij,t-1}$	3.145**	3.190**	2.855	3.175*	4.010*	-0.408
	(1.525)	(1.579)	(2.392)	(1.658)	(2.068)	(2.413)
$XS_{ij,t-1}$	-0.003	0.028	0.036	0.034	-0.028	-0.063**
	(0.019)	(0.018)	(0.027)	(0.041)	(0.049)	(0.026)
$IS_{ij,t-1}$	0.110	0.061	0.401*	0.267	0.126	1.560***
	(0.131)	(0.140)	(0.210)	(0.165)	(0.237)	(0.296)
Expected demand $(t-1)$	0.040***		0.041***	0.044***	0.047***	-0.005
	(0.007)		(0.007)	(0.009)	(0.014)	(0.008)
Past demand $(t-1)$	0.036***		0.028***	0.025***	0.021*	-0.010
	(0.007)		(0.009)	(0.008)	(0.011)	(0.007)
Mark-up $(t-1)$	0.126***		0.156***	0.122**	-0.014	0.578***
	(0.047)		(0.055)	(0.059)	(0.071)	(0.104)
$\Delta FGDP_{jt}$	0.138			0.485	0.338	0.018
	(0.416)			(0.373)	(0.441)	(0.925)
ΔR^I_{jt}	0.000	0.000		0.000	0.000	0.000
	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
ΔR^X_{jt}	0.000	0.000		0.000	0.000	0.000
	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
$y_{ij,t-1}$				0.953***	0.984***	
				(0.034)	(0.037)	
$y_{ij,t-2}$					0.046	
					(0.048)	
Constant	-0.072***	-0.043*	-0.278**	0.073	-0.205	-0.127
	(0.027)	(0.025)	(0.141)	(0.128)	(0.138)	(0.084)
Observations	2,259	2,259	2,259	2,259	1,091	2,015
$\bar{\varepsilon}_{R^X}$	-0.302***	-0.332***	-0.345***	-0.257***	-0.181*	0.130
	[0.085]	[0.087]	[0.119]	[0.085]	[0.106]	[0.109]
$\bar{\varepsilon}_{R^I}$	0.449**	0.455**	0.407	0.453*	0.573*	-0.058
	[0.218]	[0.225]	[0.341]	[0.237]	[0.295]	[0.345]
Period effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry trends	Yes	No	Yes	No	No	Yes
Industry-period effects	No	No	Yes	No	No	No
p-value test $\alpha_3 = \alpha_6 = 0$	0.83	0.72		0.48	0.88	0.77
p-value Hansen J test				0.350	0.450	
p-value AR(2) test				0.650	0.560	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.2 The skill-biased effect of exchange rate movements

The main argument of this paper is that although many firms may not strongly adjust total employment to changes in the REER, workers with certain skills may be more exposed to those movements than others. Table 3 therefore presents estimations of the baseline model (eq. 1) separately for two groups: high-skilled workers as well as medium/low-skilled workers. Workers are assigned to these two groups based on their highest educational attainment.[26]

The results suggest that there exists a skill bias in the effects of exchange rate fluctuations. Column 1 shows that high-skilled workers are not significantly affected by exchange rate movements on the revenue side although the point estimate of the interaction term $\Delta R^X_{jt} \times XS_{ij,t-1}$ is negative. However, high-skilled workers clearly benefit from reductions in the costs of intermediate inputs if exchange rates appreciate. Taking the point estimates of the two exchange rate interactions at face value, a real appreciation of the Swiss franc actually increases FTE employment of high-skilled workers for most firms in our estimation sample.

The situation is different for low- and medium-skilled workers. Contrary to high-skilled workers, their export-side elasticity is statistically significant and negative and is approximately twice as large. Moreover, low- and medium-skilled workers do not benefit from reduced costs of intermediate inputs. In fact, the robustness tests to these regressions shown in Table A.4 in the Appendix indicate that it is mainly in the exposure to this import-side elasticity in which high-skilled and less-skilled workers differ. A further refinement of the result is presented in Table A.5 in the Appendix, which shows employment elasticities separately for high-, medium-, and low-skilled workers as well as for apprentices. These regressions indicate that the negative effect of reduced revenues on less-skilled employment is nearly exclusively due to the effect on medium-skilled workers. On the other hand, the point estimate of the import-side elasticity increases with the skill level of the worker group.

In Columns 3 and 4 of the table, the exercise is repeated for the imputed wage bill of the two skill groups, i.e., the outcome variable is the product of the

[26]Low-skilled workers are those who have not attained a secondary school degree or apprenticeship (results for apprentices are shown in Table A.5 in the Appendix). High-skilled workers have a post-secondary degree. Since the regressions in Table 3 are estimated on log changes and the same sample of firms, only firms with a positive number of employees in each of the skill categories remain in the estimation sample.

Table 3: Effect of exchange rate movements on number of FTE employees of different skill groups

VARIABLES	(1) Employment High-skilled	(2) Employment Medium-/ Low-skilled	(3) Wage bill High-skilled	(4) Wage bill Medium-/ Low-skilled
$\Delta R^X_{jt} \times XS_{ij,t-1}$	-0.700	-1.103***	-0.692	-1.039***
	(0.612)	(0.358)	(0.618)	(0.372)
$\Delta R^I_{jt} \times IS_{ij,t-1}$	11.299***	0.287	11.175***	-0.101
	(3.665)	(2.285)	(3.702)	(2.402)
$XS_{ij,t-1}$	0.112**	0.034	0.120**	0.026
	(0.050)	(0.032)	(0.052)	(0.033)
$IS_{ij,t-1}$	-0.072	0.330	-0.100	0.403
	(0.482)	(0.262)	(0.481)	(0.274)
Expected demand $(t-1)$	0.067***	0.030***	0.071***	0.027***
	(0.017)	(0.009)	(0.018)	(0.009)
Past demand $(t-1)$	0.034**	0.038***	0.036**	0.043***
	(0.017)	(0.009)	(0.017)	(0.010)
Mark-up $(t-1)$	0.201*	0.149**	0.222*	0.172**
	(0.113)	(0.066)	(0.116)	(0.069)
$\Delta FGDP_{jt}$	0.877	1.633	0.210	1.430
	(2.125)	(1.210)	(2.156)	(1.257)
ΔR^I_{jt}	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
ΔR^X_{jt}	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.087	-0.259***	0.109	-0.190*
	(0.166)	(0.096)	(0.168)	(0.100)
Observations	1,918	1,918	1,886	1,886
$\bar{\varepsilon}_{R^X}$	-0.286	-0.450***	-0.281	-0.422***
	[0.250]	[0.146]	[0.251]	[0.151]
$\bar{\varepsilon}_{R^I}$	1.633***	0.041	1.611***	-0.014
	[0.530]	[0.330]	[0.534]	[0.346]
Period effects	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes
p-value test $\alpha_3 = \alpha_6 = 0$	0.27	0.80	0.24	0.88

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

number of FTE workers with their imputed average wage.[27] This is an important robustness test, as skill-groups may differ in the relative responsiveness of wages and employment to exchange rates. For example, minimum wage regulations might hinder firms in adjusting the wages of low-skilled workers, giving rise to a higher reaction of low-skilled employment to the REER compared to high-skilled workers. Comparing Columns 3–4 with Columns 1–2 in Table 3, we see that the numerical results of the wage-bill regressions are very close to those obtained from the employment regressions. Thus, we find no evidence for skill-specific wage adjustments in response to exchange rate shocks.

These results indicate, first, that surviving manufacturing firms respond to movements in the real exchange rate by adjusting their composition of workers. Second, they indicate that unskilled workers are much more exposed to exchange rate movements than skilled workers. As has been argued in Section 3, the skill-biased effect of exchange rate changes might result from (i) skill-specific adjustment costs for hiring and firing, (ii) changes in relative factor prices or (iii) changes in competition. These potential sources of the skill bias in exchange rate movements differ in their implications for unskilled workers. If the exchange rate fluctuations are skill biased because firms adjust their method of production, jobs lost during an appreciation period may not reappear if the currency devaluates. By contrast, if low-skilled jobs are reduced because of differences in adjustment costs across skill groups, firms might rehire low-skilled workers in subsequent devaluation periods.

6.3 Examining potential channels

In this section, we thus examine how exchange rate movements affect firms' adjustments in production methods. We do this by estimating a set of reduced form regressions that have the same form as in the previous analysis. The approach is justified by the notion that real exchange rates are exogenous for the individual firm. As before and conceptually similar to Ekholm et al. (2012), we capture exchange rate effects on the different outcomes by analyzing the two

[27]The reason why we need to use an imputed average wage is that our data does not provide skill-group specific wages. We therefore predict them using the Swiss wage structure survey. In particular, we estimate average skill-group specific wages by three-digit industry, firm size category, and NUTS-II region and subsequently assign these average wages to each firm in the data set. The wage structure surveys covers between 15% and 50% (depending on the year) of all employees in firms with more than 3 employees in Switzerland, which allows for precise estimation of mean wages by skill group in each of the region-industry-size cells.

interaction terms indicating the firm-specific exposure to exchange rate movements on the revenue side ($\Delta R^X_{jt} \times XS_{ij,t-1}$) and the cost side ($\Delta R^I_{jt} \times IS_{ij,t-1}$). This analysis reveals whether there are systematic differences in outcomes between firms with different degrees of exchange rate exposure.

One adjustment to exchange rate shocks with a potentially persistent effect on the firm's skill demand is outsourcing parts of production.[28] Our survey data provide a direct measures of firms' outsourcing activities. In particular, in the waves 2005, 2008, and 2011, firms were explicitly asked whether they have outsourced complex tasks (R&D and IT), production-related tasks (final production and product components), or services in the years preceding the survey.[29] We examine in a set of OLS regressions in Table 4 whether movements in the real exchange rate lead to changes in the *intensity* of outsourcing.[30] In this table as well as in the following tables, we use (log changes of) exchange rates of the year before the outcome is measured. We do this because we expect that it takes time until exchange rate fluctuations manifest themselves in outsourcing, investment or innovation decisions of firms.[31]

Column 1 of Table 4 suggests that there is no statistically significant effect of exchange rate fluctuations on the outsourcing of complex tasks. By contrast, outsourcing of production-related tasks seems to be increased if firms are confronted with lower revenues due to an appreciation of the exchange rate (Column 2). This effect is not offset by a reduction in outsourcing of these tasks through the cost side for the firm with average export and imported inputs share. The last column of the table also provides suggestive evidence that firms hit by an appreciation of the exchange rate also increase outsourcing of service tasks. Overall, these results suggest that exchange rate movements trigger outsourcing decisions of firms which are potentially associated with shifts in the skill intensity of production.

[28]The focus on outsourcing rather than offshoring is due to data availability: we do not know whether firms outsource tasks to domestic or foreign workplaces. A potential effect of exchange rate fluctuations on the outsourcing intensity of firms identified in our framework, however, is likely to result at least partly in the outsourcing of tasks to foreign workplaces as it is caused by REER movements.

[29]See Section C of the Appendix for further information on the construction of these outcomes.

[30]We also estimated ordered probit models for these outcomes which produced qualitatively similar results.

[31]This is empirically confirmed, i.e., the estimated elasticities, although similar in both cases, are slightly larger and more precisely estimated if we employ the log change of exchange rates that represent averages of monthly exchange rates of the year preceding the outcome instead of the contemporaneous exchange rate (as used above).

Table 4: Effect of exchange rate movements on outsourcing

VARIABLES	(1) Outsourcing Complex tasks	(2) Outsourcing Production	(3) Outsourcing Services
$\Delta R^X_{jt} \times XS_{ij,t-1}$	-0.982	5.435**	2.085
	(1.973)	(2.597)	(1.365)
$\Delta R^I_{jt} \times IS_{ij,t-1}$	-5.114	0.222	-2.944
	(9.447)	(10.641)	(6.304)
$XS_{ij,t-1}$	-0.010	-0.037	0.129**
	(0.086)	(0.119)	(0.064)
$IS_{ij,t-1}$	0.537	0.152	0.522
	(0.823)	(0.937)	(0.518)
Expected demand $(t-1)$	0.007	0.045	0.001
	(0.032)	(0.043)	(0.024)
Past demand $(t-1)$	0.023	-0.041	-0.011
	(0.033)	(0.042)	(0.026)
Mark-up $(t-1)$	0.328	-0.053	0.038
	(0.232)	(0.301)	(0.152)
$\Delta FGDP_{jt}$	1.536	-4.568	0.409
	(6.160)	(6.381)	(5.405)
Constant	-0.379	-0.690**	-0.274*
	(0.230)	(0.321)	(0.163)
Observations	654	654	654
R-squared	0.134	0.158	0.116
Period effects	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes
p-value test $\alpha_3 = \alpha_6 = 0$	0.85	0.14	0.06

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
ΔR^X_{jt} and ΔR^I_{jt} constrained to 0 but not shown

Another potential channel operates through decreasing prices of capital goods. If capital and skill are complementary, increased capital adoption induced by an exchange rate appreciation may shift relative skill demand (Burstein et al., 2013; Eaton and Kortum, 2001; Parro, 2013). Therefore, Table 5 studies the nexus between firms' exposure to exchange rate movements and its investment decisions. The first column shows the effect of changes in real exchange rates on the firms' changes in log gross investment. The regression provides no evidence that the REER and investments are positively associated. On the contrary, the estimated coefficients suggest that an appreciation of the exchange rate lowers investment. This finding is in line with the results of previous studies examining the nexus between investment and exchange rates. These papers generally document a strong negative response of investment to exchange rate changes (Campa and Goldberg, 1995; Nucci and Pozzolo, 2001).[32]

Columns 2 and 3 of Table 5 examine the possibility that exchange rate movements cause firms to switch to potentially more skill-biased capital goods. The columns examine the impact of real exchange rates on changes in log investments in information and communication technology (ICT) (Column 2) and changes in the log share of ICT in total investments (Column 3). We do this for the subsample of firms for which data on ICT investment are available. The reason for the focus on ICT investments is that increases in ICT capital are strongly associated with shifts in labor demand towards skilled workers and are therefore generally thought to be a major cause of capital-skill complementarity (Krusell et al., 2000). The two regressions provide, however, no evidence that an exchange rate appreciation leads to increased ICT investment. If at all, an exchange rate appreciation seems to reduce ICT investment even more than total investment. Consistent with this finding, the fourth column of the table shows no or rather a negative effect of the REER on the change in the ICT user share in firms.[33] Overall, increased incentives to invest in capital in general or ICT capital in particular do not seem to contribute significantly to the apparent skill bias in exchange rate fluctuations.

Table 6 studies two additional channels how real exchange rates may affect the skill intensity of production. The first channel is that firms who face an

[32]The negative impact of exchange rates on investment is usually attributed to the increase in uncertainty associated with exchange rate swings, causing firms to "wait and see" rather than to spend money on potentially irreversible investment (Bloom et al., 2007).

[33]More specifically, the dependent variable in the regression is the change in the log average of the shares of employees in the firm using computers, internet and the intranet, respectively.

Table 5: ICT taking over? Effect of exchange rate movements on ICT use, ICT investment, and investment

VARIABLES	(1) Investment	(2) ICT investment	(3) ICT inv. share	(4) ICT user share
$\Delta R^X_{jt} \times XS_{ij,t-1}$	-0.562	6.834	-1.533	-0.461
	(1.192)	(5.945)	(3.634)	(1.011)
$\Delta R^I_{jt} \times IS_{ij,t-1}$	-11.990	-61.418***	-9.719	-5.417
	(8.271)	(21.082)	(16.696)	(6.093)
$XS_{ij,t-1}$	0.107	0.421**	0.157	-0.101*
	(0.104)	(0.210)	(0.148)	(0.061)
$IS_{ij,t-1}$	-0.094	-4.889**	-1.564	-0.281
	(0.986)	(2.064)	(1.542)	(0.505)
ΔR^I_{jt}	-4.180	0.000	0.000	0.000
	(4.602)	(0.000)	(0.000)	(0.000)
ΔR^X_{jt}	-3.965**	0.000	0.000	0.000
	(1.838)	(0.000)	(0.000)	(0.000)
Expected demand $(t-1)$	0.101***	0.163**	0.105*	-0.054**
	(0.038)	(0.079)	(0.060)	(0.023)
Past demand $(t-1)$	0.061	0.076	-0.030	0.033
	(0.040)	(0.075)	(0.059)	(0.022)
Mark-up $(t-1)$	0.144	-0.010	-0.195	0.072
	(0.279)	(0.542)	(0.355)	(0.172)
$\Delta FGDP_{jt}$	-0.741	-10.283	-5.081	-6.795**
	(5.693)	(14.148)	(11.844)	(3.432)
Constant	0.163	1.074	1.593***	0.434**
	(0.546)	(0.749)	(0.604)	(0.193)
Observations	1,483	593	658	1,229
Period effects	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes
p-value test $\alpha_3 = \alpha_6 = 0$	0.05	0.93	0.41	0.39

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

appreciation of their currency try to escape increased product market competition by developing more innovative products (Aghion et al., 2005; Bloom et al., 2011). We study this hypothesis by examining the impact of exchange rates on firms' R&D adoption. In particular, the outcome of the regression takes on a value of 1 if firms start to have positive R&D expenditures from one period to the next. The outcome is -1 if they stop spending on R&D. Otherwise the variable is zero. The results indeed provide evidence that an appreciation of the export exchange rate positively impacts firms' decisions to adopt R&D. The coefficient of the interaction between the export REER and the lagged export share is statistically significant and positive.

The second channel, studied in Columns 2 and 3 of Table 6, is the effect of competition on the importance of market forces in the determination of wages formulated by Bertrand (2004). In her model, greater price competition incentivizes firms to switch to performance-oriented pay schemes and to reduce pay-setting based on tenure or previous experience. She tests these predictions by comparing the sensitivity of wages to the current unemployment rate relative to the sensitivity of wages to the unemployment rate prevailing at the time of hiring, depending on the competition that firms encounter. She isolates exogenous variation in price competition using exchange rate induced changes in import competition.

Our survey data allow us to more directly measure how exchange rates impact on firms' wage-setting behavior. In particular, firms were asked to assess on a 5-point Likert scale how important certain factors are in determining the wages of their employees. We construct two composite variables from firms' answers to these survey items. The first variable combines the importance of individual and group-specific performance in determining wages, the second variable, measuring the importance of "rule-based" pay in the firm, reflects the importance of tenure and experience (cf. Section C for further details).

The regressions in Columns 2 and 3 of Table 6 indicate that an appreciation of the exchange rate increases the importance of performance-based pay. In other words, firms that experience a fall in competitiveness due to an appreciation of the currency tend to switch towards more performance-oriented pay schemes. The regression in Column 3 only provides weak evidence that this effect takes place at the expense of rule-based pay schemes.[34] These impacts of

[34]We exclude the industry trends in these specifications. The reason is that the sample size is too small to estimate around 100 industry trends. Moreover, there are only few *a*

Table 6: Upskilling: the effect of exchange rates on firms' R&D adoption and wage-setting schemes

VARIABLES	(1) R&D	(2) Performance-based pay	(3) Rule-based pay
$\Delta R^X_{jt} \times XS_{ij,t-1}$	1.052***	5.209**	-3.665
	(0.354)	(2.556)	(2.866)
$\Delta R^I_{jt} \times IS_{ij,t-1}$	-0.784	16.198	10.239
	(2.602)	(11.941)	(12.199)
$XS_{ij,t-1}$	-0.020	0.179*	-0.061
	(0.030)	(0.097)	(0.115)
$IS_{ij,t-1}$	0.458	-0.309	-0.835
	(0.284)	(0.736)	(0.797)
Expected demand $(t-1)$	-0.019	0.103**	0.036
	(0.012)	(0.042)	(0.044)
Past demand $(t-1)$	0.001	0.053	0.034
	(0.011)	(0.041)	(0.042)
Mark-up $(t-1)$	0.055	-0.471	-0.449
	(0.079)	(0.293)	(0.333)
$\Delta FGDP_{jt}$	-3.659**	2.092	-1.477
	(1.671)	(1.868)	(1.862)
Constant	0.001	-0.151	-0.382**
	(0.094)	(0.177)	(0.188)
Observations	2,132	722	722
R-squared	0.059	0.036	0.113
Period effects	Yes	Yes	Yes
Industry trends	Yes	No	No
p-value test $\alpha_3 = \alpha_6 = 0$	0.24	0.87	0.20

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
ΔR^X_{jt} and ΔR^I_{jt} constrained to 0 but not shown

exchange rate movements on firms' wage setting practices reinforce the overall picture that an appreciation of the real exchange rate has a skill-biased influence on workers because it increases the reward for well-performing workers.

7 Conclusions

This paper has examined whether exchange rate movements exhibit a skill bias in their effects on employment. We highlight three mechanisms through which such a bias might arise. First, if hiring and firing costs increase with the skills of workers, the magnitude of firms' adjustments in labor input to an exchange rate shock is likely to be larger for low-skilled labor. Second, an appreciation

priori reasons why there should be industry trends in these qualitative survey questions.

increases the price of domestic labor relative to foreign-produced inputs. In the presence of complementarity between foreign inputs and skills, shifts in the input mix triggered by an appreciation of the exchange rate are likely to take place at the expense of low-skilled workers. Third, exchange-rate-induced competitive pressure may lead to changes in production methods and innovation activities in ways that favor high-skilled at the expense of low-skilled workers.

Our empirical analysis is based on a panel data analysis of Swiss manufacturing firms covering the years 1998 to 2012, a period characterized by large swings in the real exchange rate of the Swiss franc. By constructing industry-specific exchange rates, we take into account the heterogeneity across industries in their exposure to exchange rate movements. Moreover, our data allow us to exploit firm-level heterogeneity in the exposure to exchange rates, and allow us to examine potential channels through which the skill-bias in the exchange rate effects operates.

Several important findings emerge from our analysis. In an average surviving manufacturing firm, we find that FTE employment is not significantly affected by an appreciation of the Swiss franc. The reasons are that, on the one hand, firms are naturally hedged against the revenue-side losses from currency appreciations because the costs of imported intermediate inputs decline, and thus offset the negative employment effects generated by the loss of competitiveness. On the other hand, exporters also appear to absorb part of the exchange rate shock in profit margins rather than shedding labor. The estimated elasticities of total employment to real exchange rates, however, mask considerable heterogeneity in the effects across different types of workers. In particular, a currency appreciation reduces less-skilled employment and increases high-skilled employment in the average firm, as less-skilled workers benefit less from lower costs of intermediate inputs but suffer more from the exposure on the revenue side. We present evidence that these skill-biased effects of exchange rate movements may be associated with outsourcing of production tasks, innovation efforts, and the importance of performance-oriented compensation.

In a broader context, our results also complement the theoretical and empirical findings of a recent literature that studies the effects of trade integration on the skill intensity of production. For example, the closely related paper of Bustos (2011) finds that tariff reductions lead to an increase in the skill intensity of production, especially in exporting firms, and that exporters facing tariff reductions adopt new product technologies and increase product innovation. Evidently, manufacturers appear to make similar adjustments when facing currency appreciations and tariff reductions.

It bears emphasis that our study has some limitations. First, we focus on surviving firms, therefore neglecting the impact of establishment closures. Second, the focus on the firm as the unit of observation precludes us from making quantitative statements with respect to aggregate employment effects. Most importantly, our analysis masks the potentially substantial between-firm reallocation of labor caused by exchange rate swings (Gourinchas, 1999; Klein et al., 2003). It also ignores the possible employment effects of exchange rate movements due to changes in import competition in the domestic market. Moreover, while high-skilled workers are less prone to exchange rate shocks in a given firm, they are more likely to be employed in an export-oriented firm than low-skilled workers. This composition effect hence increases the *ex ante* exposure of high-skilled workers to exchange rate shocks, and may partially offset the positive effects of an appreciated currency on employment of high-skilled workers operating through the within-firm increase in the skill intensity of production.

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Appendix

A Construction of industry-specific export and import real effective exchange rates

This section discusses the construction of the industry-specific imported inputs and export real effective exchange rates used in the empirical section of the paper. These exchange rates are constructed by appropriately weighting movements in the real exchange rate of the following 9 trade markets/regions: France, Germany, and the rest of Europe, the UK, the United States, China, Japan, the rest of Asia, and the rest of the World.[35] The bilateral real exchange rates for the nine currency regions are published by the Swiss National Bank (SNB).

The import and export weights assigned to the real exchange rate of region i depend on the geographic distribution of the industries' trading partners and the location of its main competitors. These currency weights are time-varying. In particular, the weight in year t is given by a moving average of the past three years, i.e., the weights reflect the geographic spread of trade flows averaged across years t, $t-1$, and $t-2$. In order to avoid potential endogeneity that could arise because exchange rate movements affect the geographic composition of trade flows, the weights are lagged by one (three-year) period in the estimation.

The weight of market i in the total industry-specific *import* exchange rate in year t, denoted w_{it}^I, is simply determined by the share of imported intermediate inputs of an industry from region i in year t, I_{it}, relative to all imported intermediate inputs of this industry in that year, I_t (where the industry-subscript j is omitted for brevity of notation). Hence, the weights are given by the following fraction:

$$w_{it}^I = I_{it}/I_t \tag{4}$$

This weighting scheme reflects the geographic composition of inputs imported to Switzerland. The relevant trade data on imported inputs by source country and industry stem from the OECD Trade in Value Added (TiVA) database and reveal the share of each region in total value added of 11 Swiss manufacturing industries. These data are available for the years 1995, 2000, 2005, 2008, and 2009. We linearly inter- and extrapolate the data for years where data is missing. Importantly, the TiVA data reveal market i's value added share only for Swiss *exports*, not for total final production. We do not view this as a substantial problem for our empirical analysis

[35] The rest of Europe is assigned to the Euro, the rest of Asia is assigned to a basket of major Asian currencies (Hongkong, India, Singapore and Saudi-Arabia), and the rest of the world is assigned to a basket of the remaining major trading partners of Switzerland (Canada, South America, Central America and Australia).

since 77% of the firms in our estimation sample are exporters.

The weights for the industry-specific *export* real effective exchange rate w_i^X are computed according to the methodology of the Bank of International Settlement (BIS), see Turner and van't Dack (1993). They are given by:

$$w_{it}^X = \Big(\frac{EX_{it}}{EX_t}\Big)\Big(\frac{y_{it}}{y_{it} + \sum_{k\neq i} EX_{it}^k}\Big) + \sum_{k\neq i}\Big(\frac{EX_{kt}}{EX_t}\Big)\Big(\frac{EX_{kt}^i}{y_{kt} + \sum_{h\neq k} EX_{kt}^h}\Big) \tag{5}$$

The first summation term on the right-hand side captures that movements in the bilateral real exchange rate affect the competitiveness of Swiss firms in its export market i. It multiplies the annual share of exports of an industry to region i in total Swiss exports of this industry, EX_{it}/EX_t, with the relative market share of the supply of domestic producers in region i in a given year t (given by y_{it} relative to $y_{it} + \sum_{k\neq i} EX_i^{kt}$, where $\sum_{k\neq i} EX_i^{kt}$ represents the sum of exports of all other regions $k \neq i$ to i of the industry, excluding Switzerland).[36] Intuitively, the effect of exchange rate movements on the direct price competitiveness of Swiss firms in market i is larger, the more important market i is for Swiss firms and the more important the domestic market is for firms in market i.

The second term on the right-hand side of eq. (5) shows how changes in the bilateral exchange rate affect the relative price competitiveness in all $k \neq i$ export markets in which firms from Switzerland and firms from market i compete. Intuitively, this third-market competition effect is larger if k is an important export market for Swiss firms in the industry and/or if the market share of i's exporters in k is large.

Data on industry-specific exports stem from the Swiss Federal Customs Administration (SFCA). The bilateral trade data required to construct the competition effect of real exchange rate movements (i.e., the second term on the right-hand side of Equation (5)) are taken from the World International Trade Services (WITS) database. Both data sets were recoded from the six-digit HS classification to the 3-digit NACE classification (rev. 2) using the appropriate correspondence table.

Table A.1 shows an unweighted average of the weights of the nine currency regions across all manufacturing industries of Switzerland. Column 1 presents the average imported-inputs weight of each market (Equation 4) and Column 2 presents the weights of market i as determined by the first term on the right-hand side of Equation 5, i.e., the weights reflect the importance of the export market of i for Swiss firms. Column 3 shows the weight of the third-market effect, i.e., the importance of third-market competition between Swiss firms and firms from market i. The overall

[36]However, we lack industry-specific data to construct the size of the home market supply in i, y_{it} in each region. We approximate y_{it} by the total export volume of region i into the world EX^{it} in a given year. This substitution captures the idea of competition among exporters. That is, we assume that Swiss exporters only compete with region i's exporters and not with domestic suppliers even in market i.

Table A.1: Average industry-specific imported inputs weights and export weights in the construction of the real industry-specific effective exchange rates

market/region	w_i^I	Exports	Competitor	w_i^{EX}
		Weight		
China	0.03	0.01	0.06	0.03
France	0.11	0.10	0.05	0.08
Germany	0.37	0.29	0.07	0.20
Japan	0.02	0.02	0.03	0.02
Rest of Asia	0.04	0.08	0.09	0.08
Rest of Europe	0.37	0.36	0.43	0.39
Rest of the World	0.05	0.03	0.18	0.09
UK	0.04	0.05	0.04	0.04
USA	0.04	0.06	0.05	0.06

Notes: Weights represent unweighted averages over all manufacturing industries and years

weight of a specific export market is shown in Column 4, which combines the weights in Columns 2 and 3 according to Equation 5.

B Robustness to short-time work scheme

Switzerland, as some other OECD countries, operates a short-time work scheme, which aims to preserve jobs within firms that experience temporarily low demand. Firms can apply at a cantonal unemployment agency to participate in the scheme. If firms are eligible, they are allowed to employ workers part-time, while employees receive compensation for short-time work from the cantonal unemployment agency. The compensation of the employees amounts to 80% of lost earnings.

Relatively many Swiss manufacturers benefited from this short-time work scheme during the recession of 2009. This raises the concern that our results are affected by firms who used the short-time work scheme to dampen the exchange rate effects on employment.

In principle this should not be the case, as firms that participated in the short-time work scheme should report reductions in *FTE* employment. However, it is unclear whether the firms' answers to the survey adequately mirror reductions in the activity levels of employees subject to the short-time work scheme. To examine this question, we merged data on short-time hours worked as published by the State Secretariat of Economic Affairs (SECO) to the firm-level data. The data are a complete count of the number of hours recorded in the short-time work scheme by firms in Switzerland. In particular, we added to each firm the period-to-period absolute change in the number of hours of short-time work per firm. The merge is based on firms' two-digit industry affiliation, canton and firm size.

When using this variable as *outcome*, it shows a statistically significant relationship to the exchange rates. However, when using it as a control in a regression using FTE employment as the outcome (Column 1–3 in Table 2), it turns out to be statistically insignificant and unrelated to the coefficients of interests. Moreover, the results in Tables 2 and 3 are qualitatively robust to excluding all firms which are located in regions, industries, and firm size categories in which SECO recorded a positive number of hours of short-time work. Since the SECO data is a complete count, the remaining sample should contain only few firms which may have used the short-time work scheme. We are thus confident that the Swiss short-time work scheme has no qualitative influence on the results presented in the paper.

C Variable definitions

Variable	Definition and measurement	Source(s)	Coverage
Dependent variables			
Employees	FTE employment, ln	KOF innovation survey	1999–2013
Employment high-skilled	Number of FTE high-skilled employees, ln High-skilled are workers with post-secondary education	KOF innovation survey	1999–2013
Employment medium-/low-skilled	Number of FTE medium- and low-skilled employees, ln Medium-skilled are workers with a secondary, low-skilled are workers with less than a primary degree (excluding apprentices)	KOF innovation survey	1999–2013
Wages	Average wage per FTE employee, ln Derived from the share of wage costs in total sales, total sales and the number of FTE employees	KOF innovation survey	1999–2013
Labor share	Ratio of wage costs to value added, ln	KOF innovation survey,	1999–2013
Wage bill high-skilled	Total wage bill of high-skilled employees, ln FTE employment of high-skilled workers times their imputed wage (see Section 6.2). Imputed wage equals average wage in firm's 3-digit industry (NACE rev. 1.2), size class (2 categories), and NUTS-II region. Wages in 2013 are the same as those in 2011.	KOF innovation survey, wage structure survey	1999–2013
Wage bill medium-/low-skilled	Total wage bill of medium and low-skilled employees, ln FTE employment of medium/low-skilled workers times their imputed wage (see Section 6.2). Imputed wage equals average wage in firms 3-digit industry (NACE rev. 1.2), size class (2 categories) and NUTS-II region. Wages in 2013 are the same as those in 2011.	KOF innovation survey, wage structure survey	1999–2013
Outsourcing of complex tasks	Firm has outsourced complex tasks in the past five years Sum of two binary variables which are 1 if 'R&D' or 'IT-services' were outsourced, value 0 otherwise	KOF innovation survey	2005–2011
Outsourcing of production	Firm has outsourced production tasks in the past five years Sum of two binary variables which are 1 if 'intermediate production' or 'final production' were outsourced, respectively, value 0 otherwise	KOF innovation survey	2005–2011
Outsourcing of services	Binary variable which is 1 if 'other internal services" (e.g., cleaning)' were outsourced, respectively, value 0 otherwise	KOF innovation survey	2005–2011
Investment	Gross investments, ln	KOF innovation survey	1999–2013
ICT investment	Gross ICT investments, ln	KOF innovation survey	2005–2011

Variable	Definition and measurement	Source(s)	Coverage
	Derived from gross investments and ICT investment share		
ICT investment share	Share of ICT investments in total investments, ln	KOF innovation survey	2005–2011
ICT user share	Intensity of ICT use Mean of three six-level ordinal variables measuring the share of employees regularly using 1) a computer, 2) the internet and 3) the intranet; 0% (value 1), 1-20% (value 2), 21-40% (value 3), 41-60% (value 4), 61-80% (value 5) and 81-100% (value 6)	KOF innovation survey	2005–2011
Perceived price competition	Intensity of price competition in main selling market Five-level ordinal variable, ranging from 'very weak' (value 1) to 'very strong' (value 5).	KOF innovation survey	1999–2013
R&D	Indicator showing whether firm had positive R&D expenditures in the three years prior to the survey or not.	KOF innovation survey	1999–2013
Performance-based pay	Importance of performance-oriented pay in firm Mean of two 5-level ordinal variables indicating the importance of 'individual performance' and 'group performance' in setting wages (ranging from 1 'not important' to 5 'very important'), standardized to mean 0 and standard deviation 1.	KOF innovation survey	2005–2011
Rule-based pay	Importance of rule-oriented pay in firm Mean of two 5-level ordinal variables indicating the importance of 'tenure' and 'experience' in setting wages (ranging from 1 'not important' to 5 'very important'), standardized to mean 0 and standard deviation 1.	KOF innovation survey	2005–2011
Independent variables			
$XS_{ij,t-1}$	Share of exports in total sales in period $t-1$	KOF innovation survey	1999–2013
ΔR^X_{jt}	Growth of export real effective exchange rate from t to $t-1$ in 3-digit industry (NACE rev. 2) (see Section A)	SNB, SFCA, WITS	1999–2013
$IS_{ij,t-1}$	Share of imported inputs in total variable costs in period $t-1$ Imputed imported intermediate inputs as a share of wage costs plus total intermediate inputs. The share of imports in intermediate inputs by industry is derived from the OECD Input-Output table 2001 for Switzerland (NACE rev. 1.2, 19 industries)	KOF innovation survey, OECD STAN	1999–2013

Variable	Definition and measurement	Source(s)	Coverage
ΔR^I_{jt}	Growth of imported inputs real effective exchange rate from t to $t-1$ in broad 2-digit industries (NACE rev. 1.2, 10 industries) (see Section A)	SNB, OECD STAN	1999–2013
$\Delta FGDP_{jt}$	Export-weighted industry-specific growth of real GDP in export markets from $t-1$ to t	SFCA, IMF World Economic Outlooks	1999–2013
Expected demand $(t-1)$	Expected development of demand in next three years in $t-1$ Five-level ordinal variable (level 1: 'strong decrease'; 5; 'strong increase')	KOF innovation survey	1999–2013
Past demand $(t-1)$	Perceived development of demand in past three years in period $t-1$ Five-level ordinal variable (level 1: 'strong decrease'; 5; 'strong increase')	KOF innovation survey	1999–2013
Mark-up $(t-1)$	Price over cost margin in $t-1$	KOF innovation survey	1999–2013

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D Additional tables

Table A.3: Interaction between market structure and the effect of exchange rates on FTE employment

VARIABLES	(1) Low mark-up	(2) High mark-up	(3) Strong price competition	(4) Weak price competition	(5) Price- cost margin
$\Delta R^X_{jt} \times XS_{ij,t-1}$	-1.014***	-0.614*	-1.365***	-0.465*	-0.320**
	(0.297)	(0.333)	(0.353)	(0.272)	(0.134)
$\Delta R^I_{jt} \times IS_{ij,t-1}$	4.508**	0.371	2.497	3.222	0.143
	(2.206)	(2.593)	(2.363)	(2.182)	(0.919)
$XS_{ij,t-1}$	-0.003	0.085**	0.081**	0.005	-0.008
	(0.028)	(0.042)	(0.037)	(0.035)	(0.011)
$IS_{ij,t-1}$	0.225	0.346	0.058	0.378	0.713***
	(0.267)	(0.233)	(0.279)	(0.253)	(0.108)
Expected demand $(t-1)$	0.056***	0.028***	0.037***	0.045***	0.004
	(0.010)	(0.010)	(0.010)	(0.010)	(0.004)
Past demand $(t-1)$	0.027***	0.025*	0.038***	0.022**	-0.003
	(0.008)	(0.013)	(0.009)	(0.011)	(0.004)
Mark-up $(t-1)$	0.319**	0.061	0.181**	0.138**	
	(0.138)	(0.089)	(0.086)	(0.062)	
$\Delta FGDP_{jt}$	0.082	1.738	0.660	2.043	-0.649
	(1.221)	(1.228)	(1.217)	(1.277)	(0.510)
Constant	0.169***	-0.281**	-0.269***	0.127**	-0.003
	(0.055)	(0.135)	(0.096)	(0.065)	(0.043)
Observations	1,234	1,025	1,095	1,114	2,061
R-squared	0.188	0.179	0.231	0.152	
$\bar{\varepsilon}_{R^X}$	-0.378***	-0.255*	-0.559***	-0.176*	-0.127**
	[0.111]	[0.138]	[0.145]	[0.103]	[0.053]
$\bar{\varepsilon}_{R^I}$	0.675**	0.050	0.354	0.463	0.020
	[0.331]	[0.348]	[0.335]	[0.314]	[0.131]
Period effects	Yes	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes	Yes
Industry-period effects	No	No	No	No	No
p-value test $\alpha_3 = \alpha_6 = 0$	0.48	0.51	0.87	0.82	0.35

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
α_3 and α_6 constrained to 0 but not shown

Table A.4: Robustness of effect of exchange rate movements on the FTE employment of different skill groups

VARIABLES	(1) OLS High-skilled	(2) OLS Medium-/ Low-skilled	(3) OLS High-skilled	(4) OLS Medium-/ Low-skilled	(5) Sys GMM High-skilled	(6) Sys GMM Medium-/ Low-skilled
$\Delta R^X_{jt} \times XS_{ij,t-1}$	-0.637	-1.151***	-0.921	-1.279**	-0.525	-0.592*
	(0.587)	(0.337)	(0.800)	(0.504)	(0.596)	(0.342)
$\Delta R^I_{jt} \times IS_{ij,t-1}$	9.325***	1.227	13.635**	4.383	9.260**	-0.201
	(3.485)	(2.168)	(6.237)	(3.487)	(3.604)	(2.138)
$XS_{ij,t-1}$	0.069*	0.033	0.093*	0.044	0.935***	0.263***
	(0.039)	(0.023)	(0.054)	(0.036)	(0.151)	(0.093)
$IS_{ij,t-1}$	-0.244	0.248	0.006	0.193	1.358**	0.862***
	(0.304)	(0.178)	(0.533)	(0.303)	(0.602)	(0.326)
Expected demand $(t-1)$			0.054***	0.029***	0.092***	0.043***
			(0.020)	(0.010)	(0.021)	(0.012)
Past demand $(t-1)$			0.033	0.042***	0.061***	0.047***
			(0.020)	(0.011)	(0.019)	(0.012)
Mark-up $(t-1)$			0.198	0.171**	-0.008	0.061
			(0.125)	(0.074)	(0.154)	(0.099)
$\Delta FGDP_{jt}$					1.626	-1.150
					(1.494)	(0.978)
$y_{ij,t-1}$					0.414***	0.692***
					(0.088)	(0.088)
Constant	-0.171**	-0.070	-0.220**	-0.099*	0.769***	1.008***
	(0.078)	(0.052)	(0.086)	(0.060)	(0.175)	(0.330)
Observations	1,918	1,918	1,918	1,918	1,918	1,918
$\bar{\varepsilon}_{R^X}$	-0.260	-0.470***	-0.376	-0.522**	-0.214	-0.242*
	[0.240]	[0.137]	[0.326]	[0.205]	[0.243]	[0.139]
$\bar{\varepsilon}_{R^I}$	1.348***	0.177	1.970**	0.633	1.338**	-0.029
	[0.504]	[0.313]	[0.901]	[0.504]	[0.521]	[0.309]
Period effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry trends	No	No	Yes	Yes	No	No
Industry-period effects	No	No	Yes	Yes	No	No
p-value test $\alpha_3 = \alpha_6 = 0$	0.17	0.80			0.33	0.32
p-value Hansen J test					0.130	0.630
p-value AR(2) test					0.270	0.890

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Dependent variable: Skill-specific FTE employment
ΔR^X_{jt} and ΔR^I_{jt} constrained to 0 but not shown

Table A.5: Effect of exchange rates on different types of workers

VARIABLES	(1) Employment High-skilled	(2) Employment Medium-skilled	(3) Employment Low-skilled	(4) Employment Apprentices
$\Delta R^X_{jt} \times XS_{ij,t-1}$	-0.907	-1.576***	-0.116	0.095
	(0.629)	(0.530)	(0.531)	(0.608)
$\Delta R^I_{jt} \times IS_{ij,t-1}$	12.656***	5.031	0.361	-7.124**
	(3.880)	(3.189)	(3.658)	(3.579)
$XS_{ij,t-1}$	0.126**	0.029	0.005	0.017
	(0.050)	(0.040)	(0.046)	(0.054)
$IS_{ij,t-1}$	-0.067	0.136	-0.078	0.824
	(0.471)	(0.351)	(0.411)	(0.593)
Expected demand $(t-1)$	0.061***	0.016	0.050***	0.039**
	(0.017)	(0.014)	(0.016)	(0.018)
Past demand $(t-1)$	0.033*	0.021	0.039**	0.052***
	(0.017)	(0.014)	(0.016)	(0.020)
Mark-up $(t-1)$	0.215*	0.157	0.246**	0.151
	(0.112)	(0.100)	(0.120)	(0.146)
$\Delta FGDP_{jt}$	1.386	3.215*	-1.132	1.140
	(2.119)	(1.867)	(1.957)	(2.251)
Constant	-1.003***	-0.183	0.089	-0.190
	(0.244)	(0.189)	(0.133)	(0.185)
Observations	1,951	2,054	1,971	1,345
R-squared	0.095	0.062	0.082	0.112
$\bar{\varepsilon}_{R^X}$	-0.372	-0.613***	-0.045	0.039
	[0.258]	[0.206]	[0.207]	[0.251]
$\bar{\varepsilon}_{R^I}$	1.826***	0.717	0.052	-1.034**
	[0.560]	[0.454]	[0.523]	[0.520]
Period effects	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes
p-value test $\alpha_3 = \alpha_6 = 0$	0.18	0.63	0.30	0.65

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
ΔR^X_{jt} and ΔR^I_{jt} constrained to 0 but not shown