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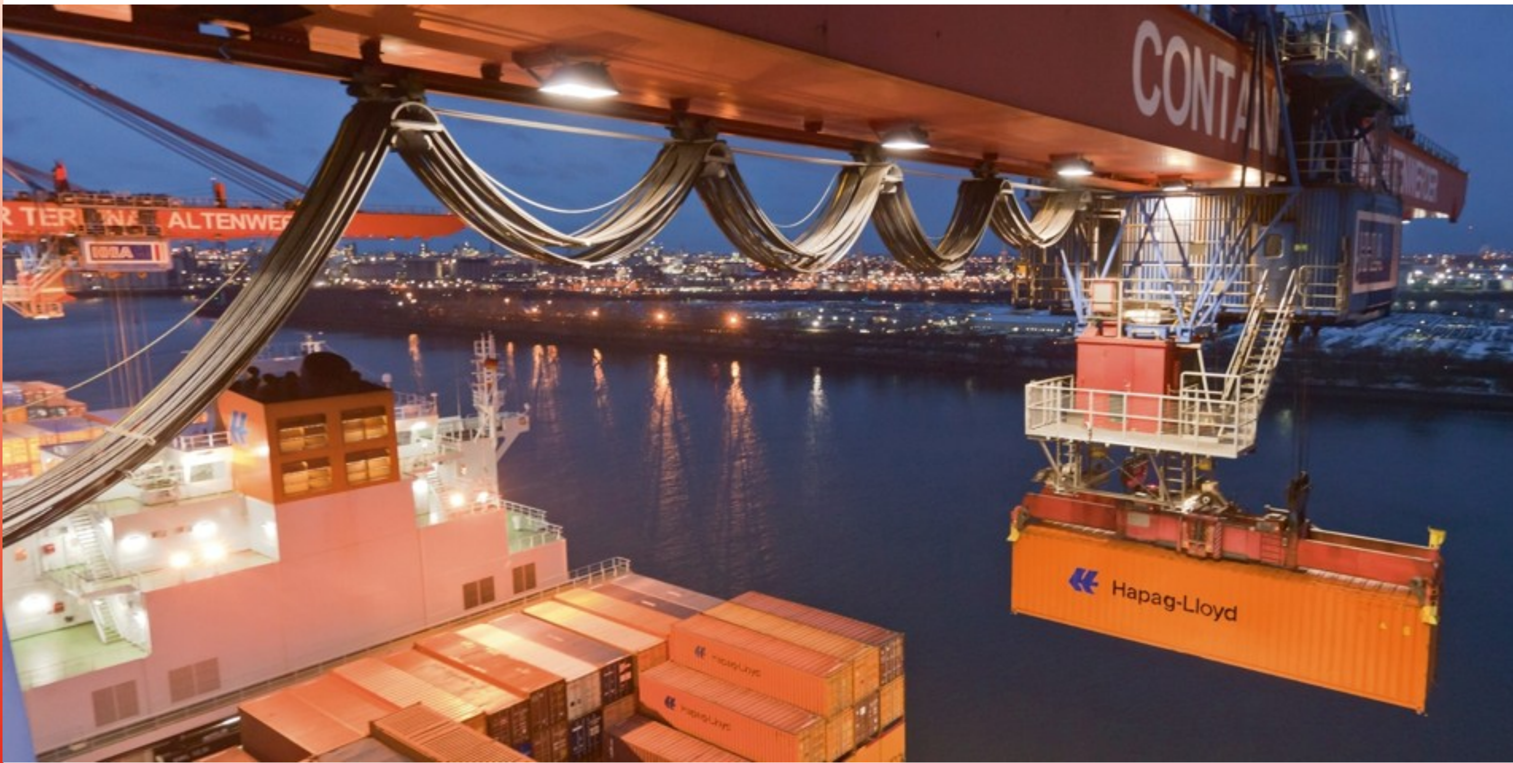

Exchange rate effects: A case study of the export performance of the Swiss Agriculture and Food Sector

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Abstract

The Swiss franc appreciated strongly against the currencies of Switzerland's most important trading partners after the global financial crisis in 2008. This has led to renewed interest in the question of how sensitive Swiss exports are with respect to exchange rate movements. We analyze this question for exports of the Swiss Agriculture and Food Sector, using both time series and dynamic panel data models based on data from 1999 to 2012. We find that in the long-run a one percent appreciation of the Swiss franc leads on average to a decrease in exports of agricultural and food products of approximately 0.9 percent. Our results suggest that on average, producers in the Swiss Agriculture and Food Sector are able to successfully avoid price competition by differentiating their products, producing high-quality products for niche markets.

JEL classification: F14, F31, Q17

Keywords: exchange rate, exports, agriculture and food sector, time series analysis, dynamic panel data models

1 Introduction

Since the global financial crisis in 2008 the Swiss franc has appreciated strongly against the currencies of Switzerland's major trading partners. During two years, from the onset of the global financial crisis in 2008 to the introduction of the exchange rate peg against the Euro by the Swiss National Bank in September 2011, the Swiss franc appreciated about 25 percent (in real terms) against the currencies of Switzerland's most important export markets for agriculture and food products, thus, potentially depressing foreign demand for Swiss products. At the same time, the Swiss Agriculture and Food Sector has become more integrated into the world market. Against this backdrop, there has been renewed interest in the question of how changes in the exchange rate affect exports in general, and exports of the Swiss Agriculture and Food Sector in particular.

The main contribution of this paper is to estimate and quantify the effects of exchange rate fluctuations on Swiss agro-food exports. The case study of the Swiss Agriculture and Food Sector has the following advantages. On the one hand, Switzerland is a small open economy, with an independent economic and monetary policy, which has lately experienced sharp movements of its currency. On the other hand, the Agriculture and Food Sector is relatively small compared to the rest of the Swiss economy, which has the advantage that a causal interpretation of the results becomes more plausible (in particular, we don't have to worry much about reverse causality).[1] Hence, for policy makers this case study could yield valuable insight into the reaction of exporters to exchange rate fluctuations under a particular set of economic policies. We will see below that the behavior of exporters in other sectors of the Swiss economy is relatively similar. Thus, we think that the lessons learned could be generalized to some extent to other sectors, as well as to other economies similar to Switzerland. Furthermore, we exploit time series as well as panel data to estimate exchange rate effects. The time series analysis has the advantage of a clear identification strategy since only variation over time is used to identify parameters but might suffer from a large bias due to small sample size. The panel data analysis allows us to increase sample size and exploit the information contained in the cross-section, which might ameliorate potential bias. The downside is that the estimated (dynamic) panel data models are sensitive to model specification (and the set of instruments). However, the analysis of both time series and panel data helps us to assess the sensitivity of our results with respect to model specification, estimation methods and data structure.

We find that the estimated elasticities are remarkably similar across all models and estimation methods. In the short-run, an appreciation of one percent of the Swiss franc implies on average a decrease in real exports of agriculture and food exports between 0.6 and 0.8 percent, one year after the appreciation. In the long-run, we find that a one percent appreciation of the Swiss franc leads on average to a permanent decrease in real exports in the range of 0.8 to 0.9 percent. The average exchange rate effects seem economically rather small. This suggests that on average, producers are able to avoid price competition by successfully differentiating their products, producing high-quality products for niche markets. These results are similar to the ones found in the existing related literature.

We are not aware of comparable studies that focus on exchange rate effects on the exports of the Agriculture and Food Sector in a small open economy like Switzerland. The existing literature can broadly be divided into two categories. On the one hand, there is a recent literature looking into exchange rate effects on aggregate exports of Switzerland. This literature generally finds surprisingly small effects of changes in the exchange rate on aggregate Swiss exports. Estimates of long-run elasticities from time series models are between -0.9 and -1.1 percent (see e.g. SECO 2010, Tressel and Arda 2011, and Fürer 2013). Estimates of long-run elasticities from panel data models are slightly lower, in the range between -0.5 and -0.7 percent (see e.g. Auer and Saure 2011, and Gaillard 2013). On the other hand, there is a relatively large literature concerned with exchange rate effects on agricultural exports of large countries or regions like the United States, Canada or the European Union. Kristinek and Anderson (2002) give an excellent survey of this literature. In general, it seems that the evidence is mixed - some studies find exchange rate effects on agricultural exports while others don't. For example, estimating

[1] According to the theory of foreign exchange rate markets, the main determinants of exchange rates are international goods and (financial) capital flows (Husted and Melvin 2009). Recently, the emphasis has been put on financial-asset markets, i.e. exchange rates adjust to equilibrate international flows in financial assets rather than international flows in goods. Note that in times of financial distress, like in the aftermath of the global financial crisis, the Swiss franc serves as a "safe haven" currency offering a hedge against global equity market risk. Thus, the Swiss franc tends to appreciate during episodes of increased global risk (see e.g. Grisse and Nitschka 2013).

a vector error-correction model, Kim et al. (2004) find that the exchange rate has a significant impact on U.S. agricultural trade with Canada, whereas Vellianitis-Fidas (1976) does not find evidence that the exchange rate of the United States does affect its agricultural exports using cross-section and time series data. The literature on exchange rate effects in general has also been interested in the effects of exchange rate volatility on exports. For example, Chit et al. (2010) find that exchange rate volatility has a negative effect on the exports of emerging East Asian economies. While we think the effects of exchange rate volatility on exports are interesting, we focus on the effects of exchange rate movements on exports in this paper.

The remainder of this paper is organized as follows. In Section 2 we give a brief introduction to the Swiss Agriculture and Food Sector, focusing on relevant issues for exports. Section 3 discusses the data in detail. Section 4 introduces the time series models and discusses the results, respectively. To see how sensitive the results are to model specification and estimation methods, we discuss dynamic panel data models in Section 5. Section 6 concludes.

2 The Swiss Agriculture and Food Sector

For the reader unfamiliar with the Swiss Agriculture and Food Sector this section provides a short introduction. It focuses on the aspects relevant for exports, and thus, should help to interpret the results and put them into perspective. For more detailed descriptions of the sector, Bösch et al. (2011) and Aepli (2011) are excellent sources.

2.1 Structure of the sector

The total share of the Swiss Agriculture and Food Sector in Swiss GDP was about 2.9% in 2007, of which 0.9 percentage points go to agriculture and 2 percentage points to the food industry (Bösch et al. 2011). In 2008, about 5.4% of the labor force was employed in the sector, about 3.9% in agriculture and 1.5% in the food processing industry (Swiss Federal Statistical Office 2008). Most of the approx. 60,000 farms in Switzerland were small family farms, averaging a size of about 17 hectares. There has been slow structural change in the sector. In 2013, there were still about 55,000 farms operating, and the average farm size had increased to 19 hectares (Swiss Federal Statistical Office 2014). Topography is not very favorable in Switzerland for farming leading to a cost disadvantage. About half of the farms were located in hilly or mountainous regions (Federal Office for Agriculture FOAG 2009). In the Swiss food industry approx. 60% of all companies were small and medium-sized (less than 250 employees) businesses and 40% were large (more than 250 employees) enterprises (Aepli 2011). The Swiss food industry includes well-known companies (and brands), for example, the chocolate manufacturer Lindt & Sprüngli, multinational food and beverage company Nestlé, energy drink producer Red Bull, candy manufacturer Ricola, the producer of dairy products Emmi, food processor Hochdorf (milk, baby care, cereal & ingredients), or the chocolate bar "Toblerone" produced in Switzerland by Mondelez International Inc.

2.2 Exports

In 2008, exports (measured in Swiss francs) of the Swiss Agriculture and Food Sector were about 3.5% of aggregate Swiss exports (Swiss Customs Administration 2014b). Note that the export share of the Agriculture and Food Sector has steadily increased from 2.5% in 2002 up to 3.8% in 2012. However, its share is still small compared to other sectors (e.g. watches and pharmaceuticals). Switzerland is traditionally an exporter of processed products like cheese and chocolate, but also of bakery products (biscuits and waffles) and candy (bonbons). Lately, the Swiss Agriculture and Food Sector has started to export highly processed products like beverages (energy drink "Red Bull") and coffee ("Nespresso" coffee capsules). Processed products accounted for about 80-90% of total agriculture and food exports of Switzerland between 1999 and 2012 (for details see Footnote 4 in Section 3). Most of the producers in the food processing sector are highly export-oriented. The companies mentioned in the previous section are typical examples. Nestlé Switzerland exported almost 80% of its domestically produced goods in 2013, earning CHF 3.76 billion in sales (Nestlé 2014b). Emmi earned

44% of its sales abroad (Emmi 2014), Ricola AG about 90% (Ricola 2014), and Hochdorf derived about 40% of its revenue from export sales (Hochdorf 2014). Also firms like Lindt & Sprüngli in the chocolate manufacturing industry earn a large share of their sales from exports. About 60% of all chocolate produced in Switzerland was exported in 2013 (Association of Swiss Chocolate Manufacturers 2014). Similarly, every second Red Bull can that is sold worldwide is produced in Switzerland (Handelszeitung 2013). We know from empirical and theoretical work that exporters tend to perform better than non-exporters along multiple dimensions, e.g. they tend to be larger, more productive or more skill-intensive (see e.g. Bernard and Jensen 1995, Bernard and Jensen 1999, Melitz and Redding 2012). At a quick glance, this seems also to be true for exporters in the Swiss Agriculture and Food Sector.[2] The most important export market is Europe, especially the European Union, where in 2008 about 67% of all goods were exported, followed by Asia with 16% and America with 14%. Recently, Europe's share has slightly declined, whereas Asia's and America's share has increased (see Kohler 2014). In sum, this suggests that exports of the Swiss Agriculture and Food Sector are driven by (highly) processed products manufactured by large export-oriented firms. In other words, there is almost no (direct) export of agricultural commodities (like e.g. live animals). The importance of Europe as export market further suggests that the exchange rate of the Swiss franc to the Euro is particularly relevant.

2.3 Swiss Agricultural Policy and its impact on exports

The Agriculture and Food Sector has considerable political clout, especially the agricultural sector, which is the only economic sector that has its own federal department within the Swiss Administration. An excellent overview of the most important aspects of Switzerland's Agricultural Policy is given in Federal Office for Agriculture FOAG (2004). The main goals of the Swiss Agricultural Policy are to ensure food security using environmental-friendly production methods that conserve natural resources (e.g. organic production, animal-friendly conditions), provide public goods (e.g. landscaping), and maintain rural areas. To help achieve those goals the Swiss Farm Bill includes mostly non-distorting support measures for farmers, like various direct payments. In recent years, agricultural policy has focused especially on fostering innovation, improving competitiveness (in particular, through the facilitation of the production of high-quality goods), and ensuring public good provision.

As argued above, foreign demand for Swiss agricultural commodities manifests itself mainly through indirect demand for processed products. The Swiss Agricultural Policy affects demand for Swiss agricultural commodities (as intermediate goods of the processing industry) primarily through its emphasis on quality, and a so-called "chocolate" law ("Schoggigesetz"). The agricultural policy intends to increase the incentive to use high-quality intermediate goods produced by the agricultural sector in processed products. The idea is that those products can be marketed at high prices abroad under the umbrella brand "Swissness", which is associated with high-quality products.[3] The quality-strategy includes the definition of production standards (e.g. labels), and the financial support of innovative projects (Federal Office for Agriculture FOAG 2013). The "chocolate" law introduces financial incentives that encourage the domestic food processing industry to use locally produced agricultural commodities in the processing of products intended for export. Producers can apply to be reimbursed for the difference between foreign and domestic reference prices for agricultural commodities (in general, domestic prices in Switzerland are higher than world market prices). To this end, the Swiss Farm Bill allocates CHF 70 million per year to export contributions for processed agricultural products (Swiss Customs Administration 2014a). According to Dudda (2013), Nestlé Switzerland received about CHF 20 million, Mondelez International CHF 16 million, the Hochdorf Group CHF 7 million, Lindt & Sprüngli CHF 5.3 million, and Emmi CHF 3.6 million in 2012. The focus of the Swiss Agricultural Policy to expand and utilize the export potential of the Agriculture and Food Sector, in

[2]For example, Nestlé is a giant in the food processing industry, earning revenues of about CHF 90 billion and employing 330,000 people worldwide in 2013 (Nestlé 2014a), of which more than 10,000 individuals were employed in Switzerland (Nestlé 2014b). Similarly, Lindt & Sprüngli employed 8,949 people worldwide and earned revenues of CHF 2.88 billion in 2013 (Lindt & Sprüngli 2014), Red Bull GmbH had 9,694 employees worldwide and earned revenues in excess of EUR 5 billion (Red Bull 2014) in 2013, and in the same year Emmi AG employed 5,217 individuals and earned sales of CHF 3.3 billion (Emmi 2014). Ricola AG employed more than 400 people, earning revenues of approx. CHF 300 million (Ricola 2014). Likewise, the Hochdorf Group employed 338 individuals, and earned CHF 376 million in sales (Hochdorf 2014).

[3]Switzerland plans to implement a law in 2017, which requires 80 percent of raw materials (in terms of weight) in food products to be produced domestically (with some exceptions for raw materials that are not produced locally), if producers want to market a product using Switzerland or any symbols associated with Switzerland (see e.g. Schöchli 2014).

particular its quality-strategy for agricultural products, is also a reaction to recent market liberalization. During the last 15 years, the pace at which the Swiss Agriculture and Food Sector has been liberalized picked up noticeably. In particular, since 1999 Switzerland has signed 25 bilateral free trade agreements, which in some cases include extensive concessions for agriculture and food products (a list with all free trade agreements can be found in Federal Office for Agriculture FOAG 2014). As a result, the sector has become more export-oriented. Increasing liberalization has led inevitably to higher exposure to international macroeconomic factors in general, and the exchange rate in particular. This suggests that the quality-strategy as well as the "chocolate" law are important policy instruments, which might help exporters to successfully differentiate their products, and thus enable them to avoid price competition on foreign markets.

3 Data

3.1 Time series data

We use data on real exports X_t in quarter t measured in Swiss francs of the Swiss Agriculture and Food Sector from 1999q1 until 2012q4 provided by the Swiss Customs Administration (2014b). The exports of the Agriculture and Food Sector are recorded under the Harmonized System's (HS) classifications 01 to 24. These classifications include unprocessed and processed products. Note that the latter comprise a large share in total real exports of the Agriculture and Food Sector.[4] We observe multilateral Swiss exports of HS categories 01-24 to 36 countries, including all OECD member countries (except Chile and Greece) and Brazil, Russia, India, South Africa, and Indonesia (see Table 3 in Appendix A). Exports to those 36 countries cover between 80 and 90 percent of all Swiss agriculture and food exports (HS 01-24) during the observation period.

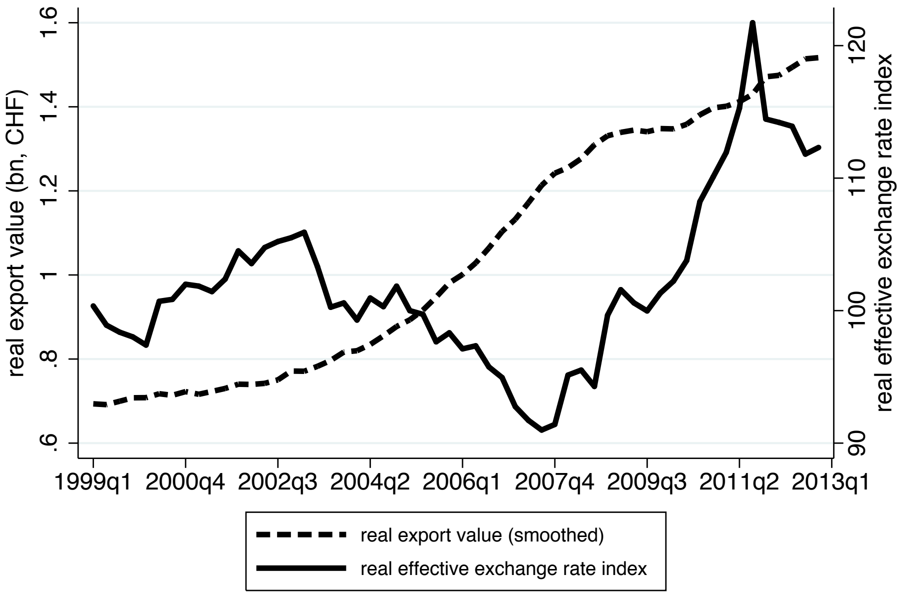
Changes in the value of the Swiss franc relative to the value of the 23 official currencies circulating in the 36 countries between 1999 and 2012 are measured with a real effective exchange rate index RER_t. The index is defined such that a decrease implies a relative depreciation of the Swiss franc, and vice versa. We construct our real effective exchange rate index based on a Törnqvist index, with the weights based on the exports of the Swiss Agriculture and Food Sector. Data on quarterly exchange rates is obtained from the Swiss National Bank (2014) and Eurostat (2014).

Figure 1 below shows the joint evolution of the real effective exchange rate index and real exports of the Swiss Agriculture and Food sector between 1999 and 2012. Between 1999 and 2012, real agro-food exports increased from approx. CHF 0.7 billion per quarter to about CHF 1.5 billion per quarter. We see that the growth rate of real exports was higher in the years right before the global financial crisis in 2008 than it has been since the aftermath of the financial crisis. At the same time, we observe that after 2002 the Swiss franc depreciated about 15 percent until the onset of the financial crisis in 2008, and appreciated strongly afterwards until 2012 (approx. 20-30 percent). We note that during the depreciation of the Swiss franc between 2002 and 2008 exports increased at a higher rate than during the periods of appreciation between 1999 and 2002, and more importantly, between 2008 and 2012. This can be seen more clearly from Figure 4 in Appendix A, which depicts the percentage changes in real exports (smoothed) and in the real exchange real exchange rate index.

We approximate changes in foreign demand for Swiss agriculture and food products with changes in aggregate GDP of Swiss trading partners (purchasing power parity adjusted, baseyear 2005), denoted by GDP_t. In particular, we compute a weighted average of the 36 countries' GDPs using export shares as weights. The data is provided by OECD (2014). See Appendix A for details on the construction of the real effective exchange rate measure and the demand variable.

Table 4 in Appendix A reports the results from augmented Dickey-Fuller and Phillips-Perron tests. The results show that the log transformed time series, $\log(X_t)$, $\log(GDP_t)$ and $\log(RER_t)$, are all integrated of order one, i.e.

[4] Examples of unprocessed products are HS categories "01 Live Animals", "07 Edible Vegetables" or "10 Cereals". Examples of processed products are found in HS categories "04 Dairy, Eggs, Honey & Edible Products" (e.g. cheese), "09 Coffee, Tea, Mate & Spices" (e.g. Nespresso coffee capsules), "18 Cocoa & Cocoa Preparations" (e.g. chocolate), "19 Preparations of Cereals, Flour, Starch or Milk" (e.g. baby food, biscuits), "21 Miscellaneous Edible Preparations" (e.g. chewing gum, bonbons), "22 Beverages, Spirits & Vinegar" (e.g. energy drink Red Bull), and "24 Tobacco & Manufactured Tobacco Substitutes" (e.g. cigarettes). The latter 7 HS categories of processed products mentioned above had a share of 80 to 90 percent in total agricultural and food exports during the observation period (see Kohler 2014).



Sources: Swiss Custons Administration (2014), OECD (2014), SNB (2014), Eurostat (2014)
Note: Real export values are smoothed using a moving average filter with 4 leads and lags.

Figure 1: Real effective exchange rate index and real exports

I(1). To make the time series weakly dependent (so that a law of large numbers and a central limit theorem apply), we transform each by first-differencing, i.e. $x_t \equiv \Delta \log(X_t)$, $gdp_t \equiv \Delta \log(GDP_t)$, and $rer_t \equiv \Delta \log(RER_t)$. Note that the first difference of a log transformed variable is approximately equal to the proportional percentage change in that variable. Hence, the observations are quarter-to-quarter percentage changes (i.e. approximate quarterly growth rates). Appendix A also discusses the results from a Johanson test for co-integration. The results do not suggest that there exists a long-term relationship among the variables. The appendix also provides summary statistics in Table 2.

3.2 Panel data

Since the panel dataset is based on the same data as the time series provided by the Swiss Customs Administration (2014b), we will keep its description brief.

The panel dataset contains the annual exports of 194 HS4 product categories (all HS4 categories included in the HS2 classifications 01 to 24) to 36 countries (these correspond to the same countries included in the time series data; see Table 3 in Appendix A) for the years 2002 until 2012.[5] The original dataset contains $194 \times 36 \times 11 = 76,824$ observations. As common with disaggregated trade data, the data at the HS4 level include a large number of zero observations for exports (approx. 68 percent). Since we log transform all variables in our analysis, we lose the zero observations. We construct a balanced panel, i.e. for exports of a given product to a given country we observe a positive trade flow for every year between 2002 and 2012, ending up with a dataset containing 12,716 observations. Again, we have data on (bilateral) real exchange rates provided by the Swiss National Bank (2014) and Eurostat (2014), and on countries' GDP by OECD (2014). Summary statistics for the balanced panel data can be found in Table 5 in Appendix A.

[5] Examples for HS4 product categories include "0406 Cheese and curd", "0901 Coffee, whether or not roasted or decaffeinated" (e.g. "Nespresso" capsules), "1806 Chocolate and other food preparations containing cocoa", "1905 Bread, pastry, cakes and other bakers' wares, whether or not containing cocoa", "2106 Food preparations, n.e.s." (incl. bonbons), "2202 Waters, incl. mineral waters and aerated waters, containing added sugar or other sweetening matter or flavored" (e.g. "Red Bull").

4 Time series analysis

This section introduces the time series models used to estimate the exchange rate effects, and discusses the results. From the discussion in Section 3.1, remember that the time series are integrated of order one, so that we take first-differences of the log transformed variables, and that we don't find evidence for a co-integration relationship among the variables. Thus, we cannot apply (vector) error-correction models in our analysis. Instead, we will look at distributed lag (DL) and autoregressive distributed lag (ADL) models.

4.1 Time series models

We start our analysis with a simple finite distributed lag (DL) model based on quarterly time series data. In particular, we want to test whether exchange rate movements (controlling for demand changes) have a lagged effect on changes in exports. The reason is that we believe long-term contracts and consumption habits might matter in the context of exchange rate effects. Thus, we estimate the following DL model by OLS

$$x_t = \alpha + \sum_{k=0}^{K} \beta_k gdp_{t-k} + \sum_{j=0}^{J} \gamma_j rer_{t-j} + A_t + \nu_t, \tag{1}$$

where x_t denotes the quarter-to-quarter percentage change in real exports, gdp_{t-k} and rer_{t-j} denote the kth and jth lag of the quarter-to-quarter percentage changes, in the weighted aggregate GDP of all trading-partners and the real effective exchange rate index, respectively.[6] A_t includes quarterly dummies (capturing seasonal effects), a linear annual time trend (allowing for a trend in growth rates over the years) and a dummy variable indicating the introduction of the exchange rate peg against the Euro by the Swiss National Bank in September 2011. We assume that the zero conditional mean assumption holds for the error term ν_t. DL models often have serial correlation in the error term, even if there is no underlying misspecification (see Wooldridge 2009). We know that this does not affect the consistency of the OLS estimator but makes inference based on OLS invalid. Thus, we compute Newey-West standard errors, which are robust to heteroskedasticity and autocorrelation in the error terms.[7] DL models have the following drawbacks. In general, they impose strong, possibly incorrect restrictions on the lagged response of the dependent variable to changes in an independent variable (Greene 2003). Keele and Kelly (2005) argue that with autocorrelated data one should be hesitant to use OLS with corrected standard errors. Using Monte Carlo simulations they show that OLS can be severely biased in that case if the model is misspecified (i.e. the true data generating process is dynamic). In particular, there is often multicollinearity, i.e. high autocorrelation of the independent variables. This makes it difficult to obtain precise estimates of the individual coefficients. Nevertheless, it is often possible to obtain good estimates of the long-run effect (Wooldridge 2009). In order to check how sensitive the results from the DL model are to model specification, we also estimate the following autoregressive distributed lag (ADL) model by OLS

$$x_t = \alpha + \sum_{i=1}^{I} \rho_i x_{t-i} + \sum_{k=0}^{K} \beta_k gdp_{t-k} + \sum_{j=0}^{J} \gamma_j rer_{t-j} + A_t + \nu_t, \tag{2}$$

where we added i lags of the dependent variable x_t on the right-hand side. The rest of the model specification is left unchanged compared to the DL model (1). We continue to assume that the zero conditional mean assumption holds for the error term ν_t.[8]

[6] For OLS to be consistent we need that: (1) the time series are weakly dependent (so that a law of large numbers and central limit theorem can be applied), (2) the zero conditional mean assumption holds, i.e. for each t, $E(\nu_t|\mathbf{x_t}) = 0$, where $\mathbf{x_t}$ denotes the vector including all independent variables, and (3) there is no perfect collinearity. If assumptions (1)-(3) hold, OLS is consistent. However, note that OLS is biased if the strict exogeneity assumption, for each t, $E(\nu_t|\mathbf{X}) = 0$ fails. For more details see e.g. Wooldridge (2009) or Greene (2003).

[7] Even though OLS is inefficient in that case, it has some advantages to estimate the model by OLS and correct the standard errors for serial correlation, compared to other approaches like Feasible Generalized Least Squares (FGLS). If the explanatory variables are not strictly exogenous, FGLS will not even be consistent (see Wooldridge 2009).

[8] Note that models with lagged dependent variables cannot satisfy the strict exogeneity assumption. However, as long as the zero conditional mean assumption in Footnote 6 holds, OLS is consistent. In that case, the lagged dependent variables x_{t-i} are said to be predetermined with respect to the error term ν_t. This has the following implications. Not only is x_{t-i} realized before ν_t, but its realized value has no impact on the expectation of ν_t (Davidson and MacKinnon 2003). In our case, this requires that past quarterly growth rates of real exports are uncorrelated with unobserved factors ν_t affecting the contemporaneous growth rate of real exports. Greene (2003) states that

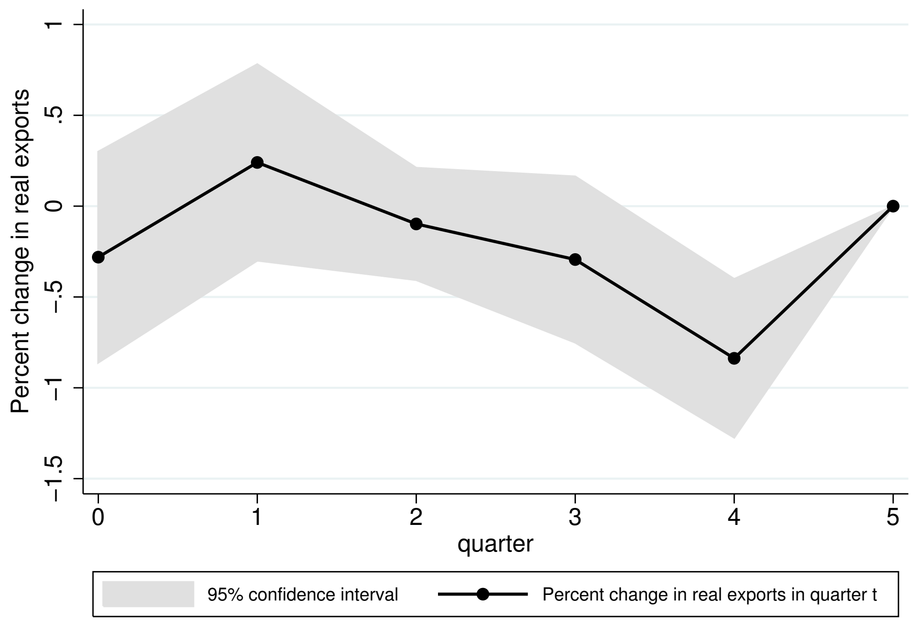
We select the number of lags in both models according to Hayashi's (2000) general-to-specific sequential t rule. Since we have quarterly data, we start at 4 lags of each variable, and sequentially exclude lags that are not statistically significant (at the 5% level). We further check for autocorrelation in the residuals after each elimination, using Durbin's alternative test and the Breusch-Godfrey LM test. Note that according to Hayashi (2000), this rule has the disadvantage of possibly overfitting the model. Thus, as a check, we also look at the Akaike information criterion (AIC) and the Bayesian information criterion (BIC).

4.2 Results and Discussion

This section discusses the DL model (1) and the ADL model (2) in turn, and compares their results. Our discussion of the results concentrates on the effect of changes in the real exchange rate of the Swiss franc on real exports. We further compare the results to the existing literature for Switzerland, and interpret them.

Table 6 in Appendix B reports the results for the DL model (1). Models DL1 to DL4 show that the estimated exchange rate effects are fairly stable with respect to different model specifications. Hence, we focus our discussion on model DL4, which represents the most parsimonious specification.

Figure 2 below shows the lag distribution of model DL4 (including a 95% confidence interval). We see that there is a lagged effect on real exports, 4 quarters after a change in the real effective exchange rate. In particular, a temporary 1 percent appreciation of the Swiss franc today leads on average to a statistically significant decrease in real exports of about 0.8 percent, 4 quarters from today, ceteris paribus. Note that a one percent appreciation in the current quarter means that the price of the Swiss franc (relative to other currencies) raises by one percent in that quarter, e.g. the real exchange rate index increases from 100 to 101 and stays at that level. However, in the next quarter there is no further appreciation of the Swiss franc, e.g. the real exchange rate index stays at 101. Summing up over the coefficients γ_j gives a long-run exchange rate elasticity of approx. $\sum_j \gamma_j = -1.3$, with a Newey-West standard error of 0.324 (p-value 0.000). Here, the Swiss franc appreciates one percent four quarters in a row, e.g. the real exchange rate index raises from 100 to 104 in one year.



Sources: Swiss Custons Administration (2014), OECD (2014), SNB (2014), Eurostat (2014)

Figure 2: Lag distribution DL Model 4

The results from the ADL model (2) are reported in Table 7 in Appendix B. Table 7 also includes the F-test statistics for Durbin's alternative test and for the Breusch-Godfrey (BG) LM test for first-order serial correlation

the usual explanation for autocorrelation in the error term is serial correlation in omitted variables. According to Wooldridge (2009), serial correlation in the error term of a dynamic model often indicates that the model has not been completely specified (i.e. not enough lags of the dependent variable have been included). Hence, we test for (first-order) serial correlation in the error term using Durbin's alternative test and the Breusch-Godfrey LM test.

(i.e. p=1) in the errors v_t. Note that the tests never reject the H_0 of no (first-order) serial correlation in the errors at a level lower than 10 percent (except the BG test for model ADL4).[9] Again, we see that the results are relatively stable across the different model specifications ADL1 to ADL5. Thus, we focus our discussion on model ADL5, the most parsimonious specification. For model ADL5, Table 8 in Appendix B reports the F-test statistics also for higher-order serial correlation. A further issue in ADL models concerns stability. For the stochastic difference equation (2) to be stable we need that $\sum_i \rho_i < 1$, which holds for all models ADL1 to ADL5.

First, we look at temporary or short-run effects again. Due to the lagged dependent variable, the effects of changes in the real exchange rate index on real exports have to be calculated.[10] The lag distribution up to 12 lags including a 95% confidence interval for model ADL5 is depicted in Figure 3. We see that on average a 1 percent appreciation of the Swiss franc today only leads on average to a statistically significant decrease in real exports of about 0.8 percent, 4 quarters or one year from today, ceteris paribus. All other lags are not significant at the 5% level. In other words, this one-time appreciation of the Swiss franc leads only to a temporary (lagged) response in exports. Second, consider the permanent or long-run effect of exchange rate movements on exports. The permanent effect in model ADL5 is equal to $\sum_j \gamma_j / (1 - \sum_i \rho_i) = -0.9$ (standard error 0.382; p-value 0.021). This means that if the Swiss franc appreciates 1 percent every quarter, exports are on average 0.9 percent lower in every quarter, ceteris paribus. Again, short-run elasticities are lower than long-run elasticities, which is intuitive. We would expect that the reaction to temporary shocks is lower than to permanent ones.

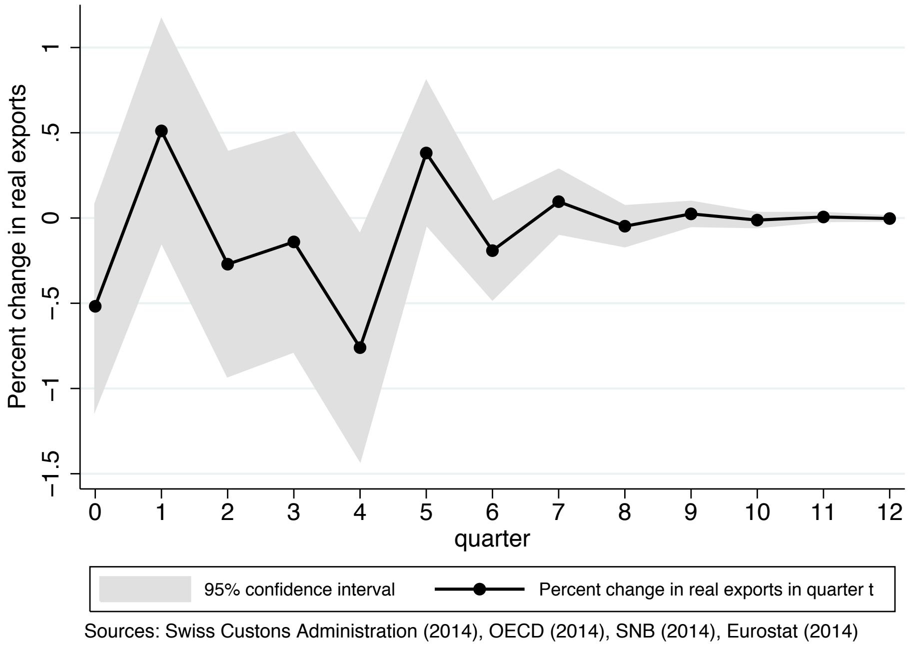


Figure 3: Lag distribution ARDL Model 5

We note that the short- and long-run effects in the DL and ADL models are relatively similar. However, since the DL model imposes strong restrictions on the lagged response of the dependent variable to changes in the independent variables (i.e. misspecification), we have more trust in the estimates based on the ADL models.

The estimated short- and long-run elasticities from the ADL models are broadly in line with the literature on exchange rate effects for Switzerland. For example, SECO (2010) estimate a error correction model, and find that an appreciation of the Swiss franc by 1 percent reduces aggregate Swiss exports by 0.4 percent in the short-run and by 1 percent in the long-run. Tressel and Arda (2011) also estimate an error correction model for aggregate Swiss exports. They also find a long-run elasticity of exports with respect to exchange rate changes of -0.9.

[9]Note that we alternatively estimated the models with Newey-West standard errors robust to autocorrelation in the error terms (with 4 lags for quarterly data as suggested by Wooldridge 2009), and heteroskedasticity-robust standard errors. In general, both Newey-West and heteroskedasticity-robust standard errors are slightly smaller than conventional standard errors. Following the rule-of-thumb proposed by Angrist and Pischke (2008), we report the largest standard errors to avoid misjudgments of precision.

[10]The impact elasticity (propensity) is given by γ_0. The effect after one quarter is given by $\rho\gamma_0$, after two quarters by $\rho^2\gamma_0 + \rho\gamma_1 + \gamma_2$, after three quarters by $\rho^3\gamma_0 + \rho^2\gamma_1 + \rho\gamma_2 + \gamma_3$, and after $h \geq 4$ quarters by $\rho^{h-4}\left(\rho^4\gamma_0 + \rho^3\gamma_1 + \rho^2\gamma_2 + \rho\gamma_3 + \gamma_4\right)$. The effects can be interpreted as elasticities.

Lamla and Lassmann (2011) estimate a ADL model for 6 export markets (Germany, France, Italy, UK, US, Japan) and 12 sectors, separately. For the agriculture and food sector they don't find any significant effects of exchange rate movements on exports to any of the 6 export markets.

Even though, temporary and permanent effects are statistically significant they are economically relatively small. The results further suggest that temporary responses of exchange rate movements are most likely lagged. This could be because of long-term contracts, persistent consumption habits but also because firms, especially large exporters like Nestlé, Lindt & Sprüngli and Red Bull, might hedge their foreign exchange rate risk in the currency market. Hedging could also explain why the effects on average are economically relatively small. Other reasons might be that Swiss producers can successfully differentiate their products on foreign markets, e.g. with the help of umbrella brands like "Swissness" or firm-specific brands like "Nespresso". They mostly produce high-quality specialties for niche markets, e.g. cheese specialties like Gruyère cheese or Swiss chocolate, characterized by low competition and a relatively high degree of market power. Summa summarum, this suggests that the focus of the Swiss Agricultural Policy on a quality strategy might help to mitigate the effects of exchange rate changes, at least for domestic producers of raw products. However, the effects of an appreciation of the Swiss franc might also be dampened if imported input goods become cheaper. The results could as well be interpreted in the sense, that on average producers in the Swiss Agriculture and Food Sector face relatively inelastic foreign demand (i.e. the price elasticity of demand is low).

5 Panel data analysis

To complement the time series analysis above, we estimate dynamic panel data models based on the panel data described in Section 3.2. This allows us to further check the robustness of the results from the time series analysis. The advantage is that the panel data allow us to use the information contained in the cross-section, which should lead to more efficient and less biased estimates.

5.1 Dynamic panel data models

Economic reasoning suggests that lagged effects might be important in the context of exchange rate effects. This is also implied by the time series analysis in the previous section. Hence, consider the following dynamic panel data model

$$\log(X_{ijt}) = \alpha + \rho X_{ij,t-1} + \beta \log(GDP_{it}) + \gamma \log(RER_{it}) + A_i + A_j + A_t + \nu_{ijt}$$

where i indexes countries, j products, and t time.[11] The terms A_i, A_j, and A_t denote trading-partner (country), product and time fixed-effects, respectively. The (idiosyncratic) error term ν_{ijt} is assumed to be independent and identically distributed (i.i.d.).

We follow the usual procedure in the literature (see e.g. Angrist and Pischke 2008, Roodman 2009), and transform the model above by taking first-differences

$$\Delta\log(X_{ijt}) = \rho\Delta\log(X_{ij,t-1}) + \beta\Delta\log(GDP_{it}) + \gamma\Delta\log(RER_{it}) + \Delta A_t + \Delta\nu_{ijt}, \quad (3)$$

killing the fixed-effects A_i and A_j. Note that even though the fixed-effects are gone now, the lagged dependent variable $\Delta\log(X_{ij,t-1})$ is still correlated with the errors $\Delta\nu_{ijt}$, since the latter contains ν_{ijt} and the former $\log(X_{ij,t-1})$; the classic reference is Nickell (1981). However, with the fixed-effects eliminated, equation (3) can be estimated using instrumental variables (IV). Instruments for $\Delta\log(X_{ij,t-1})$ can be constructed from second and higher lags of $\log(X)$, either in levels or differences. If ν_{ijt} is i.i.d., those lags will be correlated with $\Delta X_{ij,t-1}$ but uncorrelated with $\Delta\varepsilon_{ijt}$. We will test whether this assumption holds by reporting the value of the Arellano-Bond AR(2) test on the residuals in first differences (i.e. to detect AR(1) in the underlying levels variables). Furthermore,

[11] Similar to ADL model (2) in Section 4.1, the impact elasticity (propensity) is given by γ, the lagged effect after $h \geq 1$ years is given by $\rho^h\gamma$. The long-run elasticity is given by $\gamma/(1-\rho)$.

we test whether the instruments pass the Hansen J test for over-identification (as suggested by Roodman 2009, we don't take comfort in a p-value below 0.1 and are suspicious of p-values above 0.25).

There are several dynamic panel data estimators available (see e.g. Baum 2013). As a starting point, equation (3) is often estimated using two-stage least-squares (2SLS), following Anderson and Hsiao (1982). They propose the use of either second- or higher-order lags of the lagged dependent variable (either in levels or first differences) as instruments. Arellano (1989) argues that the estimator using instruments in levels has much smaller variances, and is therefore preferred. While the Anderson-Hsiao (A-H) estimator is consistent, Arellano and Bond (1991) argue that it is not efficient since it fails to take all the potential orthogonality conditions into account. Hence, we also estimate model (3) using the Arellano-Bond (A-B) difference GMM one-step and two-step estimator (see Arellano and Bond 1991). According to Roodman (2009) the A-B two-step GMM estimator with Windmeijer (2005) corrected standard errors seems slightly superior to the A-B one-step GMM estimator with cluster-robust standard errors (lower bias and standard errors). Hence, our discussion of the results in the following section focuses on the results from the A-B two-step difference GMM estimator with Windmeijer-corrected standard errors.

5.2 Results and Discussion

Table 1 below reports the results from the A-B two-step GMM estimator.[12] We report the results from model A-B M1 using all instruments, model A-B M2 using the collapsed set of instruments (see Roodman 2009), and models A-B M1 to A-B M8, which are the only models with valid instruments. First, note that models A-B M1 and A-B M2 are not valid since they fail both the Arellano-Bond AR(2) test, and the Hansen J test. Second, note that the estimated short-run exchange rate elasticities (given by the coefficients on $\Delta \log (RER_{it})$), and long-run exchange rate elasticities (LRE) are all very similar across the valid models A-B M1 to A-B M8. However, looking at AR(2) and Hansen J test statistics, we prefer model A-B M7 (using lags 6 to 9 as instruments), since we can be most confident that the instruments used in this model are valid. In particular, the Arellano-Bond AR(2) test suggests that there is no second-order serial correlation in the error term, and the p-value of the Hansen J test for over-identification lies between 0.1 and 0.25 (remember the discussion in the previous section). However, note that the results from the A-H 2SLS estimators and the A-B one-step difference GMM estimators are very similar, see Table 9 and Table 10, respectively, in Appendix B.2.

Nevertheless, in the following discussion we focus on model A-B M7. We see that the estimated short- and long-run exchange rate elasticities are given by approx. -0.5, and -0.8, respectively. This means that a 1 percent appreciation of the Swiss franc leads in the short- and long-run on average to a reduction of 0.5 percent and 0.8 percent in real exports, respectively. As in the time series analysis, we see that the long-run elasticities are higher than the short-run elasticities. Again, this is intuitive since the reactions to temporary shocks are expected to be smaller than to permanent ones.

Most studies estimate exchange rate effects based on time series, neglecting the panel dimension. Thus, studies which use panel data to estimate exchange rate elasticities are relatively uncommon. A notable exception is Auer and Saure (2011), who estimate dynamic panel data models for 25 product categories and 27 countries. They find that a 1 percent appreciation of the Swiss franc has a negative effect on exports of about 0.7 percent in the long-run, which is very similar to our own estimate. Another exception is Gaillard (2013), who estimates static panel data models.[13] She finds long-run exchange rate elasticities in the range of -0.5 to -0.8.

Comparing the short- and long-run elasticities based on panel data with the ones based on time series, we see that the elasticities based on time series (-0.8 and -0.9, respectively) are slightly higher than the ones

[12] In principle, one might argue that GDP and the real exchange rate index too could be endogenous in model (3). In other words, there might be unobserved shocks that affect both changes in the exchange rate as well as changes in agro-food exports. We don't think this is a problem here. However, the A-B framework offers a natural set of instruments (in the form of lagged values of GDP and the real exchange rate index) to address this issue. Hence, we also look at A-B difference GMM estimators treating GDP and the real exchange rate index as endogenous. We find statistically significant short- and long-run exchange rate elasticities that are about twice as large compared to the ones in Table 1.

[13] We also estimate the following static panel data model

$$\Delta \log (X_{ijt}) = \alpha + \beta \Delta \log (GDP_{it}) + \gamma \Delta \log (RER_{it}) + A_i + A_j + A_t + \varepsilon_{ijt}.$$

The static panel data model has the advantage that it does not rely on instrumental variables. The downside is that if the underlying data generating process is dynamic, the model is misspecified. However, the estimated short-run elasticity is -0.6 (standard error 0.186; p-value 0.001), and is similar to the short-run elasticties estimated from dynamic panel data models.

based on panel data (-0.6 and -0.8, respectively). However, any small sample bias of the estimates based on (autoregressive) time series models seems to be small. Thus, our basic interpretation of the results in Section 4.2 does not change. Since the panel data analysis suggests that the effects are economically even smaller, we have more confidence in our interpretation, that on average producers are able to successfully evade price competition. Here, one should note that this is the average reaction of exports to exchange rate changes. In other words, the exports of some business sectors within the Swiss Agriculture and Food Sector might react less or more to exchange rate changes. Furthermore, this does not necessarily imply that overall firm performance isn't affected at all if the Swiss franc appreciates or depreciates (see e.g. Swiss National Bank 2011). For example, profit margins might fall, investments could be put on hold, or there may be negative employment effects (e.g. lay-offs, cut in working hours) if the Swiss franc appreciates. Hence, it would be foolish to conclude that all is well for every producer in the Swiss Agriculture and Food Sector if the Swiss franc appreciates strongly. However, our analysis suggests that not all is lost - at least on average the effects of exchange rate changes on the export performance of producers are relatively small.

Table 1: Arellano-Bond two-step difference GMM estimators (dep Var $\Delta \log (X_{ijt})$)

	A-B M1 all	A-B M2 collapsed	A-B M3 lag5	A-B M4 lag6to7	A-B M5 lag6to8	A-B M6 lag7to8	A-B M7 lag6to9	A-B M8 lag7to9
$\Delta \log (X_{ij,t-1})$	0.361***	0.350***	0.219	0.483	0.322	0.097	0.319	0.170
	(0.043)	(0.043)	(0.307)	(0.318)	(0.289)	(0.419)	(0.278)	(0.322)
$\Delta \log (GDP_{it})$	1.019**	1.070**	1.097*	0.741	0.975*	1.260*	0.963*	1.122*
	(0.462)	(0.465)	(0.624)	(0.631)	(0.581)	(0.762)	(0.578)	(0.666)
$\Delta \log (RER_{it})$	-0.654***	-0.546***	-0.537**	-0.476**	-0.534**	-0.570***	-0.543***	-0.575***
	(0.197)	(0.207)	(0.224)	(0.225)	(0.210)	(0.209)	(0.206)	(0.206)
LRE	-1.023***	-0.840***	-0.687**	-0.920	-0.788**	-0.631**	-0.797**	-0.693**
	(0.314)	(0.319)	(0.321)	(0.583)	(0.379)	(0.298)	(0.380)	(0.318)
Observations	10404	10404	10404	10404	10404	10404	10404	10404
No Instruments	56	20	16	18	20	16	21	17
AR(2) test (pv)	0.000	0.000	0.362	0.091	0.187	0.722	0.176	0.472
Hansen J (df)	44	8	4	6	8	4	9	5
Hansen J (pv)	0.000	0.029	0.101	0.185	0.135	0.234	0.176	0.285

Notes: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. Cluster-robust standard errors in parentheses (Windmeijer 2005 finite-sample correction). Arellano-Bond two-step difference GMM estimator, assuming that GDP and RER are strictly exogenous. All models include year dummies. LRE denotes the long-run real exchange rate elasticity. AR(2) test reports the p-value for the Arellano-Bond test for AR(2) in first differences. Hansen J (df) and (pv) report the degrees of freedom and the p-value for the Hansen J test of overidentifying restrictions, respectively.
Sources: Swiss Customs Administration (2014b), OECD (2014), Swiss National Bank (2014), Eurostat (2014).

6 Conclusion

After the global financial crisis in 2008 the Swiss franc has appreciated strongly against the currencies of Switzerland's most important trading partners. This has raised the old question of how sensitive exports react to exchange rate changes. We investigate this question for the exports of the Swiss Agriculture and Food Sector. Focusing on the Swiss Agriculture and Food Sector has the advantage that the sector is economically small, so that we don't have to worry about reverse causality of exchange rate fluctuations.

We use time series and panel data models to estimate short- and long-run exchange rate elasticities. This allows us to assess how sensitive the results are with respect to model specification, estimation methods and data structure. We find that the estimated elasticities are remarkably similar across all models and estimation methods. However, in general, the estimates based on panel data are slightly lower than the ones on time series. In the short-run, we find that a (temporary) appreciation of one percent of the Swiss franc implies on average a (lagged) decrease in real exports of agriculture and food exports between 0.6 and 0.8 percent, one year after the appreciation. In the long-run, we find that on average a one percent appreciation of the Swiss franc leads to a (permanent) decrease in real exports in the range of 0.8 to 0.9 percent. These estimates are similar to the findings of studies on aggregate Swiss exports. The estimated exchange rate effects seem economically small. It seems that on average, producers in the Swiss Agriculture and Food Sector are able to evade price competition by successfully differentiating their products, producing high-quality products for niche markets. This further suggests that the emphasis on product quality in the Swiss Agricultural Policy is an adequate strategy for Swiss producers to successfully compete on foreign markets. These might be a valuable lesson for policy makers in other industrialized countries with similar agriculture and food sectors (e.g. Norway, Japan) that could be learned from Switzerland. However, we think that these lessons can also be generalized to other sectors to some extent. Most other sectors of the Swiss economy also pursue a quality strategy (e.g. mechanical watches, precision instruments and mechanical appliances, electric machinery, pharmaceuticals). As previously discussed, studies looking at the aggregate Swiss economy find exchange rate elasticities in the same range as we find for the agriculture and food sector.

Future research could focus on the case study of a particular product market, e.g. cheese, chocolate or biscuits, that might help us to better understand the mechanisms/channels through which the exchange rate operates. Further research could also look at the effects of exchange rate volatility on exports of agriculture and food products. This might yield some insight into how uncertainty of price changes, proxied by exchange rate volatility, affects exports in the agriculture and food sector. Furthermore, it would be interesting to study how import price changes, due to exchange rate changes, are passed through to domestic producer and consumer prices.

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A Appendix: Data

A.1 Time Series Data

Table 2 below reports the summary statistics for the time series data over the whole sample period 1999-2012 for real exports X_t, the demand measure GDP_t, and the real effective exchange rate index RER_t, where variables are in (natural) logarithms. Our sample consists of 56 observations, i.e. we observe all variables in every quarter t between 1999 and 2012. In Figure 4, quarterly percentage changes in real exports (smoothed) and in the real exchange rate index are shown over time. Table 3 below lists all countries in the sample, and their official currencies.

Table 2: Summary statistics time series

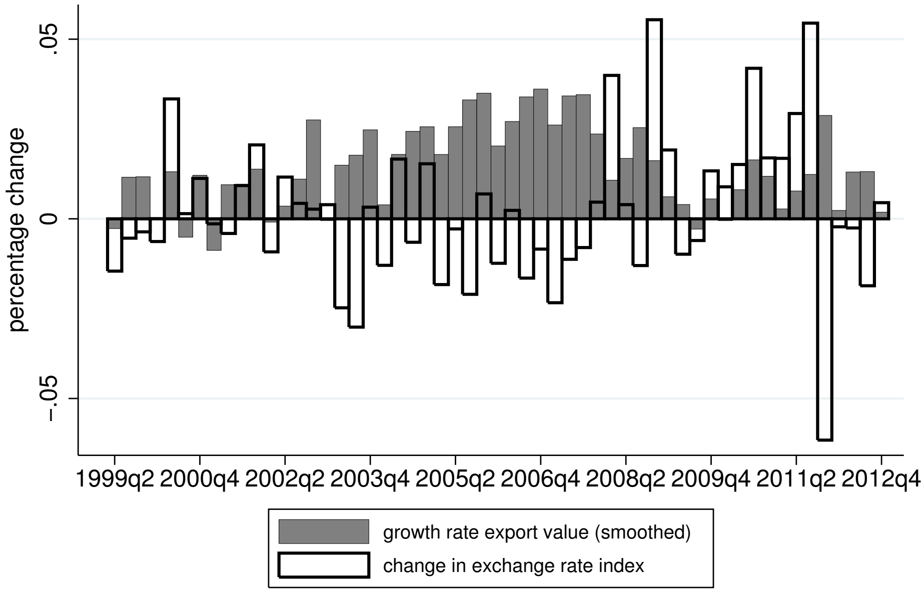
	min	mean	max	sd	T
$\log(X_t)$	-0.451	0.004	0.518	0.291	56
$\log(GDP_t)$	0.625	0.902	1.191	0.137	56
$\log(RER_t)$	4.510	4.623	4.802	0.062	56

Sources: Swiss Customs Administration (2014b), OECD (2014), Swiss National Bank (2014), Eurostat (2014).

Table 3: Country and currency list

Country	ISO3 code	Currency	OECD member
Australia	AUS	AUD	yes
Austria	AUT	EUR	yes
Belgium	BEL	EUR	yes
Brazil	BRA	BRL	no
Canada	CAN	CAD	yes
Czech Republic	CZE	CZK	yes
Denmark	DNK	DKK	yes
Estonia	EST	EUR	yes
Finland	FIN	EUR	yes
France	FRA	EUR	yes
Germany	DEU	EUR	yes
Hungary	HUN	HUF	yes
Iceland	ISL	ISK	yes
India	IND	INR	no
Indonesia	IDN	IDR	no
Ireland	IRL	EUR	yes
Israel	ISR	ILS	yes
Italy	ITA	EUR	yes
Japan	JPN	JPY	yes
Korea, Republic of	KOR	KRW	yes
Luxembourg	LUX	EUR	yes
Mexico	MEX	MXN	yes
Netherlands	NLD	EUR	yes
New Zealand	NZL	NZD	yes
Norway	NOR	NOK	yes
Poland	POL	EUR	yes
Portugal	PRT	EUR	yes
Russian Federation	RUS	RUB	no
Slovakia	SVK	EUR	yes
Slovenia	SVN	EUR	yes
South Africa	ZAF	ZAR	no
Spain	ESP	EUR	yes
Sweden	SWE	SEK	yes
Turkey	TUR	TRY	yes
United Kingdom	GBR	GBP	yes
United States of America	USA	USD	yes

Note: The United States of America includes Puerto Rico.
Sources: Swiss Customs Administration (2014b), OECD (2014), Swiss National Bank (2014), Eurostat (2014).



Sources: Swiss Custons Administration (2014), OECD (2014), SNB (2014), Eurostat (2014)
Note: Quarterly percentage changes in real export value and real effective exchange rate index.

Figure 4: Quarterly percentage changes in real effective exchange rate index and real exports

Real exports X_t are measured in billion Swiss francs, and are obtained by deflating nominal exports using the (mean) export price index for agriculture and food products (i.e. based on HS 01-24) provided by the Swiss Customs Administration (2014b). Deflating nominal exports eliminates influences from price changes. Export values are based on invoiced prices in Swiss francs free on board (f.o.b.) at the Swiss border, i.e. prices are exempt international shipping costs.

The definition of the demand measure GDP_t in period t follows Santos et al. (2003), and is given by

$$GDP_t = \exp\left(\frac{1}{\sum_{i=1}^{n} w_{it}} \sum_{i=1}^{n} w_{it} \ln GDP_{it}\right),$$

where the weight $w_{it} \equiv X_{it} / \sum_{i=1}^{n} X_{it}$ denotes the share of country i in total Swiss exports, and n denotes the total number of countries in the sample. Note that the demand measure is based on GDP data measured in trillion Swiss francs (PPP adjusted, 2005).

The construction of the real effective exchange rate index RER in period t is based on Fluri and Müller (2001), and given by

$$RER_t = \prod_{i=1}^{n} (R_{it})^{\frac{1}{2}\left(w_{iB} + \frac{w_{it} R_{it}}{\sum_{i=1}^{n} w_{it} R_{it}}\right)},$$

where $R_{it} = \frac{e_{iB} CPI_{iB} CPI_{CH,t}}{e_{it} CPI_{it} CPI_{CH,B}}$ denotes the real exchange rate index of country i in period t, e denotes the nominal exchange rate (defined as units of Swiss francs per unit of foreign currency), and CPI is the consumer price index. The weight w_{it} is defined as above. Subscript B denotes the base period, and subscript CH stands for Switzerland.

Figure 5 below shows the joint evolution of the demand measure GDP_t and real exports X_t of the Swiss Agriculture and Food Sector between 1999 and 2012. We see that demand and exports grow almost pari passu during the observation period.

As discussed above for OLS to be valid, we need the time series to be weakly dependent, i.e. integrated of order zero I(0). Table 4 reports the results of augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. Whereas the ADF test never rejects the null hypothesis of a unit root in the level of all log transformed variables, the PP test doesn't reject only in the case of RER. Nevertheless, we take the first difference Δ of all log transformed variables. Here, the ADF and the PP tests agree (except for real exports x_t), and we reject the

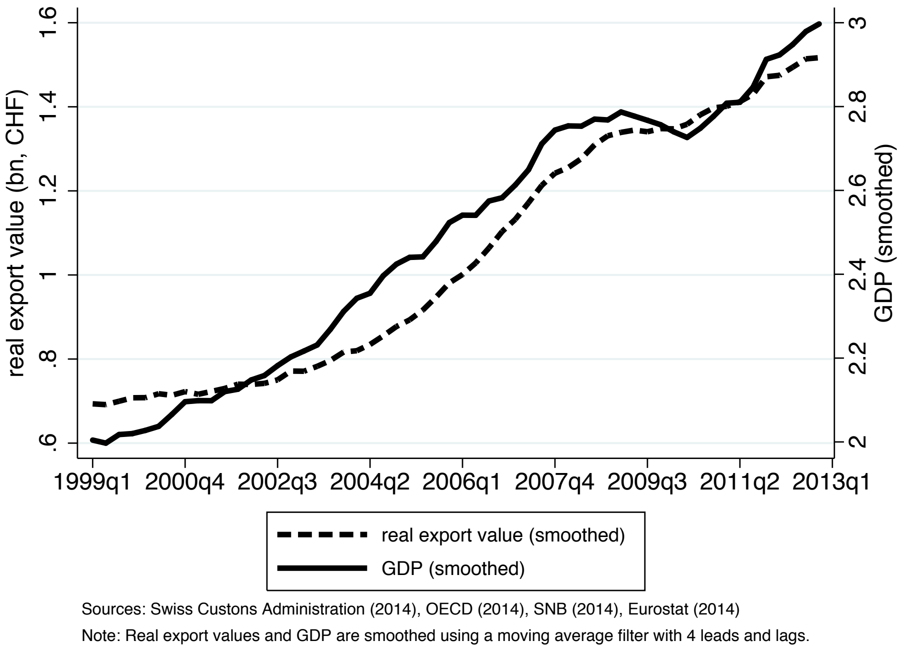


Figure 5: GDP and real exports

null hypothesis that the log transformed variables in first differences contain a unit root. In other words, the log transformed variables seem to be integrated of order one I(1).

We also test whether variables are co-integrated. To this end, we run a Johansen test (with 2 lags). We cannot reject the null hypothesis of no co-integration among the variables at the 5% level (i.e. the trace statistic of 20.38 at rank zero falls short of the 5% critical value of 29.68). Hence, we don't find evidence for the existence of a co-integration relationship.

Table 4: Unit root tests

	ADF test		PP test	
	test stats	p-value	test stats	p-value
$\log(X_t)$	-1.88	0.66	-3.95	0.01
x_t	-2.91	0.16	-11.65	0.00
$\log(RER_t)$	-1.16	0.92	-1.18	0.91
rer_t	-6.93	0.00	-6.93	0.00
$\log(GDP_t)$	-2.30	0.43	-4.70	0.00
gdp_t	-4.39	0.00	-10.46	0.00

Notes: All variables in (natural) logarithm. The table reports test statistics and the MacKinnon approximate p-values. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests (H_0: unit root) both include a time trend. The number of lags has been chosen according to Schwarz's Bayesian information criterion (SBIC).

Sources: Swiss Customs Administration (2014b), OECD (2014), Swiss National Bank (2014), Eurostat (2014).

A.2 Panel Data

Table 5 below reports the summary statistics for the panel data over all 194 HS2 categories and the whole sample period 2002-2012.

Table 5: Summary statistics panel data

	min	mean	max	sd	N
X_{ijt}	0	0.651	493.008	6.648	76824
X_{ijt}	8.43×10^{-7}	3.795	493.008	15.936	12716
$\log(X_{ijt})$	-27.802	-15.348	-7.615	2.637	12716
$\log(GDP_{it})$	9.631	14.178	17.026	1.382	12716
$\log(RER_{it})$	4.172	4.630	5.086	0.108	12716

Note: Real exports are denoted in millions Swiss Francs.

Sources: Swiss Custons Administration (2014), OECD (2014), SNB (2014), Eurostat (2014).

B Appendix: Results

This appendix shows the tables with the results from the DL and ADL models. For ADL Model 5 it also reports the table containing the tests for higher-order serial correlation in the error terms. Furthermore, the appendix shows the tables with the results from the A-B one-step and two-step difference GMM estimators.

B.1 Results Time Series Analysis

Table 6: DL models (dependent Variable x_t)

	DL1	DL2	DL3	DL4
gdp_t	0.384**	0.404*	0.396*	0.383**
	(0.172)	(0.216)	(0.200)	(0.189)
gdp_{t-1}	-0.384*	-0.375**	-0.409**	-0.422**
	(0.194)	(0.185)	(0.183)	(0.192)
gdp_{t-2}	0.046	0.075	0.048	
	(0.141)	(0.171)	(0.152)	
gdp_{t-3}	0.077	0.095		
	(0.206)	(0.226)		
gdp_{t-4}	-0.066			
	(0.222)			
rer_t	-0.299	-0.273	-0.279	-0.281
	(0.342)	(0.315)	(0.296)	(0.286)
rer_{t-1}	0.257	0.247	0.242	0.240
	(0.283)	(0.259)	(0.273)	(0.267)
rer_{t-2}	-0.093	-0.091	-0.100	-0.098
	(0.172)	(0.164)	(0.158)	(0.152)
rer_{t-3}	-0.297	-0.291	-0.293	-0.294
	(0.255)	(0.243)	(0.232)	(0.226)
rer_{t-4}	-0.802***	-0.806***	-0.819***	-0.838***
	(0.233)	(0.231)	(0.228)	(0.215)
Observations	51	51	51	51
Adjusted R^2	0.584	0.594	0.602	0.612
AIC	-163.5	-165.4	-166.9	-168.9
BIC	-132.6	-136.4	-139.9	-143.8
Durbin (p,df)	10.87(1,34)	10.52(1,35)	11.18(1,36)	11.43(1,37)
Durbin (pv)	0.002	0.003	0.002	0.002
BG (p,df)	12.36(1,34)	11.79(1,35)	12.09(1,36)	12.04(1,37)
BG (pv)	0.001	0.002	0.001	0.001

Notes: * p<0.1, ** p<0.05, *** p<0.01. Newey-West standard errors with 4 lags in parentheses. All models include quarterly dummies, a linear annual time trend, and a dummy variable indicating the introduction of the exchange rate peg against the Euro. Durbin (p,df) reports the F-test statistics for Durbin's alternative test and BG (p,df) reports the F-test statistics for the Breusch-Godfrey LM test, with lags p and degrees of freedom df in parentheses. Durbin (pv) and BG (pv) report the corresponding p-values.

Sources: Swiss Customs Administration (2014b), OECD (2014), Swiss National Bank (2014), Eurostat (2014).

Table 7: ADL models (dependent Variable x_t)

	ADL1	ADL2	ADL3	ADL4	ADL5
x_{t-1}	-0.517***	-0.528***	-0.540***	-0.442***	-0.502***
	(0.162)	(0.155)	(0.153)	(0.136)	(0.133)
x_{t-2}	-0.146	-0.167	-0.140		
	(0.173)	(0.166)	(0.143)		
x_{t-3}	-0.139	-0.139			
	(0.177)	(0.157)			
x_{t-4}	0.049				
	(0.161)				
gdp_t	0.246	0.275	0.211	0.253	0.276
	(0.203)	(0.191)	(0.174)	(0.162)	(0.164)
gdp_{t-1}	-0.287	-0.259	-0.323*	-0.272	
	(0.214)	(0.192)	(0.173)	(0.169)	
gdp_{t-2}	-0.169	-0.100	-0.133		
	(0.218)	(0.185)	(0.178)		
gdp_{t-3}	0.104	0.124			
	(0.189)	(0.182)			
gdp_{t-4}	-0.127				
	(0.206)				
rer_t	-0.636*	-0.603*	-0.606**	-0.539*	-0.518*
	(0.317)	(0.299)	(0.294)	(0.291)	(0.296)
rer_{t-1}	0.204	0.176	0.187	0.262	0.251
	(0.289)	(0.278)	(0.269)	(0.258)	(0.263)
rer_{t-2}	-0.045	-0.040	0.024	-0.013	-0.014
	(0.288)	(0.279)	(0.264)	(0.262)	(0.268)
rer_{t-3}	-0.276	-0.288	-0.327	-0.350	-0.276
	(0.300)	(0.282)	(0.274)	(0.271)	(0.273)
rer_{t-4}	-0.980***	-0.984***	-1.039***	-0.928***	-0.831***
	(0.313)	(0.300)	(0.291)	(0.278)	(0.277)
Observations	51	51	51	51	51
Adjusted R^2	0.665	0.681	0.690	0.690	0.677
AIC	-172.7	-176.1	-178.6	-179.8	-178.3
BIC	-134.1	-141.3	-147.7	-152.7	-153.2
Durbin (p,df)	1.73(1,30)	1.52(1,32)	2.58(1,34)	3.61(1,36)	0.63(1,37)
Durbin (pv)	0.198	0.227	0.118	0.066	0.433
BG (p,df)	2.79(1,30)	2.31(1,32)	3.60(1,34)	4.65(1,36)	0.85(1,37)
BG (pv)	0.106	0.139	0.067	0.038	0.362

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard errors in parentheses. All models include quarterly dummies, a linear annual time trend, and a dummy variable indicating the introduction of the exchange rate peg against the Euro. Durbin (p,df) reports the F-test statistics for Durbin's alternative test and BG (p,df) reports the F-test statistics for the Breusch-Godfrey LM test, with lags p and degrees of freedom df in parentheses. Durbin (pv) and BG (pv) report the corresponding p-values.

Sources: Swiss Customs Administration (2014b), OECD (2014), Swiss National Bank (2014), Eurostat (2014).

Table 8: Tests for serial correlation in error of ADL Model 5

	Durbin test		BG test	
lags(p)	F	Prob>F	F	Prob>F
1	0.628	0.433	0.851	0.362
2	0.870	0.428	1.175	0.320
3	1.440	0.248	1.867	0.153
4	1.097	0.374	1.457	0.237
5	0.861	0.518	1.177	0.341
6	0.705	0.518	0.992	0.447
7	0.697	0.648	0.991	0.456
8	0.590	0.778	0.867	0.554

Notes: Shown are the F-test statistics and the corresponding p-value for Durbin's alternative test (Durbin test) and Breusch-Godfrey LM (BG test) test (H_0: no serial correlation) for serial correlation in the errors.

Sources: Swiss Customs Administration (2014b), OECD (2014), Swiss National Bank (2014), Eurostat (2014).

B.2 Results Panel Data Analysis

Table 9: Anderson-Hsiao 2SLS estimators (dep Var $\Delta \log (X_{ijt})$)

	A-H estimator (level)			A-H estimator (difference)		
	lag 2	lag 2-7	lag 4-6	lag 2	lag 2-5	lag 2-6
$\Delta \log (X_{ij,t-1})$	0.284***	0.090	0.214	0.001	0.089	0.078
	(0.041)	(0.083)	(0.218)	(0.069)	(0.083)	(0.086)
$\Delta \log (GDP_{it})$	0.990**	0.561	0.551	1.263***	0.770	0.578
	(0.455)	(0.674)	(0.685)	(0.477)	(0.613)	(0.674)
$\Delta \log (RER_{it})$	-0.539***	-0.751**	-0.691***	-0.717***	-0.699***	-0.751***
	(0.204)	(0.292)	(0.233)	(0.193)	(0.224)	(0.291)
LRE	-0.753***	-0.826**	-0.880**	-0.718***	-0.768***	-0.815**
	(0.286)	(0.319)	(0.348)	(0.197)	(0.250)	(0.314)
Observations	10404	4624	5780	9248	5780	4624
F-test statistic	229.71	22.80	12.73	225.97	36.02	22.66
AR(2) test (pv)	0.000	0.914	0.259	0.764	0.329	0.977
Hansen J (df)	n.a.	5	2	n.a.	3	4
Hansen J (pv)	n.a.	0.186	0.267	n.a.	0.106	0.159

Notes: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. Clustered standard errors in parentheses (by country and HS4 code). A-H denotes the Anderson-Hsiao 2SLS estimator (using levels and differences as instruments), assuming that GDP and RER are strictly exogenous. LRE denotes the long-run real exchange rate elasticity. F-test statistic reports the corresponding statistic from the first-stage. AR(2) test (pv) denotes the p-value for the Arellano-Bond test for AR(2) in first differences. Hansen J (df) and (pv) report the degrees of freedom and the p-value for the Hansen J test of overidentifying restrictions, respectively.

Sources: Swiss Customs Administration (2014b), OECD (2014), Swiss National Bank (2014), Eurostat (2014).

Table 10: Arellano-Bond one-step difference GMM estimators (dep Var $\Delta \log (X_{ijt})$)

	all	collapsed	lag5	lag6to7	lag6to8	lag7to8	lag6to9	lag7to9
$\Delta \log (X_{ij,t-1})$	0.305***	0.317***	0.374	0.360	0.224	0.162	0.215	0.244
	(0.035)	(0.038)	(0.296)	(0.250)	(0.209)	(0.381)	(0.210)	(0.379)
$\Delta \log (GDP_{it})$	1.681***	1.144**	0.915	0.900	1.101**	1.179*	1.109**	1.058
	(0.472)	(0.461)	(0.616)	(0.566)	(0.529)	(0.716)	(0.530)	(0.707)
$\Delta \log (RER_{it})$	-0.549***	-0.561***	-0.526**	-0.525**	-0.547***	-0.559***	-0.548***	-0.545**
	(0.203)	(0.207)	(0.221)	(0.218)	(0.204)	(0.206)	(0.203)	(0.212)
LRE	-0.790***	-0.822***	-0.840*	-0.820**	-0.705**	-0.667**	-0.698**	-0.721*
	(0.293)	(0.303)	(0.446)	(0.397)	(0.289)	(0.322)	(0.285)	(0.377)
Observations	10404	10404	10404	10404	10404	10404	10404	10404
No Instruments	56	20	16	18	20	16	21	17
AR(2) test (pv)	0.000	0.000	0.127	0.100	0.191	0.559	0.208	0.403
Hansen J (df)	44	8	4	6	8	4	9	5
Hansen J (pv)	0.000	0.029	0.101	0.185	0.135	0.234	0.176	0.285

Notes: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. Cluster-robust standard errors in parentheses. Arellano-Bond one-step difference GMM estimator, assuming that GDP and RER are strictly exogenous. All models include year dummies. LRE denotes the long-run real exchange rate elasticity. AR(2) test reports the p-value for the Arellano-Bond test for AR(2) in first differences. Hansen J (df) and (pv) report the degrees of freedom and the p-value for the Hansen J test of overidentifying restrictions, respectively.

Sources: Swiss Customs Administration (2014b), OECD (2014), Swiss National Bank (2014), Eurostat (2014).