Exchange Rates and Import Prices in Switzerland

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1. Introduction

Exchange rates reflect the relative price between currencies and, by changing the cost of imported goods and services, affect a country's price level. In particular, the purchasing power parity (PPP) theory, which often serves as a benchmark in macroeconomics and international finance, postulates a perfect relationship in the sense that e.g. a (nominal) depreciation of the domestic currency will be completely offset by a proportional increase of domestic relative to foreign prices. However, despite the transition of the leading global currencies from fixed to floating exchange rates and the increasingly international organisation of economic activities since the 1970s, the nexus between exchange rates and prices remains far less complete than implied by the PPP. A voluminous body of research has indeed found that the exchange rate pass-through – that is the percentage change of import prices in response to a percentage change of the exchange rate – is below one for most countries and industries. In particular, contemplating the behaviour of aggregate import prices, studies such as those of MCCARTHY, (2000), ANDERTON (2003), CHOUDHRI and HAKURA (2006), or IHRIG, MARAZZI, and ROTHENBERG (2006), among many others, find pass-through elasticities that often fall somewhere in the range between 0.3 and 0.7.[1] Prices tend to react more sensitively to exchange rates when countries are more open to international trade (MCCARTHY, 2000; BENIGNO and FAIA, 2010) whilst

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1 Earlier studies on the pass-through elasticity of exchange rates on import prices find somewhat higher values. However, as discussed in the survey by MENON (1995), early studies did not account for the non-stationary behaviour of prices and exchange rates and might, therefore, suffer from spurious correlations.

the pass-through effect tends to be lower in countries with a low inflation environment (TAYLOR, 2000; CHOUDHRI and HAKURA, 2006).

Arguably, aggregate import prices do not properly account for the price trends or the evolution of non-trade barriers dominating certain industries (MENON, 1995). Furthermore, since the seminal contribution of DORNBUSCH (1987) embedded the exchange rate pass-through into models of industrial organisation, the extent to which fluctuations in the value of a currency are transmitted onto import prices is thought to depend on such things as market structure (see also FROOT and KLEMPERER, 1989), product differentiation (see also YANG, 1997), or entry barriers (see also BALDWIN and KRUGMAN, 1989) in a certain industry. A common topic of this literature is that imperfect competition – or in other words the extent of market power within an industry – lowers the pass-through effect by allowing importing firms to act, to a certain degree, independently from local competition permitting them to keep import prices stable even when production costs change due to fluctuating currencies (see e.g. BERNHOFEN and XU, 2000). To reflect the role of competitive conduct, arguably, a disaggregated approach is warranted. BERNHOFEN and XU (2000) focus e.g. on petrochemicals whilst FEENSTRA (1989) contemplates the effect of exchange rates upon prices in the automotive industry. The most comprehensive industry-specific study is, probably, that of YANG (1997), who finds considerable variation in the exchange rate pass-through across US industries with particularly high values for machinery and sophisticated instruments.

Hitherto, only scant research has been available about the exchange rate pass-through in Switzerland. The only exception is a study dedicated to the Swiss case by STULZ (2007), who finds an elasticity of 0.2 to 0.5 using aggregate import prices. MCCARTHY (2000), GAGNON and IHRIG (2004), CAMPA and GOLDBERG (2005), and CAVALIERE (2007) all estimate the impact of exchange rates upon import price aggregates within a sample of countries and find, for the case of Switzerland, similarly incomplete pass-through effects. However, the lack of research as regards the differential effect across industries is maybe surprising since Switzerland provides a reasonably good example of a small open economy with the exchange rate being an important economic determinant for many industries. Also, during the creation of a European Monetary Union, Switzerland has retained its own currency with the Swiss Franc playing a disproportionately large role in the global foreign exchange market. This implies that there are several episodes where international, rather than domestic events drove the value of the Swiss Franc (compare REYNARD, 2007). In this regard, the so-called safe haven effect, that is an appreciation of the Swiss Franc in response to economic and political instability around the world (see e.g. SOEDERLIND and RANALDO, 2010), can give rise to public concern when the Swiss export industry is confronted with a loss of international price competitiveness as well as a weakening of foreign demand. However, some of this could be compensated by falling import prices benefitting the Swiss economy by reducing input cost and sustaining the purchasing power of domestic consumption. Against this background, this paper endeavours to estimate the exchange rate pass-through across 13 Swiss industries during the 1999 to 2010 period. Confirming the above-mentioned highly incomplete effect as regards aggregate import prices, substantial variation arises across different industries with a closer relationship between import prices and exchange rates being observed for commodities and relatively standardised products such as paper, minerals, and timber whilst the impact for automobiles, agriculture, and textiles is negligible and almost always statistically insignificant.

The paper is organised as follows. Section 2 develops the theoretical background connecting the role of imperfect competition with the exchange rate pass-through. Owing to the modeling of preferences with the transcendental logarithmic expenditure function of Feenstra (2003) and the usage of conjectural elasticities as in Bernhofen and Xu (2000), the proposed theoretical framework is compatible with a broad range of market conduct and provides the basis to compare the degree of competition between importers and local producers across different industries. Section 3 discusses the data and econometric strategy. Section 4 presents the results of estimating the pass-through elasticities of exchange rates upon import prices and infers the corresponding degree of import competition for the 13 industries included in the sample. Section 5 concludes.

2. Theoretical Framework

This section develops a theoretical framework illustrating how importers adapt their prices according to exchange rates and other economic conditions. In particular, consider an industry i where the demand in Switzerland can either be served by local producers, whose variables are labelled with superscript +, or importers, whose variables are labelled with superscript $*$. During a given period t, import prices are denoted with p^*_{it} and local producer prices with p^+_{it}.

The price-setting behaviour of a foreign firm depends, among other things, on the degree of substitutability between imports and locally produced goods. To model the demand for imports, the bulk of the applied literature about the exchange rate pass-through employs preferences with a constant elasticity of substitution (CES) (e.g. Dornbusch, 1987; Yang, 1997; Bodnar, Dumas, and Marston, 2002). However, CES preferences imply that demand elasticities, the markup of prices over cost, and market shares are constant and independent from the conduct of e.g. importers competing on the same market (BERGIN and FEENSTRA, 2000, pp. 660–661; FEENSTRA, 2003, pp. 84–85). This may be undesirable within the present context since the Swiss market consists of sectors such as the oil industry that depend almost completely on imports (see e.g. EHRSAM, HERGER, and SUTTER, 2007) whilst e.g. the agricultural sector is relatively closed and subject to substantial trade barriers (see e.g. HENTSCH and BAUR, 2008). Considering the interdependencies between competition and openness in small economies, it seems unlikely that the market share or the price-cost markup remains unaffected by, say, the entry decisions of foreign producers. Therefore, drawing on the duality between utility maximisation and expenditure minimisation, demand will here be modelled with a flexible expenditure function of the transcendental logarithmic – or in short 'translog' – form as developed in BERGIN and FEENSTRA (2000, 2001) and FEENSTRA (2003).[2] As derived in appendix 5.1, from a general translog expenditure function fulfilling the property of homogeneity of degree one in prices, with two firms representing, respectively, Swiss producers and importers, the expenditure on products of industry i during period t is given by

$$\begin{aligned} \ln E_{it}(\overline{U}, p^*_{it}, p^+_{it}) = \alpha_0 + \ln\overline{U} + \alpha^*_i \ln p^*_{it} + (1-\alpha^*_i)\ln p^+_{it} - \frac{1}{2}\gamma^*_i \ln p^*_{it} \ln p^*_{it} \\ + \frac{1}{2}\gamma^*_i \ln p^*_{it} \ln p^+_{it} + \frac{1}{2}\gamma^+_i \ln p^+_{it} \ln p^*_{it} - \frac{1}{2}\gamma^+_i \ln p^+_{it} \ln p^+_{it} \end{aligned} \tag{1}$$

where α_0 is a constant and $\overline{U}$ denotes the utility level to be reached at prices $\{p^*_{it}, p^+_{it}\}$. The parameter α^*_i is a weight attached to expenditure on imports with the counterpart $(1-\alpha^*_i)$ attached to Swiss products in industry i. With parameters γ^*_i and γ^+_i, the remaining terms of (1) reflect in how far the prices set by importers and local producers affect the expenditure on industry i in an interdependent manner. When such interdependencies are ignored, in terms of adopting the parameter constellation $\gamma^*_i = \gamma^+_i = 0$, (1) becomes an expenditure function that is compatible with preferences where a constant fraction α^*_i of income is spent on imports. However, more often than not, imports and local products are to some degree substitutable manifesting in positive values for γ^*_i and γ^+_i. Note that (1) does not impose the symmetry condition of $\gamma^*_i = \gamma^+_i$. Hence, contingent

2 The usage of translog functions in consumer choice theory can be traced back to CHRISTENSEN, JORGENSON, and LAU (1976) and DIEWERT (1974), who provides a thorough discussion within the context of duality theory.

on the origin of products, the expenditure of industry i might react differently to price changes.

In general, the parameters α_i^*, γ_i^* and γ_i^+ do not map into a specific utility function. Rather, the merit of (1) lies in its flexibility in terms of being compatible with any twice continuously differentiable expenditure function whilst satisfying entrenched properties of consumer theory such as homogeneity of degree one in prices.

Applying Shephard's Lemma[3] to (1) yields the demand function for imports. It will be convenient to express this in terms of the market share s_{it}^* of imports in industry i during period t, which is given by

$$s_{it}^*(p_{it}^*, p_{it}^+) = \frac{\partial \ln E_{it}}{\partial \ln p_{it}^*} = \alpha_i^* - \gamma_i^* \ln p_{it}^* + \underbrace{\frac{\gamma_i^* + \gamma_i^+}{2}}_{\Gamma_i \gamma_i^*} \ln p_{it}^+. \tag{2}$$

Aside from the weight α_i^* attached to imports, the share of foreign products in industry i decreases with higher import prices p_{it}^* and increases with higher prices p_{it}^+ charged by Swiss producers. The degree of substitutability determines the magnitude of these price effects.[4] Specifically, as long as $\gamma_i^* = \gamma_i^+$, the own and cross-price effects of, respectively, imports and local products on the market share of foreign firms are of identical magnitude (but work in opposite directions). Otherwise, a differential impact arises. To summarise the extent of such asymmetries, it is convenient to introduce a re-parametrisation with $\gamma_i^+ = (2\Gamma_i - 1)\,\gamma_i^*$ such that the last term of (2) becomes $(\gamma_i^* + \gamma_i^+)/2 = \Gamma_i \gamma_i^*$. With $\Gamma_i = 1$, the countervailing price effects of imports and local products are of identical magnitude. A case with $\Gamma_i > 1$ means that the market share of imports reacts disproportionately strong to price changes of competing local products. Conversely, $0 \leq \Gamma_i < 1$ suggests that the market share of imports is relatively immune to such cross-price effects. In the extreme event of $\Gamma_i = 0$, the share of imports s_{it}^* is not affected by the prices of locally produced goods.

3 Shephard's Lemma states that the Hicksian demand function is given by $h_{it}^* = \partial E_{it} / \partial p_{it}^*$. Expanding this with p_{it}^* / E_{it} yields the market share since

$$s_{it}^* = \frac{h_{it}^* p_{it}^*}{E_{it}} = \frac{\partial E_{it}}{\partial p_{it}^*} \frac{p_{it}^*}{E_{it}} = \frac{\partial \ln E_{it}}{\partial \ln p_{it}^*}.$$

4 Recall that in the Cobb-Douglas case, $\gamma_i^* = \gamma_i^+ = 0$ implying that the market share s_{it}^* equals the constant α_i^*.

As regards the supply side, the importing sector's revenue accrues in domestic currency whilst production costs are expressed in foreign currency. Denoting the nominal exchange rate between Swiss Francs and foreign currency during period t with e_t and operating with a linear function with industry cost c_i^*, the profit of importers equals

$$\pi_{it}^* = p_{it}^* q_{it}^* - e_t c_i^* q_{it}^*, \tag{3}$$

where q_{it}^* denotes the imported quantity. A decrease of e_t reflects an appreciation of the Swiss Franc and reduces the cost of producing abroad (and vice versa). Dividing (3) by q_{it}^* and multiplying by expenditure E_{it} transforms profits into market share form, that is

$$\pi_{it}^* = \left[1 - \frac{e_t c_i^*}{p_{it}^*}\right] s_{it}^*(p_{it}^*, p_{it}^+) E_{it}. \tag{4}$$

Following BERNHOFEN and XU (2000), it is assumed that importers anticipate the reaction of local producers when changing import prices, as reflected by the conjectural elasticity

$$\nu_i = \frac{\partial p_{it}^*}{\partial p_{it}^+} \frac{p_{it}^*}{p_{it}^+}.$$ [5]

Then, as shown in appendix 5.2, the optimal price setting rule is given by

$$p_{it}^* = \left[1 + \frac{s_{it}^*}{(1 - \nu_i \Gamma_i)\gamma_i^*}\right] e_t c_i^*. \tag{5}$$

The degree of market power – in terms of the ability to raise prices p_{it}^* above cost $e_i c_i^*$ expressed in the same currency – that can be exerted by importing firms decreases (i.) with their market share s_{it}^*, (ii.) when international markets are highly integrated manifesting in a high value for γ_i^*, (iii.) with lower values of the conjectural elasticity ν_i, and (iv.) the higher the value of the asymmetry parameter Γ_i when $\nu_i > 0$ (and vice versa when $\nu_i < 0$).

5 For a textbook discussion of conjectural elasticities see MARTIN (2002, ch. 3).

The merit of including conjectural elasticities ν_i is to make the pricing decision (5) compatible with a broad range of market conduct. In particular, a negative conduct parameter ν_i implies that import and local producer prices are strategic substitutes in the sense that local firms are anticipated to behave competitively by reacting with price cuts to an increase in import prices. A value of $\nu_i = -\infty$ reflects the polar case of perfect competition whereby, according to (5), import prices equal marginal cost. Conversely, a positive conjectural elasticity reflects a case of strategic complementarity where import prices and prices charged by local producers are expected to follow each other.[6] Such a price coordination might reflect some form of collusion, but could also arise when multinational firms control local producers and importing firms within the same industry *i*. The impact of the conjectural elasticity depends also on the value of asymmetry parameter Γ_i. With preferences such that $\Gamma_i = 0$, no cross price effects arise between local and importing firms and the value of the conjectural elasticity is irrelevant whereas the role of the conjectures about price changes is exacerbated with increasing values of Γ_i. Taken together, the conditions on the demand (as embodied in the preference parameter Γ_i) and supply side (as embodied in the conduct parameter ν_j) jointly affect the market power in industry *i*. It will therefore be convenient to summarise this with a market power parameter, defined by

$$\theta_i = \nu_i \Gamma_i. \tag{6}$$

A higher value of θ_i reflects, according to (5), more market power (in terms of the ability to raise prices above cost). Note that $-\infty < \theta_i < 1$. The lower bound arises under perfectly competitive conditions with $\nu_i = -\infty$. The upper bound ensures that the condition $1 - \nu_i \Gamma_i > 0$ – that is, prices are above marginal cost – holds. Inserting the market share s_{it}^* of (2) into (5) and taking logarithms yields, as derived in appendix 5.3, the import pricing equation

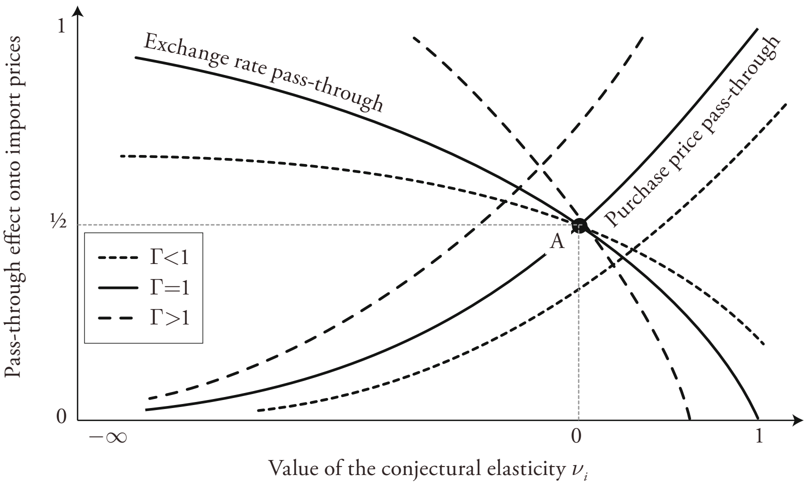
$$\begin{aligned} \ln p_{it}^* \approx & \frac{\alpha_i^*}{(2-\nu_i \Gamma_i)\gamma_i} + \frac{1-\nu_i \Gamma_i}{2-\nu_i \Gamma_i} \ln c_i^* \\ & + \frac{1-\nu_i \Gamma_i}{2-\nu_i \Gamma_i} \ln e_t + \frac{\Gamma_i}{2-\nu_i \Gamma_i} \ln p_{it}^+. \end{aligned} \tag{7}$$

6 With differentiated products, a positive conjectural elasticity can also arise as a result of basic Betrand competition.

Note again the implications of different values of the conjectural elasticity and whether or not preferences are symmetric as regards the origin of products. Consider first a benchmark with constant price expectations, e.g. $\nu_i = 0$, and symmetric conditions, e.g. $\Gamma_i = 1$. Inserting these values into (7) suggests that changes in the exchange rate e_t and local producer prices p^+_{it} are both passed through with an elasticity of ½ percent. This transmission pattern, illustrated by point A in Figure 1, is a feature of the symmetric translog expenditure function (see BERGIN and FEENSTRA, 2000, pp. 662–663). However, as soon as local firms are thought to react to changing import prices, e.g. $\nu_i \neq 0$, deviations from this strict pattern arise. Maintaining for the moment the symmetry assumption $\Gamma_i = 1$, the solid curves of Figure 1 trace the development of the pass-through effect of (7) as a function of the conjectural elasticity ν_i. The exchange rate pass-through decreases with the value of ν_i whilst the converse relationship arises with respect to the impact of local producer prices. To understand why, contemplate the case with $\nu_i = -\infty$. Recall that this reflects essentially a scenario of perfect competition, which forces importers to charge cost based prices and, hence, pass on the changes of the exchange rate in a complete and instantaneous manner. However, a less aggressive price setting behaviour by local producers – involving increasing values of ν_i and a move to the right in Figure 1 – gives rise to imperfect competition with an incomplete exchange rate pass-through (DORNBUSCH, 1987). Then, importers can also draw on the behaviour of local firms when setting their prices and exchange rates become less relevant. In the event of $\nu_i = 1$, which designates a fully matched price setting behaviour, the exchange rate becomes even irrelevant since importers set prices entirely according to the conditions on the local market.

With the symmetry assumption $\Gamma_i = 1$, the conjectural elasticity ν_i is compatible with a specific constellation of pass-through effects of the exchange rate and local producer prices. Therefore, deviations from this pattern offer clues about a differential impact of import and local producer prices as regards the market share (2) and the underlying expenditure function (1). In particular, as shown in a synoptic manner by the dashed curves in Figure 1, a relatively large cross-price effect, that is $\Gamma_i > 1$, shifts the producer price pass-though upward and increases the sensitivity with which the exchange rate pass-through reacts with respect to different values of the conjectural elasticity ν_i. As depicted by the dotted curves, the opposite pattern arises when $\Gamma_i < 1$.

Figure 1: Pass-Through Effect and Conjectural Elasticity



3. Econometric Implementation

Equation (7) provides the basis for estimating the pass-through elasticity of the exchange rate e_t onto import prices p^*_{it}. For Switzerland, monthly price data are published in the Annual Yearbook of the Federal Statistical Office (Bundesamt für Statistik; Office Fédéral de la Statistique) for the following industries: agriculture, automobiles, food products, furniture, leather products, machinery, metal products, minerals, oil and petrol products, paper products, rubber and plastic products, textiles, and timber. Across these 13 industries,[7] indices measuring import prices at customs appear in the top panels of Figure 2. Substantial fluctuations arise with commodities such as oil and petrol, metal and timber, as well as paper products. For the remaining industries, the import prices evolve in a more gradual manner. Indices reflecting domestic ex-factory prices appear in the bottom panels. Compared with imports, domestic producer prices are more

7 At the beginning of the year 2011, the Federal Statistical Office revised the import and producer price index introducing a more refined industry classification based on the European NOGA standard (Bundesamt für Statistik, 2008). To retain a sufficiently large number of observations, the present analysis employs the old classification including 13 industries with common import and producer price indices.

Figure 2: Import and Producer Prices in Switzerland

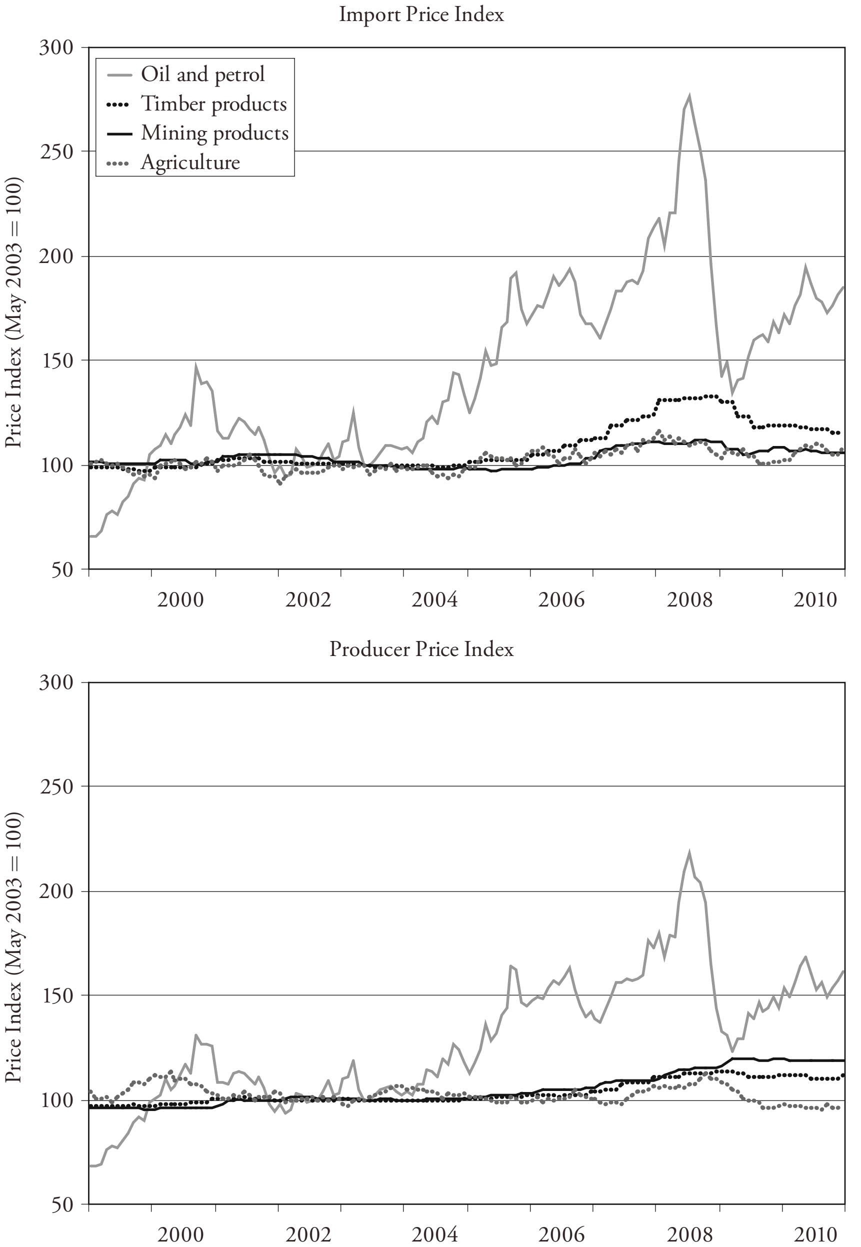
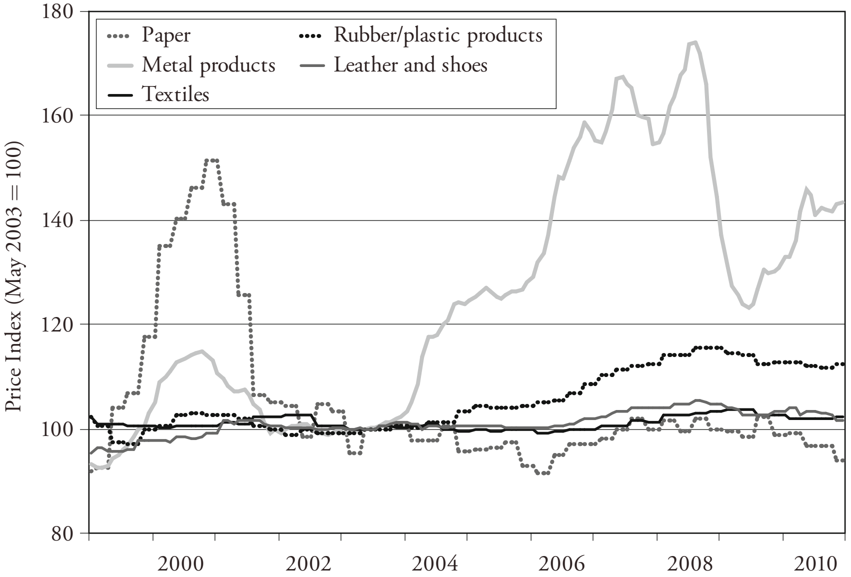


Figure 2 continued

Import Price Index



Producer Price Index

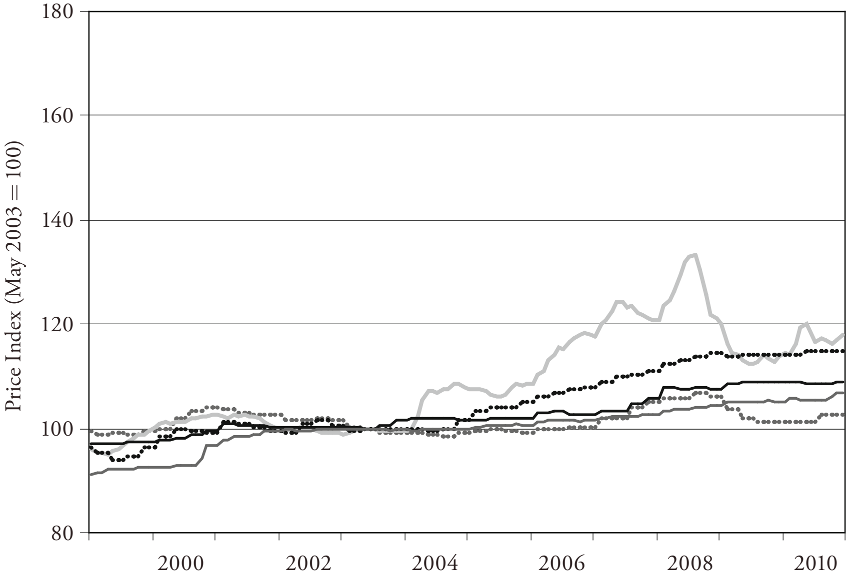
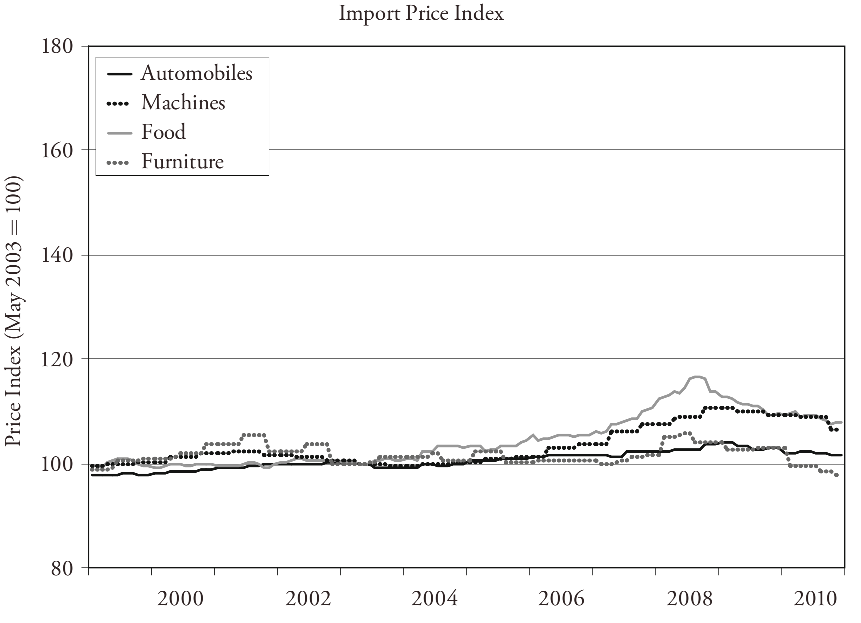
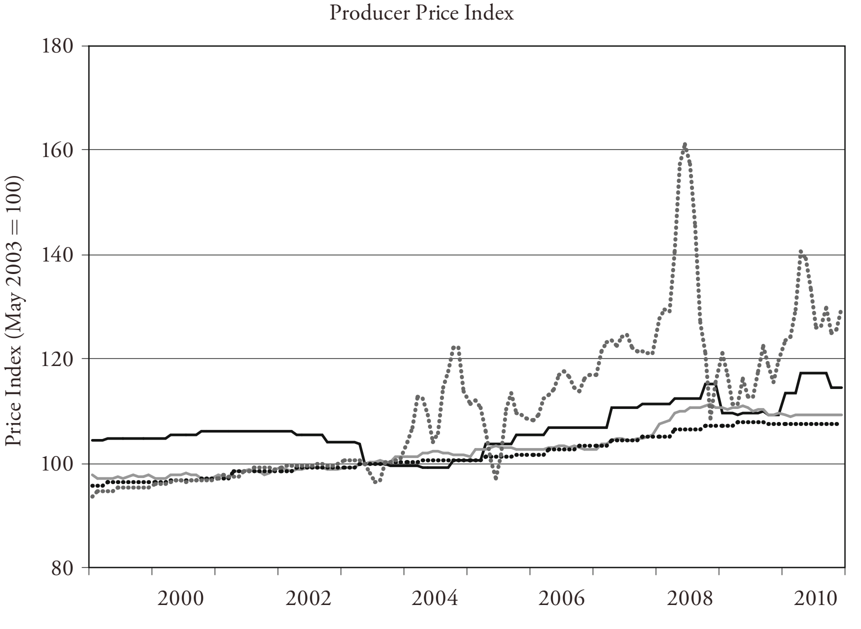


Figure 2 continued

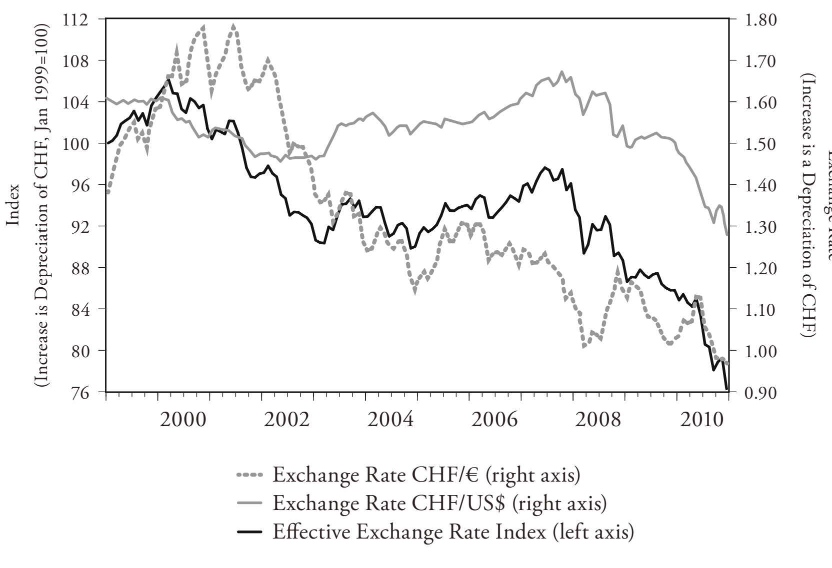




stable. Note that both price indices reflect the conditions before imposing taxes or tariffs wherefore the corresponding values are not driven by policy-induced changes of the fiscal burden.

Fluctuations in the value of the Swiss Franc are reflected by a nominal effective exchange rate index measuring the export weighted average with the currency value of 40 foreign countries. As shown in Figure 3, between 2000 and the beginning of 2003 and, more recently, since the outbreak of the global financial crisis during the year 2008, the Swiss Franc followed a downward trend reflecting an appreciation against this basket of currencies. Owing to a solidly growing world economy and a high degree of financial stability, between 2003 and 2008, the Swiss Franc witnessed a period of relative weakness. Similar developments can be observed for the bilateral exchange rate with the Euro (€) and the US dollar ($). The common sample of price and exchange rate data covers the years between 1999 and 2010. A detailed description and sources appear in Table 2 of the data appendix.

Figure 3: Swiss Franc Exchange Rates



It is well known that prices and exchange rates are rarely stationary when expressed in terms of levels. For the current data, the established statistical tests confirm this result regardless whether the variables are thought to have common or, when it comes to the price indices of the 13 industries i, to be driven by individual unit roots. However, taking differences, which here involves subtracting the same month of the previous year, makes the data stationary.[8] For the sake of brevity, the array of test statistics on stationarity are not reported here, but are available on request.

Prices and exchange rates could be cointegrated and, hence, warrant estimation in terms of levels to account for the long-term equilibrium relationships. However, the corresponding tests yield mixed results with bivariate, or Engle-Granger based tests providing some statistical evidence for cointegration whilst multivariate, or Johansen based tests do not support this conclusion. To avoid ambiguities, the econometric models will be estimated with differenced data bearing in mind that this uncovers short-term, rather than long-term pass-through effects.[9]

Taken together, for the above-mentioned 13 industries i, a system of equations similar to that of Yang (1997) will be used for estimation, that is

$$\Delta \ln p_{it}^{*} = \beta_0 + \beta_i^{e} \Delta \ln e_t + \beta_i^{p} \Delta \ln p_{it}^{+} + \epsilon_{it} \text{ for } i = 1,\ldots,13, \quad (8)$$

where β_0 is a constant, $\Delta \ln p_{it}^{*} = \ln p_{it}^{*} - \ln p_{is}^{*}$, $\Delta \ln e_t = \ln e_t - \ln e_s$, and $\Delta \ln p_{it}^{+} = \ln p_{it}^{+} - \ln p_{is}^{+}$ with $s = t - 12$, and ϵ_{it} denotes a stochastic error term.

Note that, taking differences eliminates the industry-specific effect

$$\frac{\alpha_i^{*}}{(2-\nu_i\Gamma_i)\gamma_i} + \frac{1-\nu_i\Gamma_i}{2-\nu_i\Gamma_i} \ln c_i^{*}$$

from (7). The coefficients to be estimated may vary between industries and, according to (7), are connected with the underlying parameters as follows:

$$\beta_i^{e} = \frac{1-\nu_i\Gamma_i}{2-\nu_i\Gamma_i} \text{ and } \beta_i^{p} = \frac{\Gamma_i}{2-\nu_i\Gamma_i}. \quad (9)$$

An empirical pass-through effect of $\hat{\beta}_i^{e} = 1/2$ and $\hat{\beta}_i^{p} = 1/2$ is compatible with the values $\hat{\Gamma}_i^{e} = 1$ and $\hat{\nu}_i = 0$. This reflects the conditions depicted by point A of

8 Differences could also be taken from the value of the previous month. However, this would lower the fit of the model and increase the standard deviation of most coefficients estimated without overturning the essence of the results reported in Section 4 below.

9 Cointegrated variables would lend themselves to an analysis with a vector-error-correction-model (VECM), with which the differences between short- and long-term pass through effects could be distinguished. Owing to the ambiguities when testing for cointegration in the present data, this avenue is not pursued here.

Figure 1. Consistent with the theoretical framework of Section 2, ceteris paribus, a smaller value of the conjectural elasticity ν_i increases the pass-through elasticity of the exchange rate and reduces the pass-through elasticity of local producer prices.

In combination, the two coefficient estimates $\hat{\beta}_i^e$ and $\hat{\beta}_i^p$ permit one to gauge the value of the asymmetry parameter and the conjectural elasticity from

$$\hat{\nu}_i = \frac{1-2\hat{\beta}_i^e}{\hat{\beta}_i^p} \quad \text{and} \quad \hat{\Gamma}_i = \frac{\hat{\beta}_i^p}{1-\hat{\beta}_i^e}. \tag{10}$$

According to (6), this can be summarised by a market power parameter now given by

$$\hat{\theta}_i = \hat{\nu}_i \hat{\Gamma}_i = \frac{1-2\hat{\beta}_i^e}{1-\hat{\beta}_i^e}, \tag{11}$$

whose value will be reported for each industry in the next section. Note that, with a case where $\hat{\beta}_i^e = 1/2$ and $\hat{\beta}_i^p = \cdot/$ the value of the market power parameter is 0. Lower pass-through effects are compatible with more market power with the polar case of $\beta_i^e = 0$ resulting in the $\hat{\theta}_i = 1$. Conversely, with β_i^e approaching a value of 1, indicating an instantaneous and complete exchange rate pass-through, the market power parameter adopts the lowest possible value of $-\infty$. From the theoretical discussion in Section 2, it is perhaps intuitive that competitive prices tend to trace the development of cost (and hence exchange rates) whereas a situation where import prices are not driven by exchange rates would suggest that foreign firms can act more independently from local producers.

The system (8) of import pricing equations will be estimated jointly by means of a multivariate regression. In particular, the error term will be specified so as to allow for contemporaneous correlation of stochastic shocks within and between different industries *i* and *j* meaning $E[\epsilon_{it}\epsilon_{jt}] = \sigma_{ij} \neq 0$ (cross-section SUR). Furthermore, across periods *t*, the variance-covariance matrix $E[\epsilon_t \epsilon_t] = \Omega_t$ is permitted to vary reflecting seasonal or business cycle induced heterogeneity in the magnitude of economic shocks. Variances that are robust to this form of correlation will be estimated by means of the White method.[10]

10 See Wooldridge (2002, pp. 147–153) for more details. Of course, more or less restrictive assumptions can be imposed on the stochastic component ϵ_{it} such as ruling out correlation between different industries or allowing for arbitrary serial correlation across time. However, making these modifications does not change the essence of the results reported below.

A further econometric pitfall arises when, similar to (7), the price decisions of local producers depend in part on the conduct of importing firms. This simultaneous determination of prices is incompatible with the strict exogeneity assumption of $E[\Delta \ln p_{it}^{+} \epsilon_{it}] \neq 0 \, \forall t$ and, hence, introduces a bias when estimating (8) with ordinary least squares. However, with panel data, the estimation can be based on the concept of sequential exogeneity which, exploiting the idea that time moves in a single direction, warrants that stochastic shocks are uncorrelated with past prices, that is $E[\Delta \ln p_{it-l}^{+} \epsilon_{it}] = 0$ for $l > 1$, whilst correlation with contemporaneous and future values is still possible.[11] Then, the first lag of producer prices can be used as an instrument insofar as it is correlated with, but (sequentially) exogenous to the current value. The first stage regression of current onto lagged producer prices yields indeed a F-statistic that by far exceeds the threshold value of 10 suggested by STAIGER and STOCK (1997) to uncover weak instruments.

4. Results

Table 1 reports the results of regressing logarithmic differences of the exchange rate and the development of Swiss producer prices onto import prices. To provide a benchmark, column 1 employs aggregate indices for p^{+} and p^{*}, whereas the remaining columns reflect the breakdown across the 13 industries entering the system (8). These are related through the error term and have, therefore, been jointly estimated with the common diagnostic statistics reported at the bottom. Since equation (8) involves logarithmic differences from the same month of the previous year, the twelve observations of the year 1999 drop out leaving a common sample covering the 2000 to 2010 period with 1,703 observations.

The top panel of Table 4. estimates the pass-through as regards the development of the exchange rate index (see Figure 3). The resulting coefficients concur with the theoretical expectations in the sense that a depreciation of the Swiss Franc (manifesting in an increase of e_t) increases the cost to foreign producers and hence the import price. However, on aggregate, the transmission is highly incomplete with the corresponding elasticity of column (1) being 0.29. Marked differences arise when comparing the pass-through across industries with a value in excess of (but not statistically significant) from 1 for the paper industry to negligible and insignificant values for the textile and automobile industry. When it comes to the role of Swiss producer prices, the corresponding coefficient is often larger and, for aggregate prices of column 1, equals almost 2 meaning that import

11 For a textbook discussion of this see WOOLDRIDGE (2002, ch. 11.1).

Table 1: Results

Industry:	All Industries (1)	Agriculture (2)	Automobile (3)	Food Prod. (4)	Furniture (5)	Leather Prod. (6)	Machinery (7)	Metal Prod. (8)	Minerals (9)	Oil / Petrol (10)	Paper Prod. (11)	Rubber Prod. (12)	Textiles (13)	Timber Prod. (14)
Import Exchange Rate Pass-Through (Index)														
Exchange Rate	0.29***	0.19	0.003	0.15***	0.13**	0.16***	0.12***	0.34***	0.34***	0.15***	1.12***	0.18***	0.03	0.30***
	(0.06)	(0.12)	(0.02)	(0.03)	(0.06)	(0.03)	(0.03)	(0.1)	(0.06)	(0.06)	(0.23)	(0.03)	(0.03)	(0.05)
Producer Price	1.72***	0.12*	0.05***	0.98***	0.04***	0.48***	0.84***	2.09***	0.58***	1.24***	2.66***	0.76***	0.14***	1.93***
	(0.15)	(0.06)	(0.02)	(0.06)	(0.01)	(0.03)	(0.06)	(0.05)	(0.07)	(0.01)	(0.26)	(0.04)	(0.05)	(0.09)
$\hat{\theta}_i$	0.59	0.77	1.00	0.82	0.85	0.80	0.86	0.48	0.48	0.82	$-\infty$	0.78	0.97	0.58
	(0.12)	(0.19)	(0.02)	(0.04)	(0.08)	(0.04)	(0.03)	(0.24)	(0.14)	(0.08)	(∞)	(0.05)	(0.03)	(0.10)
#Obs	131							1,703						
R^2	0.56							0.88						
Import Exchange Rate Pass-Through (Euro)														
Exchange Rate CHF/€	0.05	0.06	0.001	0.12***	0.09*	0.13***	0.03	0.04	0.21***	0.14***	0.36**	0.18***	0.01	0.28***
	(0.05)	(0.11)	(0.02)	(0.03)	(0.06)	(0.03)	(0.03)	(0.08)	(0.06)	(0.06)	(0.17)	(0.03)	(0.02)	(0.05)
Producer Price	1.85***	0.08	0.09***	1.02***	0.05***	0.52***	0.94***	2.09***	0.51***	1.25***	2.62***	0.88***	0.27***	1.96***
	(0.17)	(0.06)	(0.02)	(0.05)	(0.01)	(0.03)	(0.06)	(0.05)	(0.07)	(0.01)	(0.26)	(0.05)	(0.04)	(0.09)
$\hat{\theta}_i$	0.95	0.93	1.00	0.86	0.90	0.85	0.97	0.96	0.73	0.83	0.44	0.77	1.00	0.62
	(0.12)	(0.19)	(0.02)	(0.04)	(0.08)	(0.04)	(0.03)	(0.24)	(0.14)	(0.08)	(16.84)	(0.05)	(0.03)	(0.10)
#Obs	131							1,703						
R^2	0.48							0.88						

Table 1 continued

Industry:	All Industries (1)	Agriculture (2)	Automobile (3)	Food Prod. (4)	Furniture (5)	Leather Prod. (6)	Machinery (7)	Metal Prod. (8)	Minerals (9)	Oil / Petrol (10)	Paper Prod. (11)	Rubber Prod. (12)	Textiles (13)	Timber Prod. (14)
Import Exchange Rate Pass-Through (US Dollar)														
Exchange Rate CHF/$	0.06	–0.01	0.01	–0.01	0.04	0.01	0.06***	0.10**	0.06**	–0.01	0.45***	–0.01	0.03**	0.004
	(0.04)	(0.05)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.04)	(0.03)	(0.03)	(0.1)	(0.01)	(0.01)	(0.03)
Producer Price	1.87***	0.09*	0.09***	0.96***	0.03**	0.44***	1.07***	2.11***	0.53***	1.25***	2.01***	0.78***	0.35***	1.93***
	(0.18)	(0.06)	(0.02)	(0.06)	(0.02)	(0.03)	(0.06)	(0.04)	(0.08)	(0.01)	(0.27)	(0.04)	(0.05)	(0.09)
$\hat{\theta}_i$	0.94	1.00	0.99	1.00	0.96	0.99	0.93	0.89	0.94	1.00	0.19	1.00	0.97	1.00
	(0.04)	(0.05)	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.05)	(0.03)	(0.03)	(0.34)	(0.01)	(0.01)	(0.03)
#Obs	131							1,703						
R^2	0.49							0.88						

Notes: The dependent variable is the the import price index (p^*) (logarithmic difference). Column 1 refers to aggregate prices with coefficients estimated by OLS (including a constant). Columns 2 to 14 form the system of equations (8) for the price indices of the 13 industries *i*. The corresponding coefficients have been estimated as a multivariate regression. Standard errors reported in parentheses are robust to correlation between the contemporaneous residuals across industries *i*. Coefficients are significant at the 10% level when labelled with *, at the 5% level when labelled with **, and at the 1% level when labelled with ***. The producer price is instrumented with its lagged value. The parameter θ_i has been calculated from equation (11). The corresponding standard deviation has been calculated with the delta method. For cases where the coefficient β_i^e is larger than, but not statistically different from one, a limit value of one is adopted to calculate θ_i.

prices tend to react disproportionately to changes in producer prices. Similar to the impact of the exchange rate, across industries, substantial differences arise as regards the empirical effects of producer onto import prices. Relatively large coefficients arise for bulk commodities such as paper, timber, or oil and petrol products. Conversely, the relationship between producer and import prices is less complete for more sophisticated products such as automobiles, furniture, or textiles. Finally, the low values for agriculture could be attributed to the market entry barriers shielding domestic producers from foreign competition.

Recall from (9) that, rather than interpreting the coefficients in an isolated manner, they reflect differences between industries as regards the conjectural elasticity as well as preferences in terms of the asymmetry parameter. Furthermore, taken together, the differential impact of exchange rates on import prices permits one to gauge the value of the market power parameter θ_i according to (11). Corresponding estimates appear at the bottom of each panel of Table 4. whereby the standard deviations given in parentheses have been calculated by means of the delta method.[12] For aggregate prices in column 1, the value of $\hat{\theta}_i$ is around 0.6 suggesting that importers can set prices relatively independently and appear, at least in the short-term, not to be confronted with fierce price competition from local producers. This explains the relatively modest value of the exchange rate pass-through. Then again, there is some heterogeneity between industries whereby, according to the t-statistic[13], the value of the market power parameter differs in a statistically significant manner from column (1) expect for agriculture, metal products, minerals, and rubber and timber products. High degrees of market power arise e.g. with the automobile and textile industry, whilst for paper products, the exchange rate is passed through with an elasticity that is not statistically different from one, which would be the value resulting in $\theta_i = -\infty$ suggesting perfect import competition.

12 According to the delta method, the standard deviation of a function such as $f(\beta_i^e)$ can be approximated with

$$\sqrt{[f'(\beta_i^e)]^2 \sigma^2}\ .$$

where σ^2 denotes the variance of β_i^e. For the case of (11), the delta method yields a standard deviation of

$$\sqrt{[1/(2\beta_i^e - \beta_i^e - 1)]^2 \sigma^2}\,.$$

13 In particular, the t-statistic is given by $t = (\hat{\theta} - \hat{\theta}_i) / \sqrt{\sigma^2 + \sigma_i^2}$ with the variables pertaining to industries being denoted with subscript i.

There are several caveats when calculating the pass-through with an exchange rate index. Firstly, as mentioned in Section 3., this index is export weighted, which might be misleading when looking at the impact of imports upon the Swiss economy. Secondly, the global reserve currencies dominate the payments of international trade. Therefore, the middle and bottom panel of Table 4. report the pass-through elasticities for the bilateral exchange rate of the Swiss Franc (CHF) with, respectively, the Euro and the US dollar. With this, the coefficient estimate for β_i^e tends to be lower reflecting, perhaps, that bilateral exchange rates can only partly account for the changes in the terms of trade, as production and distribution processes are more and more globally organised. Consequently, bilateral exchange rates result in somewhat higher values of the market power parameter. Though reflecting the short-term, it is nevertheless surprising that, with the exception of paper products, $\hat{\theta}_i$ is in many cases close to (and often not significantly different from) the maximum value of 1. Even for the case of the Euro, which is the currency for trade with Switzerland's neighbouring countries, (short-term) import competition is apparently weak. Using the US dollar gives rise to a similar picture with even higher levels of market power. Furthermore, it is perhaps surprising to find a low and insignificant exchange rate pass-through for oil and petrol products that are traded in dollars and whose prices are relatively volatile. This might reflect the fact that the Swiss petrol market is served, by and large, by multinationally integrated oil companies that control several stages of the supply chain and, hence, price potential currency effects directly into import prices (compare EHRSAM, HERGER, and SUTTER, 2007).

To check for the robustness of the results of Table 1, several alternative specifications have been estimated. In particular, adding industry-specific constants to (8) could mitigate against unobserved heterogeneity between industries. Furthermore, to rule out endogeneity as regards the exchange rate, the corresponding variables could also be instrumented with past values. However, neither of these alternative specifications did overturn the essence of the findings. Possibly, (8) does not properly account for the dynamics between prices and exchange rates. Empirical studies such as that YANG (1997) do use lagged import prices to better control for long-term dynamic and persistent trade effects that could arise from large exchange rate shocks (BALDWIN and KRUGMAN, 1989). An extension to this is the inclusion of lagged producer prices and exchange rates. However, the inclusion of additional variables barely improved the fit of the model and, for the case of lagged independent variables, even increased the variance of most coefficient estimates. Finally, reflecting the discussion in Section 3 about whether or not exchange rates and prices are cointegrated, the estimation could also employ the data without taking differences. This resulted in a slightly larger pass-through effect, which is in line with the view that levels account for long-term effects. However, a careful analysis of the dynamics and the transition between the short and long-term probably warrants a more versatile econometric strategy that is beyond the aspiration of this paper. Again, to save space, the results of these robustness checks are not reported here, but are available on request.

5. Conclusion

The conventional wisdom that exchange rate induced cost fluctuations tend to be passed onto import prices in a highly incomplete manner suggests that in spite of economic globalisation, trade barriers continue to inhibit the full integration of goods markets. With monthly data that cover the years between 1999 and 2010, this study confirms this finding for the case of Switzerland. In particular, even though the Swiss economy is small and open to international trade, the exchange rate pass-through elasticity onto aggregate import prices is only 0.3. However, when comparing this effect across 13 industries, remarkable differences arise with higher effects being observed for commodities and relatively standardised products whilst very low and insignificant effects arise for the automobile and the textile industry. At least in the short term, import competition is often weak in the sense that foreign firms base their pricing decisions on local conditions rather than the cost changes arising from fluctuations in the exchange rate.

6. Appendix

6.1 Translog Expenditure Function with Two Goods

In general, the translog expenditure function for N goods is given by

$$\ln E = \alpha_0 + \ln \overline{U} + \sum_{j=1}^{N} \alpha_j \ln p_j + \frac{1}{2} \sum_{j=1}^{N} \sum_{k=1}^{N} \gamma_{jk} \ln p_j \ln p_k \qquad (12)$$

whereby the restrictions

$$\sum_{j=1}^{N} \alpha_j = 1 \qquad \text{and} \qquad \sum_{j=1}^{N} \gamma_{jk} = 0 \qquad (13)$$

ensure that (12) is homogeneous of degree one in prices (BERGIN and FEENSTRA, 2000, p. 661; BERGIN and FEENSTRA, 2001, p. 337; FEENSTRA, 2003, p. 81). For the case with $N=2$ we have

$$\begin{aligned}\ln E = \alpha_0 + \ln \overline{U} + \alpha_1 \ln p_1 + \alpha_2 \ln p_2 \\ + \frac{1}{2}\gamma_{11} \ln p_1 \ln p_1 + \frac{1}{2}\gamma_{12} \ln p_1 \ln p_2 \\ + \frac{1}{2}\gamma_{21} \ln p_2 \ln p_1 + \frac{1}{2}\gamma_{22} \ln p_2 \ln p_2.\end{aligned} \tag{14}$$

Imposing the homogeneity restrictions $\alpha_1 + \alpha_2 = 1$, $\gamma_{11} + \gamma_{21} = 0$, $\gamma_{12} + \gamma_{22} = 0$ and rearranging yields

$$\begin{aligned}\ln E = \alpha_0 + \ln \overline{U} + \alpha_1 \ln p_1 + (1-\alpha_1) \ln p_2 \\ - \frac{1}{2}\gamma_{12} \ln p_1 \ln p_1 + \frac{1}{2}\gamma_{12} \ln p_1 \ln p_2 \\ + \frac{1}{2}\gamma_{21} \ln p_1 \ln p_2 - \frac{1}{2}\gamma_{21} \ln p_2 \ln p_2,\end{aligned} \tag{15}$$

which coincides with (1) when re-parameterising

$$\alpha_1 = \alpha_i^*,\ \gamma_{12} = \gamma_i^*,\ \gamma_{21} = \gamma_i^+,\ p_1 = p_{it}^* \text{ and } p_2 = p_{it}^+.$$

6.2 Optimal Pricing Rule

Differentiating the profit function (4) with respect to prices yields

$$\frac{\partial \pi_{it}^*}{\partial p_{it}^*} = \frac{e_t c_i^*}{(p_{it}^*)^2} s_{it}^* E_{it} + \left(1 - \frac{e_t c_i^*}{p_{it}^*}\right)\left[\frac{\partial s_{it}^*}{\partial p_{it}^*} + \frac{\partial s_{it}^*}{\partial p_{it}^+}\frac{\partial p_{it}^+}{\partial p_{it}^*}\right] E_{it} = 0. \tag{16}$$

Note that the envelope theorem implies that $\partial E_{it} / \partial p_{it}^* = 0$. The first term in square brackets represents the direct effect of changing p_{it}^* on s_{it}^* whilst the second term indicates the indirect effect when local producer are believed to adapt prices p_{it}^+ in response to p_{it}^*. Using (2) for s_{it}^* and rearranging yields

$$\left(1 - \frac{e_t c_{it}^*}{p_{it}^*}\right)\left[-\frac{\gamma_i^*}{p_{it}^*} + \frac{\gamma_i^* \Gamma_i}{p_{it}^+}\frac{\partial p_{it}^+}{\partial p_{it}^*}\right] = -\frac{e_t c_i^*}{(p_{it}^*)^2} s_{it}^*. \tag{17}$$

Multiplying this with $(p_{it}^{*})^2$ yields

$$(p_{it}^{*} - e_t c_i^{*})[-\gamma_i^{*} + \gamma_i^{*}\nu_i\Gamma_i] = -e_t c_i^{*} s_{it}^{*} \tag{18}$$

where

$$\nu_i = \frac{\partial p_{it}^{+}}{\partial p_{it}^{*}} \frac{p_{it}^{*}}{p_{it}^{+}}$$

is the conjectural elasticity. Solving for the import price yields

$$p_{it}^{*} = [1 + \frac{s_{it}^{*}}{\gamma_i^{*}(1-\nu_i\Gamma_i)}] e_t c_i^{*}. \tag{19}$$

6.3 Import Pricing Equation

Taking logarithms of (5) yields

$$\ln p_{it}^{*} \approx \frac{s_{it}^{*}}{(1-\nu_i\Gamma_i)\gamma_i^{*}} + \ln e_t + \ln c_i^{*}, \tag{20}$$

Inserting s_{it}^{*} of (2) into (20) and solving for $\ln p_{it}^{*}$ yields (7).[14]

14 Following Bergin and Feenstra (2000, p. 662), this result employs a first order Taylor approximation of

$$\ln\left[1 + \frac{s_{it}^{*}}{(1-\nu_i\Gamma_i)\gamma_i}\right] \approx \frac{s_{it}^{*}}{(1-\nu_i)\gamma_i^{*}} .$$

which is valid when market shares s_{it}^{*} are small. Industries with a high share of imports might warrant the inclusion of higher order terms of the the Taylor approximation. However, since these terms enter additively, the inclusion of industry specific constants permits some of these effects to be absorbed.

6.4 Data Appendix

Table 2: Description of the Data Set

This table describes the variables collected for 13 industries *i* during the 1999 to 2010 period at a monthly frequency.

Variable	Unit	Description	Source
Dependent Variable:			
Import Price Index (p^*_{it})	Index (May 2003 = 100)	The import price index measures the development of prices of imported goods as recorded at customs (excluding value added taxes and tariffs).	BUNDESAMT FÜR STATISTIK (various years, ch.5).
Independent Variables:			
Producer Price Index (p^+_{it})	Index (May 2003 = 100)	The producer price index measures the price development in Switzerland at the first stage of the value chain of a given good (ex-factory price excluding value added taxes).	BUNDESAMT FÜR STATISTIK (various years, ch.5).
Exchange Rate Index	Index (Jan 1999 = 100)	Nominal effective exchange rate index in terms of an export weighted average with respect to 40 foreign countries (AUS, AUT, BEL, BRA, BGR, CAN, CHN, CZE, DNK, DEU, ESP, EST, FIN, FRA, GBR, GRC, HKG, HUN, IND, IRL, ITA, JPN, KOR, LTU, LVA, LUX, MEX, NLD, POL, PRT, RUM, RUS, SAU, SGP, SVN, SVK, SWE, THA, TUR, USA). Original values have been reversed such that an increase designates a depreciation of the CHF.	SWISS NATIONAL BANK (various years). Details of the concept can be found in SWISS NATIONAL BANK (2001).
Exchange Rate	CHF/€	Bilateral (nominal) exchange rate between the Swiss Franc and the Euro. An increase is a depreciation of the Swiss Franc.	SWISS NATIONAL BANK (various years).
Exchange Rate	CHF/US$	Bilateral (nominal) exchange rate between the Swiss Franc and the US Dollar. An increase is a depreciation of the Swiss Franc.	SWISS NATIONAL BANK (various years).

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SUMMARY

For the case of Switzerland, this paper endeavours to estimate the empirical extent to which exchange rates are "passed-through" onto import prices. For data covering the 1999 to 2010 period, the results suggest that (i) on aggregate, the exchange rate pass-through is highly incomplete with an elasticity of around 0.3 and (ii) major differences arise between industries. In particular, larger pass-through effects can be observed for certain commodities and other standardised products such as paper, timber, or minerals whilst for automobiles and textiles, the impact of the exchange rate upon import prices is almost always negligible and statistically far from significant.