Exchange rate pass-through in Switzerland: Evidence from vector autoregressions

Jonas Stulz

Exchange rate pass-through in Switzerland:
Evidence from vector autoregressions

Jonas Stulz[*]

Contents

Abstract

This study investigates the pass-through of exchange rate and import price shocks to different aggregated prices in Switzerland. The baseline analysis is carried out with recursively identified vector autoregressive (VAR) models. The data set comprises monthly observations, and pass-through effects are quantified by means of impulse response functions. Evidence shows that the exchange rate pass-through to import prices is substantial (although incomplete), but only moderate to total consumer prices. Moreover, a sub-sample analysis reveals that the pass-through decreased in the 1990s below the levels recorded in previous decades. This decrease was more pronounced for the pass-through to consumer prices than that to import prices, and it coincided with a shift towards lower and more stable consumer price inflation.

JEL classification: C32, E31, F41
Keywords: Exchange rate pass-through, VAR, consumer prices, import prices

Zusammenfassung

Der vorliegende Artikel untersucht die Übertragung (Pass-through) von Veränderungen des nominalen Wechselkurses und der Importpreise auf das inländische Preisniveau in der Schweiz. Die empirische Analyse basiert auf monatlichen Daten, und der Pass-through wird mit Hilfe von Impuls-Antwort-Funktionen aus rekursiv identifizierten vektorautoregressiven (VAR) Modellen gemessen. Die Ergebnisse deuten darauf hin, dass Wechselkursschocks zwar nicht vollständig, aber doch zu einem beträchtlichen Teil auf die Importpreise übertragen werden. Im Vergleich dazu reagieren die Konsumentenpreise nur schwach auf Veränderungen des Wechselkurses. Anhand von Schätzungen in zwei Teilperioden wird zudem gezeigt, dass der Pass-through in den 1990er Jahren gesunken ist. Dieser Rückgang ist beim Pass-through in die Konsumentenpreise stärker ausgeprägt als bei jenem in die Importpreise. Er fällt zudem zeitlich mit dem Übergang zu tiefer und vergleichsweise stabiler Inflation zusammen.

Résumé

Cet article étudie la transmission (pass-through) aux prix domestiques des variations du taux de change et des prix à l'importation. L'analyse est basée sur l'emploi de modèles du type vecteurs autorégressifs (VAR) identifiés de manière récursive. Des données mensuelles sont utilisées pour mesurer le pass-through à l'aide de fonctions de réponses aux impulsions. Les résultats suggèrent que les chocs du taux de change se transmettent de manière substantielle – encore qu'incomplète – aux prix à l'importation. Les prix à la consommation, par contre, ne réagissent que de manière marginale aux variations du taux de change. De plus, une analyse par échantillons distincts indique que l'intensité du pass-through a diminué dans les années nonante par rapport aux décennies précédentes. Cette diminution est plus marquée en ce qui concerne la transmission aux prix à la consommation et est intervenue parallèlement au passage à un régime d'inflation plus faible et plus stable.

3

1. Introduction

The extent to which exchange rate changes are reflected in prices of goods and services, generally referred to as the exchange rate pass-through relationship, has been of interest in international economics since the breakdown of the Bretton Woods system in 1973. For monetary policymakers, a thorough understanding of pass-through mechanisms is particularly important, as the degree of pass-through has an impact on both the transmission mechanism of monetary policy and on inflation forecasts.

The international empirical literature on the exchange rate pass-through is extensive. A robust stylised fact in this literature is that the exchange rate pass-through is in general incomplete. Such evidence is documented in the survey article by Menon (1995) for a wide range of countries. Most of the earlier studies focus on the exchange rate pass-through to import or export prices. A more recent body of literature, represented for instance by McCarthy (2000) and Mihailov (2005), with their cross-country analysis, examines the pass-through to different prices. In general, these studies find that the pass-through to consumer prices, which is the major concern for monetary policy, is small. In fact, in many cases it is insignificant.

Given the particular relevance of the pass-through issue for small open economies, the empirical evidence for Switzerland is surprisingly scarce. Moreover, some of the results of the few available studies are contradictory. Campa and Goldberg (2005) and Cavaliere (2007) find evidence of – strong and in the long run almost complete – exchange rate pass-through to import prices. This does not correspond to McCarthy (2000), who reports relatively small pass-through to Swiss import prices, as compared to other industrialised countries. Moreover, his estimate of the exchange rate pass-through to consumer prices is virtually zero. By contrast, Gagnon and Ihrig (2004) acknowledge a somewhat positive, although not statistically significant, pass-through of exchange rate shocks to consumer prices.

The aim of this study is to provide thorough empirical evidence on the degree of the aggregated pass-through to different prices in Switzerland. Unlike the cross-country studies above, we focus exclusively on the Swiss case. This makes it possible to carefully test the robustness of the results, both with respect to model specifications and sample choices. We exploit the information in macroeconomic time series in order to estimate the aggregated exchange rate pass-through to both import and consumer prices. Aggregated price data (i.e. price indices) are used, as this is of direct relevance for monetary policy authorities.

In a first step, we examine the transmission of exchange rate and aggregated import price shocks to aggregated import and consumer prices over a long time period ranging from 1976.01 to 2004.12 (full-sample analysis). The empirical literature presents different methodologies for estimating the pass-through. Campa and Goldberg (2005), for instance, use single-equation models, which are estimated by ordinary least squares (OLS). Following Choudhri, Faruqee, and Hakura (2005) and others, this study relies on vector autoregressive (VAR) models, which account for endogeneity of the variables. The degree of pass-through at different time horizons is then quantified by means of impulse response functions. In the

4

baseline case, we use a recursive scheme (Choleski decomposition) for identification of the structural shocks. As evidence from VARs may heavily depend on the model specification, robustness is tested both to alternative identification schemes (different recursive as well as non-recursive VARs) and to alternative ways of dealing with non-stationary variables.

In a second step, the changes in pass-through mechanisms over time are investigated. To achieve this aim, we perform a sub-sample analysis, thereby paying special attention to the link between the degree of pass-through to consumer prices and the inflation environment, i.e. the possible role of monetary policy in influencing the pass-through.

Previewing the results, in the full-sample analysis the exchange rate pass-through to import prices is found to be substantial, yet incomplete. By contrast, exchange rate shocks cause only moderate responses in consumer prices. These results are remarkably robust to different identification schemes and, to a somewhat smaller extent, to alternative ways of accounting for the non-stationarity of the variables. Furthermore, evidence from sub-sample estimations indicates that the degree of pass-through decreased in the 1990s below the levels recorded in previous decades. This is particularly true for the pass-through to consumer prices, and it coincides with a change in the inflationary environment, i.e. a shift towards lower and more stable inflation. This finding is in line with a recent body of literature which claims that a decrease in the exchange rate pass-through to consumer prices may be attributed to increased emphasis on inflation stabilisation by central banks.

The study is organised as follows. The next section gives an overview of the theoretical literature on the pass-through issue. Section 3 presents the data set and the applied econometric framework. In Section 4, the resulting pass-through estimates and their robustness are discussed. Section 5 presents sub-sample estimates in order to assess the changes in pass-through mechanisms over time. Section 6 concludes.

2. Theoretical background

Early theoretical research on the pass-through issue was predominantly microeconomic in nature. The classic article by Goldberg and Knetter (1997) provides a comprehensive overview of this literature, which aims to explain the incompleteness of pass-through from an industrial-organisation perspective. The pass-through is then examined in an environment of imperfect competition, usually in the form of market segmentation or product differentiation. Such a setup allows exporting firms with some market power to discriminate prices across destination markets, i.e. to set export prices to each destination as the product of the common marginal cost and a destination-specific markup. Krugman (1987) introduced the concept of pricing-to-market, which stands for exchange rate induced price discrimination across countries. In other words, it describes a situation where exporting firms adjust their (destination-specific) markups in order to compensate for exchange rate changes. Pricing-to-market may thus be considered as a microeconomic explanation for incomplete exchange rate pass-through to import prices.

In macroeconomics, by contrast, research focusing on pass-through mechanisms is a relatively new field. Traditional open economy macroeconomic models were characterised by perfect competition, fully flexible prices and purchasing power parity. In these models, the pass-through was necessarily complete. Neither was microeconomic evidence on incomplete pass-through incorporated in the early days of the new open economy macroeconomic era. In their pioneering work, Obstfeld and Rogoff (1995) introduced nominal rigidities and market imperfections into a micro-founded dynamic general equilibrium model. However, purchasing power parity was still maintained at all times, and the pass-through was complete. Betts and Devereux (1996, 2000) then developed an extended version of the Obstfeld-Rogoff model allowing for pricing-to-market. More precisely, whereas the two models feature the same simple form of price rigidity (prices are predetermined for one period), they differ in the assumed pricing strategy of firms. In the Obstfeld-Rogoff model, nominal prices are set in producers' currencies (producer currency pricing). Consequently, nominal exchange rate fluctuations cause one-to-one reactions in prices of imported goods, i.e. the short-run exchange rate pass-through is complete.[1] The policy implication is then straightforward: Since flexible exchange rates can serve as a substitute for flexible nominal prices, and therefore help to achieve relative price adjustments, a flexible exchange rate regime is desirable. By contrast, in the Betts-Devereux model, a fraction of firms is allowed to set prices in destination countries' currencies (local currency pricing). This dampens the effect of exchange rate changes on domestic prices. In fact, if all firms price-discriminate across countries, the short-run transmission of exchange

---

[1] To be precise, in the Obstfeld-Rogoff model with sticky prices, the short-run exchange rate pass-through to consumer prices equals the share of imported goods in total consumer goods.

rate shocks to prices is completely blocked, i.e. the pass-through is zero.[2] Devereux and Engel (2003) demonstrate that in this setup a fixed exchange rate regime is preferable.

However, these two early model types neglect several important aspects. In particular, neither the original Obstfeld-Rogoff model nor the Betts-Devereux model explicitly distinguish different stages of the distribution chain. More recently, a new strand in the literature has begun considering imports as intermediate goods that undergo non-traded production or distribution processes before being consumed. These production or distribution channels may dampen the impact of exchange rate shocks on consumer prices. Hence, imperfect pass-through to consumer prices may be observed even in the case of producer currency pricing. McCallum and Nelson (1999), for instance, provide a model in which imports serve as raw materials in the production and distribution process. The physical good is then only a part of what the consumer actually buys. The other part comprises non-traded marketing, distribution and retailing services. Consequently, as exchange rate changes only affect the physical goods' prices, the pass-through to consumer prices is likely to be small. A related approach was chosen by Corsetti and Dedola (2005). Again, their model incorporates distributive services, whose production is intensive in local inputs. Furthermore, they focus on the consequences of vertical interactions between monopolistic producers and retailers for international transmission.

A further key issue in the macroeconomic literature is the relationship between the exchange rate pass-through to consumer prices and monetary policy. This field of research has mainly been motivated by the observed decline in the degree of pass-through in most countries in recent years. As this decline has often coincided with a stronger central bank focus on inflation stabilisation, it was natural to presume a link between the two phenomena. In its November 2000 Monetary Policy Report (p. 9), the Bank of Canada claims that "the low-inflation environment itself is changing price-setting behaviour. When inflation is low and the central bank's commitment to keeping it low is highly credible, firms are less inclined to quickly pass higher costs on to consumers in the form of higher prices." Taylor (2000) was the first to come up with a theoretical framework in which the degree of pass-through depends on the inflation environment. He uses a microeconomic model of staggered price setting in which a lower pass-through is caused by lower perceived persistence of cost changes. Moreover, he presents evidence for a positive correlation between the level and persistence of inflation in the US. He therefore concludes that the low inflation itself has caused the low pass-through.[3] Drawing on the work by Taylor (2000), the link between pass-through and inflation has been examined in many studies. Gagnon and Ihrig (2004), for example, carried out a cross-country analysis comprising twenty industrialised countries. They found that the exchange rate pass-through declined in most countries where there was a regime shift towards more inflation stabilisation in the early 1990s.

---

[2]   Note that the assumption of sticky prices is crucial to this result. With flexible prices, complete pass-through prevails even in a world with local currency pricing.

[3]   It is implicitly assumed in this line of argument that the persistence of aggregate inflation is a proxy for the perceived persistence of cost changes.

More recently, alternative arguments to the Taylor hypothesis have been put forth to explain changes in pass-through elasticities over time. Focusing on import prices, Campa and Goldberg (2005) argue that changes in the pass-through are mainly caused by changes in the composition of a country's import basket. In particular, a move away from energy (for which the pass-through tends to be relatively high) towards manufactured products (for which the pass-through tends to be relatively low) will cause a decline in the aggregate pass-through to import prices. Ceteris paribus, this will translate into lower pass-through to consumer prices. Another body of literature, notably represented by Chen, Imbs, and Scott (2004), investigates the role of globalisation, i.e. the recent entry of China, India and Eastern Europe into the global trading system. This literature claims that not only monetary policy, but also globalisation and higher competition, have contributed to the substantial decline in global inflation in the 1990s. Due to globalisation, firms now operate in a more competitive environment than in previous decades. This implies higher aggregate multifactor productivity (because of marginal exits of low-productivity firms) and downward pressure on markups. In a high competition environment of this kind, the firms' ability to pass on cost increases is reduced. Also, by holding down the unit costs of production, productivity gains enhance the capacity of firms to absorb exchange-rate-related cost increases. All in all, globalisation and higher competition impose downward pressure on the degree of pass-through.

3.   Empirical model

This section presents the econometric setup applied in this study. First, the choice of the information set is motivated. Hereafter, we introduce the baseline VAR model and the identification strategy for relevant shocks.

3.1   Data set

This study aims to shed light on the transmission of fluctuations in the exchange rate (EX) to import prices (IPI) and consumer prices (CPI). These three variables are thus the centre of the empirical analysis. It is assumed that prices are set along the distribution chain, i.e. exchange rate shocks are initially passed along to import prices and finally lead to a reaction in consumer prices. Next, the model includes a measure of the output gap (gap) in order to control for domestic economic activity. A broad measure of money (M) allows for effects of monetary policy. Finally, foreign consumer prices (CPIW) are included. Note that the choice of the information set is largely in the spirit of Choudhri, Faruqee and Hakura (2005), who examine the performance of a variety of new open economy macroeconomic models by comparing the predicted results with evidence based on VARs.

A detailed description of the data and Graphs for relevant transformations is provided in Appendix A. In short, the data are monthly observations from 1976.01 to 2004.12. All series (except the nominal exchange rate) are seasonally adjusted by means of the Census-X-12 procedure. We use monthly instead of quarterly data because the monetary policy authorities are particularly interested in short-run pass-through dynamics, which are relevant for short-term inflation forecasts. Most series exist on a monthly basis. The only exception is the output gap, as all conventional measures of this series are based on GDP figures, which are only available quarterly. In order to obtain a monthly GDP series, we applied the Chow-Lin procedure (Chow and Lin, 1971). Details are again given in Appendix A. The output gap is then computed as the deviation of actual GDP from potential GDP, where the latter is calculated by means of a Hodrick-Prescott filter.

3.2   Econometric approach

The baseline empirical model is estimated as a VAR with five endogenous and one exogenous variable. The reduced form representation of the model may be written as

$$D(L)y_t = c + \varphi(L)x_t + \varepsilon_t \qquad\qquad E(\varepsilon_t\varepsilon_t') = \sum \qquad\qquad (1)$$

where $y_t' = [gap_t, \Delta m_t, \Delta ex_t, \Delta ipi_t, \Delta cpi_t]$ is the vector of m = 5 endogenous variables. $x_t = \Delta cpiw_t$ is the only exogenous variable, meaning that foreign prices are given for the small open Swiss economy.

$D(L) = (I + D_1 L + ... + D_p L^p + D_s L^s)$ and $\varphi(L) = (\varphi_0 + \varphi_1 L + ... + \varphi_q L^q)$ are matrix and vector polynomials in the lag operator. c is a vector of constants and ε_t a vector of residuals. Lower case letters indicate natural logarithms and Δ denotes first differences. In the baseline case, all series (except the output gap) enter the model as log differences. This is one possible

way to account for the non-stationarity of the level data.[4] Alternative strategies to deal with unit roots in the data – namely level VARs and vector error correction models (VECMs) – are implemented in a sensitivity analysis of the baseline results.[5] The reduced form model (1) is estimated with six lags for both endogenous and exogenous variables, i.e. $p = q = 6$. In addition, observations of endogenous variables at lag order $s = 12$ are included.[6] Before turning to the identification issue, it is worthwhile mentioning that results are very similar when the output gap (gap) is replaced by GDP growth (Δgdp) in the model.

Given $D(L)$ is invertible, (1) has an infinite order moving average representation[7]

$$y_t = C(L)\varepsilon_t = \sum_{k=0}^{\infty} C_k \varepsilon_{t-k} \qquad\qquad E(\varepsilon_t \varepsilon_t') = \sum \qquad (2)$$

with $C(L) = D(L)^{-1}$ and $C_0 = I$. As may be seen from the non-diagonal covariance matrix $\sum = \{\sigma_{ij}, i, j = 1, 2, ... m\}$, the residuals $\varepsilon_{i,t}$ are correlated with each other. A structural VAR representation in accordance with (1) is given by

$$B(L)y_t = u_t \qquad\qquad E(u_t u_t') = I \qquad (3)$$

The vector u_t contains mutually uncorrelated shocks. The variance-covariance matrix of these shocks can, without loss of generality, be normalised to I. Given that $B(L)$ is invertible, (3) is equivalent to the structural vector moving average representation

$$y_t = A(L)u_t = \sum_{k=0}^{\infty} A_k u_{t-k} \qquad\qquad E(u_t u_t') = I \qquad (4)$$

with $A(L) = B(L)^{-1}$. The structural shocks u_t are not directly observable, but need to be identified. Identification is achieved in two steps. First, the reduced form model (1) is estimated by OLS, working through the equations one after another. Second, the reduced form residuals ε_t are transformed. (2) and (4) imply

$$A_0 u_t = \varepsilon_t \Leftrightarrow u_t = A_0^{-1}\varepsilon_t = B_0 \varepsilon_t \qquad (5)$$

---

[4] Evidence from Augmented Dickey-Fuller and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests points to I(1)-behaviour of all variables, except the output gap. The latter is I(0) by construction.

[5] Cf. Section 4.4.

[6] Successive lag reduction tests (F-tests) suggest using lag order five, with inclusion of observations at lag order twelve. Conventional information criteria (Hannan-Quinn, Schwarz and Akaike) point to even smaller lag orders. Using five lags or fewer, however, leaves the estimated residuals partly autocorrelated. Allowing for six lags is sufficient to solve the problem of autocorrelated residuals.

[7] In the notation of (2) through (4) deterministic terms (i.e. the constant and the exogenous variable) are suppressed for simplicity.

Knowledge of A_0 is sufficient for full identification of the structural system. Our model with $m = 5$ endogenous variables requires $m^2 = 25$ independent restrictions on parameters of the structural form. Setting the variance-covariance matrix of the structural shocks u_t to the identity matrix, yields $m(m+1)/2 = 15$ restrictions. Additional $m(m-1)/2 = 10$ restrictions are thus needed for full identification. Throughout this study, we will make use of short-run restrictions only. These are restrictions that are directly imposed on A_0, which determines the contemporaneous reactions of the variables to structural innovations. Note that short-run restrictions may also be imposed on B_0, as this is simply the inverse of A_0. In the baseline model, we use a recursive identification scheme, by setting A_0 equal to the Choleski decomposition of $\sum$, i.e. $A_0 A_0' = \sum$ with A_0 being lower triangular. We gave preference to this procedure instead of a non-recursive VAR approach, because we are primarily interested in the effects of shocks in the exchange rate in general, rather than in the effects of strictly identified exchange rate shocks. This way of handling things is standard in the VAR literature on the pass-through issue, but is also widely used in other fields.[8]

Recursive identification by means of a Choleski decomposition is only unique up to the ordering of the variables. In the baseline case, the following ordering is chosen

$$gap \rightarrow \Delta m \rightarrow \Delta ex \rightarrow \Delta ipi \rightarrow \Delta cpi \qquad (6)$$

This choice is largely in line with the specifications in several related studies (cf. e.g. McCarthy, 2000, Hahn, 2003, and Cavaliere, 2007). It is motivated as follows: ordering the exchange rate before import prices and consumer prices reflects the idea that prices are set along the distribution chain. In other words, it allows for exchange rate shocks to impact on prices immediately via pass-through effects. Furthermore, the output gap is ordered first, followed by money. The underlying assumption is in the spirit of Peersman and Smets (2001) and Kim and Roubini (2000): Real activity reacts only with a lag to monetary innovations (i.e. innovations in money and the exchange rate), while the exchange rate, as an asset price, responds immediately to real and monetary innovations. As discussed in Section 4.4, we also test the robustness of the results with respect to alternative recursive as well as non-recursive identification schemes.

---

[8]   Cf. e.g. Kugler and Kaufmann (2005) for an application to the role of money as an indicator for future inflation.

4. Results

Based on the identified VAR, the degree of pass-through is quantified by means of impulse response functions. The system is shocked by a structural innovation in the equation for one of the endogenous foreign variables (exchange rate or import prices) and the pass-through of this shock to prices (import prices or consumer prices) is observed. Graphs 1 to 5 track the estimated pass-through patterns within 24 months. Note that the shocks (impulses) in the log-differenced variables are normalised to one. Hence, accumulated responses may be interpreted as approximate percentage point changes in the relevant price index following a one percent shock in a foreign variable, i.e. as pass-through elasticities. Solid lines are the accumulated impulse responses. Dotted lines are two standard error confidence bands.[9] Appendix B provides additional tables with results.

4.1 Pass-through to import prices

Graph 1: Exchange rate pass-through to import prices
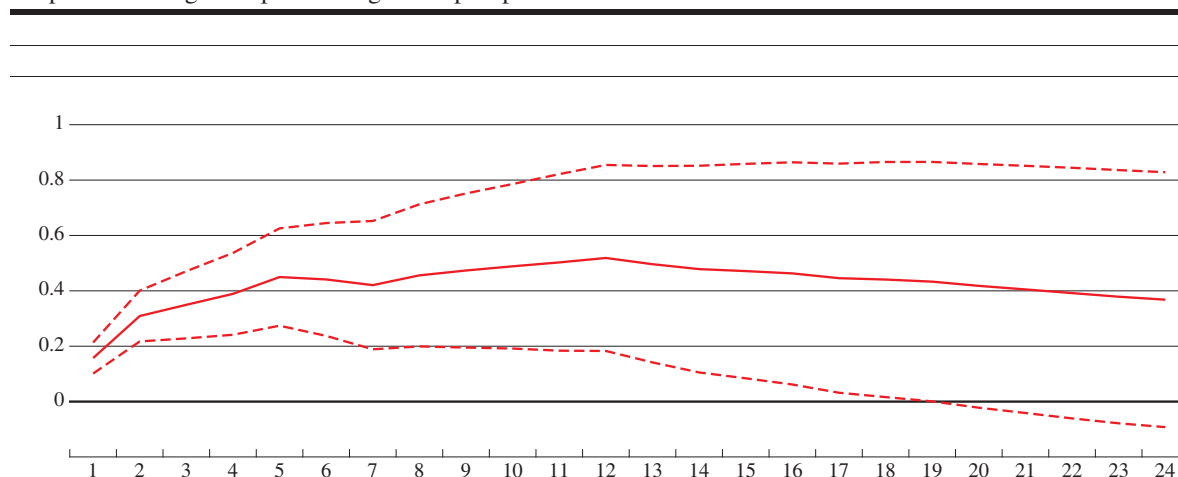
Graph 1 tracks the pass-through of an exchange rate shock to import prices. Several features are worthy of note. First, import prices react quickly to exchange rate shocks. The pass-through amounts to 0.35 after three months. Second, the impulse responses are slightly hump-shaped. The strongest response is observed after twelve months, when the pass-through reaches 0.52. In the long run, which is defined as two years in the context of this study, the pass-through comes to 0.37. Such a hump-shaped pattern, although there is no straightforward economic interpretation, is often found in studies on the pass-through to import prices. Choudhri, Faruqee, and Hakura (2005), for instance, obtain similar results for the non-US G-7 countries. As a consequence, and indicated by the confidence bands, the responses are significantly different from both zero and one for a time horizon up to 19 months, but insignificantly different from zero thereafter. All in all, we conclude that the pass-through to import prices is substantial, but incomplete. These findings are compatible with most empirical literature. Goldberg and Knetter (1997) find an average pass-through for

---

9   Confidence intervals are generated by the Monte Carlo method provided in EViews 5.1, based on 5,000 simulations.

shipments to the US of 0.5, and Hahn (2003) estimates a similar degree of pass-through for the euro area. McCarthy (2000) points out that the pass-through to import prices is relatively small in Switzerland compared to other industrialised countries. Only Campa and Goldberg (2005) come to a fundamentally different conclusion: They claim the pass-through to import prices in Switzerland is higher than in most other OECD countries and virtually complete in the long run. Instead of impulse responses from VAR models, Campa and Goldberg (2005) simply take the estimated coefficients in linear regression models as measure of the pass-through. However, applying the Campa and Goldberg (2005) methodology to the dataset used in this study produced estimates that are roughly in line with the evidence presented in Graph 1. We conclude, therefore, that the differences in the results are mainly due to different datasets rather than different methodologies.[10]

4.2   Pass-through to total consumer prices

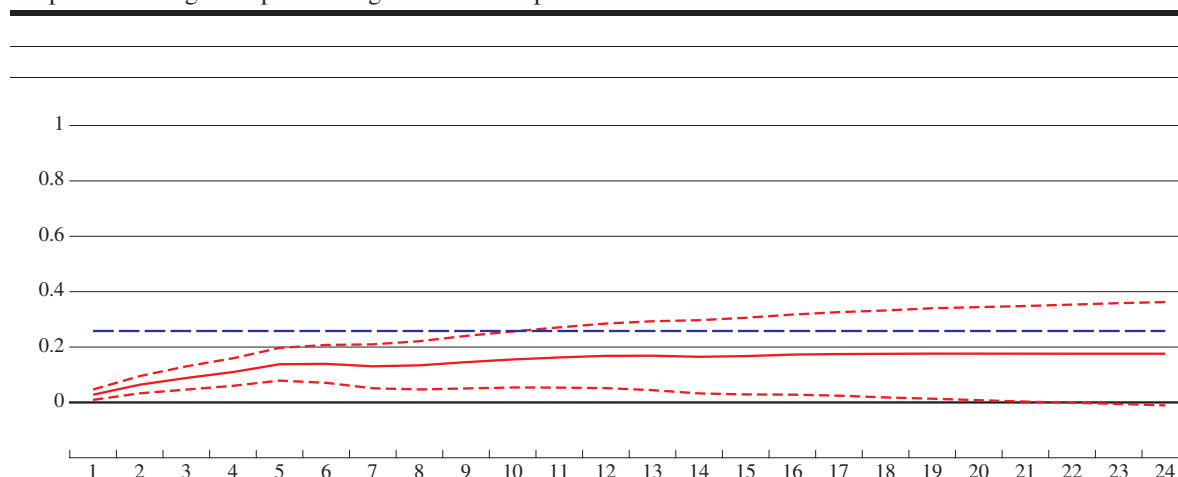Graph 2: Pass-through of import prices to consumer prices
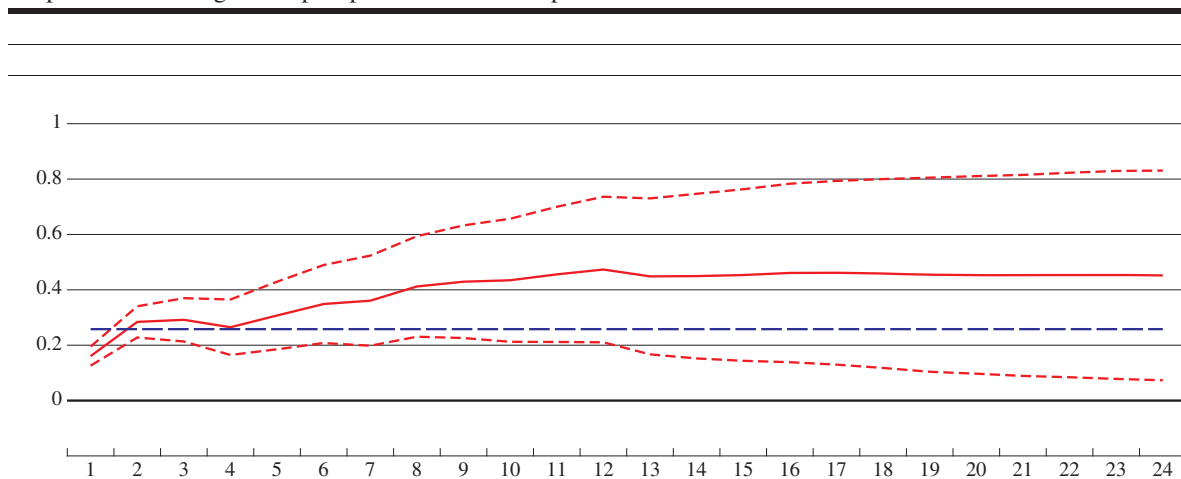
Graph 2 displays the pass-through of import price shocks to consumer prices. Again, the pass-through takes place quite quickly. Moreover, the responses are significantly different from zero for all periods considered. After three months, the pass-through amounts to 0.29. Within one year, the pass-through reaches its long-run level, which is 0.45. When interpreting these results, it is useful to consider the share of imported goods in the consumer price basket. In 2004, this share was roughly one quarter (25.8%), which is indicated by the horizontal dotted line in Graph 2. If import price shocks were completely passed through along the distribution chain, the effect on total consumer prices would approximately equal this share. Note that this is a rough rule only, since it ignores possible effects of foreign shocks on prices of competing domestic goods: Domestic firms may have incentives to adjust their prices as a reaction to changes in prices for similar imported goods. Hence, it is not implausible that the estimated pass-through exceeds the ratio of imported to total consumer goods, as it is the case in Graph 2. In the next section, we will explicitly rule out

---

[10]   Campa and Goldberg (2005) use quarterly instead of monthly data. Moreover, they use different nominal effective exchange rate and foreign price series.

this kind of effects on domestic prices by estimating the pass-through to a narrower consumer price measure. For the time being, we note that the evidence of a strong pass-through of import prices to consumer prices is in line with the results in McCarthy (2000). Amstad and Fischer (2005), who use an event study approach, also find evidence that import price releases provide important information for consumer price inflation.

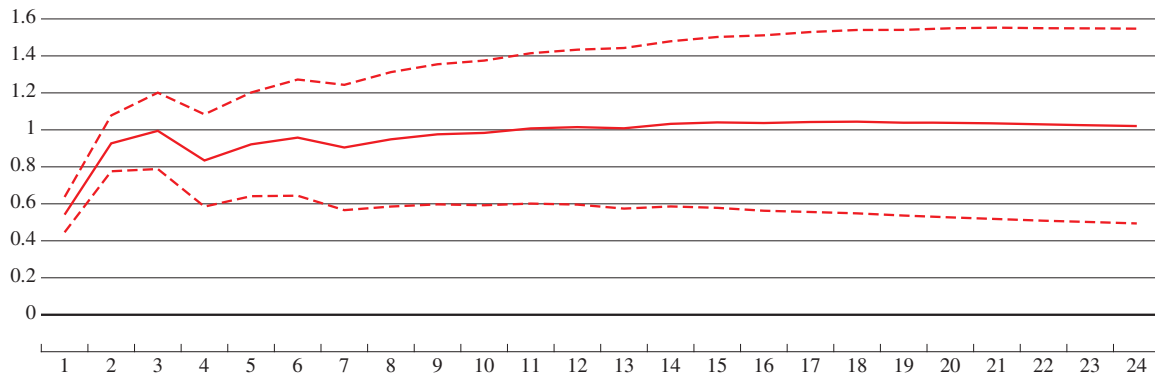Graph 3: Exchange rate pass-through to consumer prices

Finally, the pass-through of exchange rate shocks to consumer prices is presented in Graph 3. It amounts to 0.09 after three months and increases to only 0.18 after two years. Note that in both the short and the long run, there is a good match between this direct measure of the exchange rate pass-through and an indirect measure, defined as the product of estimates of the pass-through from the exchange rate to import prices and that from import prices to consumer prices. Furthermore, although estimated confidence bands in Graph 3 are relatively narrow, the exchange rate pass-through to consumer prices is only borderline significant in the longer run and lies below the share of imported goods in the consumer price basket (which is again indicated by a horizontal dotted line). This evidence of a rather weak exchange rate pass-through to consumer prices is not contradicted in the literature. Nevertheless, there is some ambiguity concerning the size of the pass-through. McCarthy (2000) reports that consumer prices respond very weakly to exchange rate shocks in most industrialised countries and that there is virtually no pass-through for Switzerland. Gagnon and Ihrig (2004), by contrast, acknowledge more or less the same degree of pass-through for Switzerland as presented in this study.

4.3   Pass-through to consumer prices for imported goods

Only about one quarter of all goods and services included in the consumer price basket are imports. Hence, there is no straightforward interpretation of estimated impulse responses for total consumer prices, i.e. responses significantly below one do not necessarily reflect an incomplete pass-through. In the section above, we suggested using the share of imports in total consumer prices as a criterion for the assessment of the strength of pass-through. This, however, does not fully solve the problem, as it is not clear how domestic competitors adjust their pricing behaviour in reaction to changes in the prices of competing imported goods. In

order to circumvent such problems, we next estimate the pass-through of foreign shocks to consumer prices for imported goods only.[11]

Graph 4: Pass-through of import prices to consumer prices for imported goods

Graph 4 displays the responses of consumer prices for imported goods to shocks in import prices. The pass-through is again remarkably fast and strong: after three months, it already amounts to 0.99. Hence, the pass-through is virtually complete within one quarter. This confirms the results in the section above, where evidence for a strong pass-through of import prices to consumer prices was found.

---

[11]   Note that for this type of estimate, money is excluded from the empirical model.

Graph 5: Exchange rate pass-through to consumer prices for imported goods
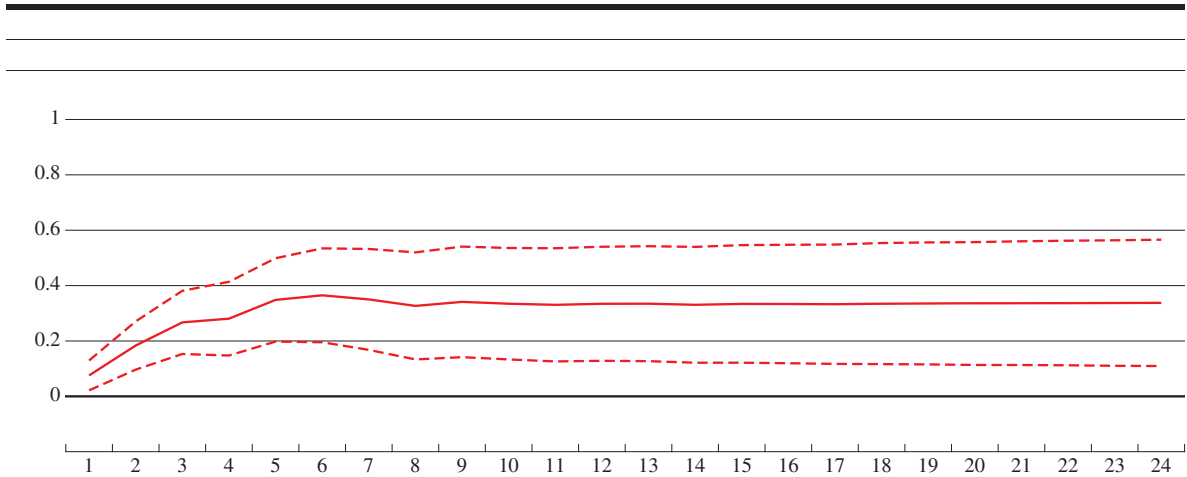
The transmission of exchange rate shocks is displayed in Graph 5. Again, the estimated responses for consumer prices for imported goods are stronger than those for total consumer prices. The degree of pass-through is 0.27 after three months and 0.34 after two years. However, confidence bands indicate that the pass-through is significantly below one over the whole horizon. This is further evidence that the exchange rate pass-through to consumer prices is weak and clearly incomplete. Moreover, the exercise in this section suggests that the transmission of exchange rate shocks to consumer prices is blocked mainly by rigid import prices.

4.4   Sensitivity analysis

As estimates from VARs may be highly dependent on the specification of the underlying model, we examine the robustness of the estimated pass-through elasticities by submitting the baseline model to several modifications. This sensitivity analysis is conducted with respect to two different considerations. First, we test robustness to the identification scheme. This is important because impulse responses from recursively identified VARs may be highly sensitive to the chosen ordering. Moreover, recursive identification schemes do not allow for simultaneous determination of the variables, although the latter may be suggested by economic theory.[12] For these reasons, we test the sensitivity of the baseline results with respect to alternative recursive orderings and to non-recursive identification schemes. Second, we implement alternative approaches to account for the non-stationarity of the data. The baseline approach, i.e. the estimation of VARs in first differences, is standard in empirical investigations into the exchange rate pass-through.[13] In general, however, there is a lot of disagreement in the literature on whether or not to difference non-stationary variables

---

[12]   In the case at hand, as discussed by authors such as Woo (1984), one should account for the possibility of simultaneous determination of exchange rates and prices.

[13]   To name a few only, McCarthy (2000), Hahn (2003), Mihailov (2005), Choudhri, Faruqee, and Hakura (2005), and Cavaliere (2007) use the same strategy.

in VARs.[14] In order to see how sensitive the baseline results are to the choice of data transformation, we decided to run both a level VAR and a VECM (i.e. a model including a long-run relationship in the spirit of the quantity theory of money), and compare the impulse responses to the baseline estimates.

To conserve space, the technical aspects and the detailed results of the various robustness exercises have been reported in a separate appendix available from the author upon request. In short, the sensitivity analysis confirms the central results of this study, as the baseline results hold qualitatively in the various robustness exercises. Given the low contemporaneous correlation between the variables used in the model, the robustness to different identification schemes is very high. As to different data transformations, the impulse responses of the level VAR are somewhat weaker than those of the baseline VAR, in particular in the case of the exchange rate pass-through to import prices. The VECM estimates, however, are close to the baseline results.

5.   Changes in the degree of pass-through

A robust stylised fact for the 1990s is that the exchange rate pass-through decreased in many countries. Gagnon and Ihrig (2004) find a decline in the pass-through to consumer prices in the vast majority of industrialised countries in their dataset, including Switzerland. Bailliu and Fujii (2004) document similar findings for eleven industrialised countries. One possible explanation for a decrease in the pass-through to consumer prices is the greater commitment of central banks to keeping inflation low. In a low-inflation environment, firms are less likely to pass on cost shocks (e.g. to exchange rates or import prices) to consumers, because they expect countervailing pressure by the central bank.

This section aims to shed more light on the specific case of Switzerland. We begin by investigating the consumer price inflation series for structural breaks. As there is evidence for a shift towards lower and more stable inflation in the early 1990s, we then carry out a sub-sample analysis and test for the significance of changes in the baseline pass-through elasticities before and after the change in the inflation environment.

---

[14]   A comprehensive discussion of this issue is provided in Enders (2004).

5.1 Selection of sub-sample periods

The solid line in Graph 6 marks month-on-month growth in consumer prices for the time period between 1976 and 2004. In order to improve legibility, a dotted line showing a centred moving average of this series has also been included.

Graph 6: Changes in the inflation environment
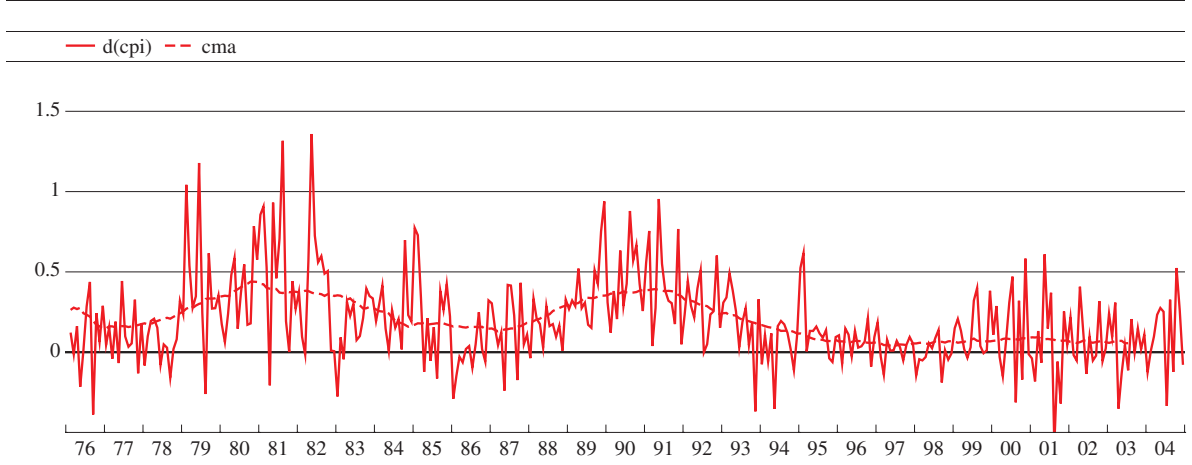
A visual inspection of the graph indicates a change in the inflation environment at a point somewhere in the first half of the 1990s. Both the mean and the variance of inflation appear to have decreased as compared to previous years. This visual evidence will be supported by a more formal investigation. To this end, consumer price inflation is modelled as a simple univariate autoregressive process of the following form

$$\Delta cpi_t = c + \sum_{j=1}^{10} \beta_j \Delta cpi_{t-j} + \varepsilon_t \tag{7}$$

The lag length is set equal to ten, following the Akaike information criterion. Note that ten lags are sufficient to obtain serially uncorrelated residuals ε_t. Model (7) is then examined for structural breaks, i.e. for changes in the parameter vector $\theta = \{c, \beta\}$. As there is no strong prior for the location of a potential breakpoint, we use a test strategy that allows for a single but unknown change point. This strategy comprises three steps:[15]

First, we consider the standard Wald test of structural change at a given change point πT, where T is the sample size and π is a given point in the interval $(0,1)$.[16] Under the null hypothesis of no structural break at πT, the test statistic and its distribution are

$$\xi_T(\pi) = \left(\hat{\theta}_1 - \hat{\theta}_2\right)' \left[V\left(\hat{\theta}_1\right) + V\left(\hat{\theta}_2\right)\right]^{-1} \left(\hat{\theta}_1 - \hat{\theta}_2\right) \overset{H_0}{\sim} \chi^2(11) \tag{8}$$

---

[15]   The notation in this paragraph closely follows Andrews (1993).

[16]   Wald tests are applied instead of standard Chow tests (F-tests), as, in large samples, the former are valid whether or not the underlying model is heteroscedastic (cf. e.g. Greene, 2003).

18

with $\hat{\theta}_1$ being the vector of parameter estimates in the regression covering data $t = 0,..., \pi T$-1 and $\hat{\theta}_2$ the respective vector resulting from the regression from $t = \pi T,...,T$. $V(\hat{\theta}_1)$ and $V(\hat{\theta}_2)$ are the covariance matrices of the estimated parameters.

Next, we allow for an unknown $\pi \in \Pi$, where Π is a pre-specified subset of [0, 1]. We then perform successive Wald tests for all potential change points in interval Π. Finally, the change point π^* that maximises the Wald statistics over all possible change points $\pi \in \Pi$ is chosen, i.e.

$$\pi^* = \arg\max_{\pi \in \Pi} \xi_T(\pi) \tag{9}$$

Note that testing for structural change with an unknown change point does not fit into the standard testing framework, i.e. the successive Wald statistics $\xi_T(\pi)$ for all $\pi \in \Pi$ no longer follow the standard $x^2(11)$-distribution in (8). The reason is that π is now treated as an unknown and not as a given. This complicates things, as π only appears under the alternative hypothesis but not under the null. Andrews (1993) provides asymptotically valid critical values for the following test statistic

$$\xi_T^*(\pi) = \sup_{\pi \in \Pi} \xi_T(\pi) \tag{10}$$

The critical values depend on the choice of Π. Andrews (1993) shows that using the full interval $\Pi = (0,1)$ results in a test with high power against alternatives of a change point near zero or one, but low power against alternatives of change points in the rest of the interval. Hence, instead of using the full interval, he suggests using a restricted interval in order to ensure reasonable power properties. In our case, the sample covers data points from 1976.01 to 2004.12. We apply an interval $\Pi = [0.15, 0.85]$, i.e. we test for an unknown structural break between 1980.05 and 2000.08. The solid line in Graph 7 displays successive Wald test statistics $\xi_T(\pi)$ for all $\pi T \in [1980.05, 2000.08]$. The maximum of $\xi_T(\pi)$ is marked with a red dot. It is at 1993.09. The null hypothesis of no structural break in 1993.09 is clearly rejected, as the test statistic lies above the one percent critical value according to Andrews (1993), which is indicated by the horizontal line in Graph 7.

Graph 7: Test for structural change with unknown change point

Whole sample (1976.01–2004.12) ― ― Early sample (1976.01–1993.04) ···· Late sample (1993.05–2004.12)
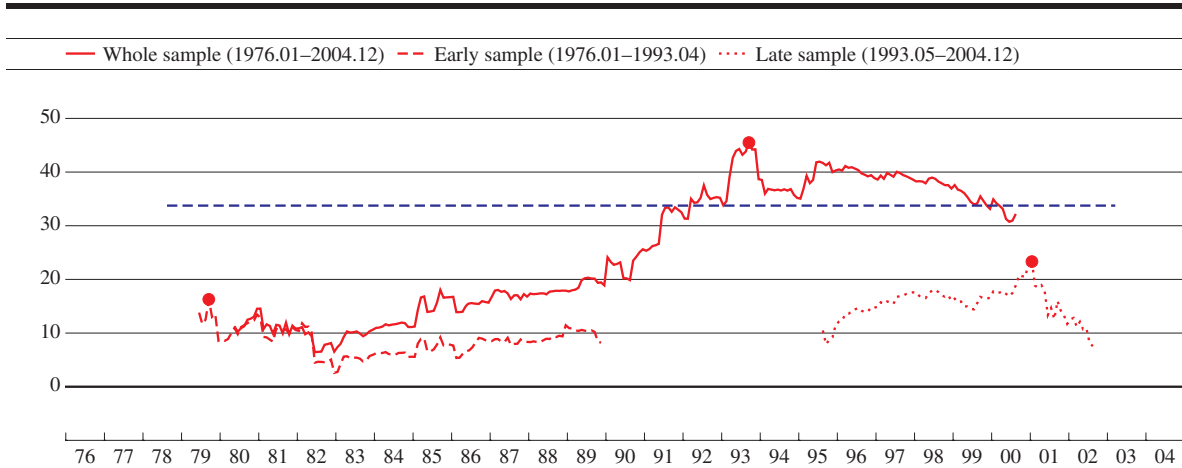
On account of the above results, we decided to split the sample in mid 1993. Thus, the analysis in the next session uses an early sample (1976.01 to 1993.04) and a late sample (1993.05 to 2004.12). The consumer price index was methodologically revised by the Swiss Federal Statistical Office in 1993.05, which made it natural to pick this date for splitting the sample, instead of 1993.09.[17] Note that the mean of consumer price inflation decreased substantially from the early to the late sample (from 0.27 to 0.07). The same was true for the standard deviation (from 0.29 to 0.19). Hence, we may deduce that there was a shift towards lower and more stable inflation. Furthermore, no evidence for a significant break within the two sub-samples is detected. This is indicated by the two dotted lines in Graph 7, which both lie clearly below the one percent critical value.

5.2   Impulse responses in sub-samples

Graphs 8 through 10 display the pass-through estimates in the two sub-samples. Again, Appendix B provides additional tables with results. We observe a decrease for all three pass-through definitions and for nearly all horizons. Only the pass-through of import prices to consumer prices increases slightly in the very short run. In the long run, however, it decreases strongly. As a consequence, the exchange rate pass-through to consumer prices becomes virtually zero in the late sample. Relative to this result, the decline in the exchange rate pass-through to import prices is moderate.

---

[17]   The revision of the consumer price index mainly consisted of a new survey of housing rents and some minor changes in the composition of the consumer basket (for further details the reader is referred to BFS, 1993). Overall, the revision was gentle and thus unlikely to have by itself caused the structural break in inflation. Likewise, it cannot by itself account for changes in pass-through mechanisms.
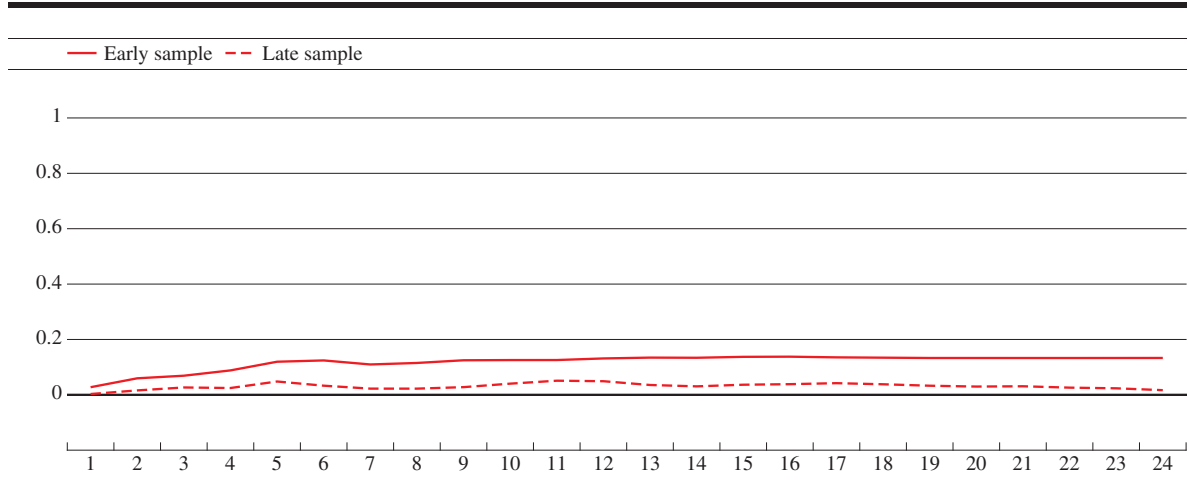
Graph 8: Changes in the exchange rate pass-through to import prices

Early sample — — Late sample
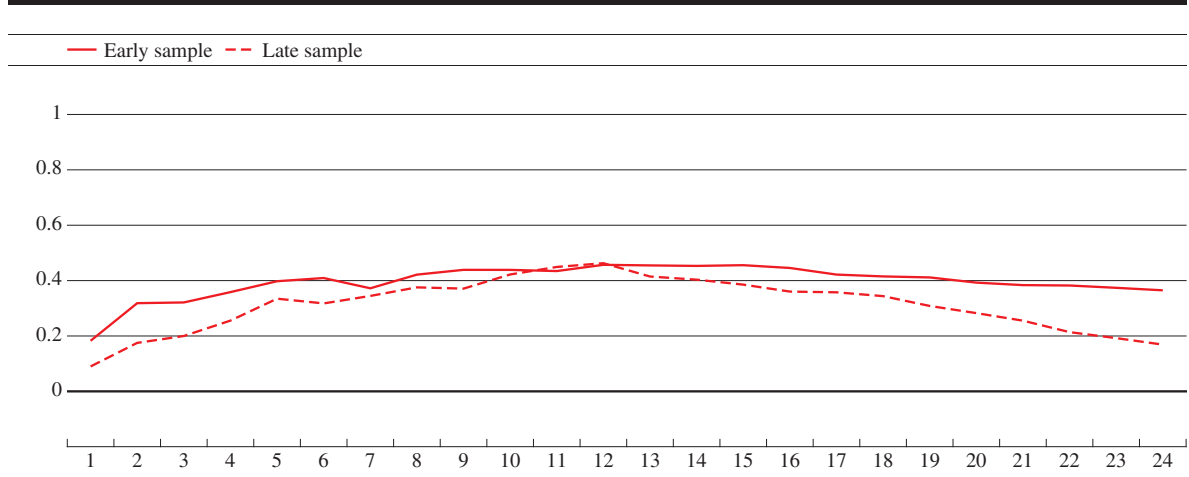
Graph 9: Changes in the pass-through of import prices to consumer prices

Early sample — — Late sample
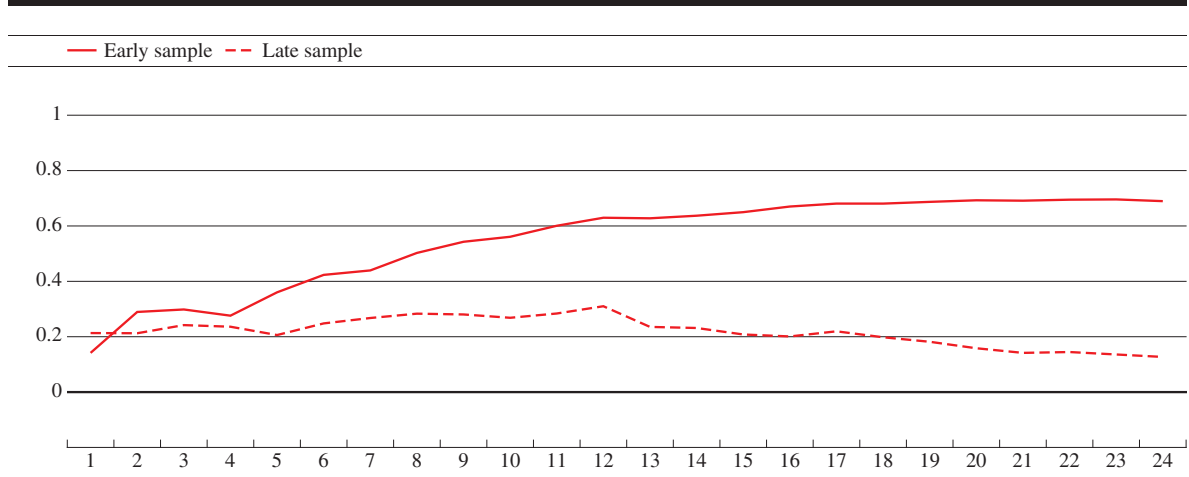
Graph 10: Changes in the exchange rate pass-through to consumer prices

Early sample — — Late sample

In order to assess whether the decreases in pass-through are statistically significant, we further applied a simple test strategy. Impulse responses are non-linear functions of the coefficients of the underlying VAR. These coefficients are estimated by OLS and thus present an asymptotically normal distribution. Hence, by means of delta methods one can show that impulse responses are also asymptotically normal. We can then set up a simple test statistic D_t on the difference between the means of two independent, normally distributed variables (with different variances) at time horizon t.

$$D_t = \frac{\left(\hat{\psi}_{t,1} - \hat{\psi}_{t,2}\right)}{\left(\sqrt{\left(\hat{s}_{t,1}\right)^2 + \left(\hat{s}_{t,2}\right)^2}\right)} \tag{11}$$

The mean estimates $\left(\hat{\psi}_{t,1}, \hat{\psi}_{t,2}\right)$ are the cumulated impulse response coefficients in the two sub-samples at time horizon t. The standard deviation coefficients $\left(\hat{s}_{t,1}, \hat{s}_{t,2}\right)$ are, once again, obtained by applying 5,000 Monte Carlo simulations. Before turning to the test results, it is worthwhile noting that – essentially – delta methods, and consequently the whole test strategy, are only valid asymptotically. Strictly speaking, the test results are thus suggestive rather than conclusive. With 195 and 140 observations in the two sub-samples above, however, we may assume that the results are credible. Moreover, the distribution of D_t is well approximated by a standard normal distribution, although $s_{t,1}$ and $s_{t,2}$ are unknown and $s_{t,1} \neq s_{t,2}$.[18]

Graph 11: Mean comparison tests
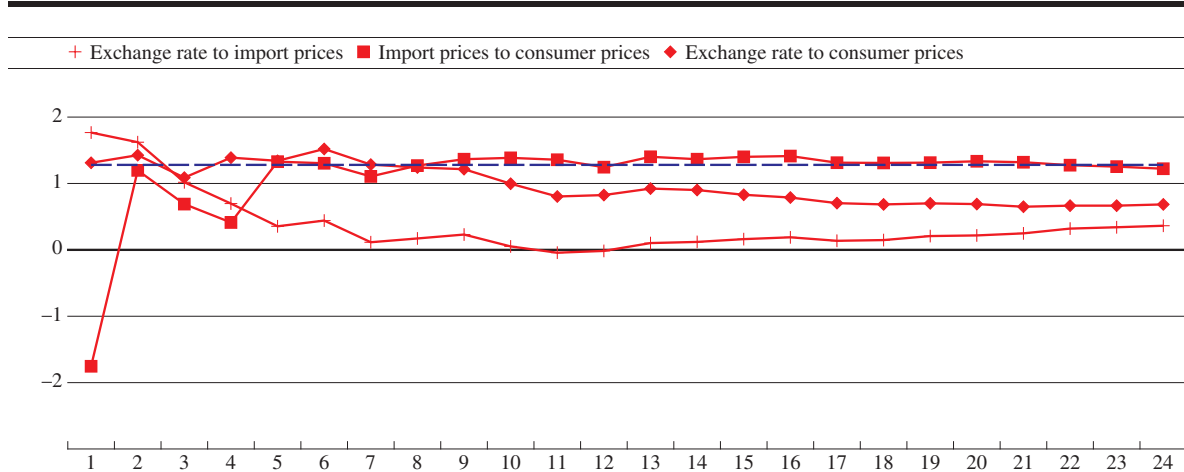
The test results are presented in Graph 11. The horizontal dotted line denotes the ten percent critical value for a one-sided test. The results are fairly conclusive. The decrease in the exchange rate pass-through to import prices is statistically significant at the ten percent level only in the very short run. For a time horizon of three months and more, the differences are statistically insignificant. Quite the opposite is true for the pass-through from import prices to consumer prices. As mentioned above, this even slightly increased in the short run.

---

[18]   Generally, comparing the means of two populations when the ratio of their variances is unknown is subject to the
         Behrens-Fisher problem. One way of dealing with this problem in small samples is to perform t-tests, with Welch
         correction for the degrees of freedom (cf. e.g. Scheffé, 1970).

At a horizon of five months and more, however, the pass-through is almost always significantly lower in the late sample. Finally, the decrease in the exchange rate pass-through to consumer prices is statistically significant for almost all horizons up to seven months. To sum up, the pass-through to consumer prices did indeed weaken substantially in the 1990s, and this decrease coincided with a shift in the inflation environment.

The above evidence supports Taylor's (2000) hypothesis which states that low and stable inflation delivered by highly credible and efficient monetary policy has a dampening impact on the firms' inclination to pass on cost increases. The evidence is also in line with the literature on the effects of globalisation and competition.[19] This literature primarily aims to explain the decline in inflation, but it also addresses the issue of changes in the degree of pass-through. In that sense, globalisation offers complementary, rather than alternative arguments, as compared to Taylor's (2000) hypothesis. Nevertheless, the two explanations have different policy implications. In general, a low pass-through is set to provide greater freedom for pursuing an independent monetary policy and to make it easier to control inflation. Further, a change in the degree of pass-through can influence inflation forecasts, a key element in the conduct of monetary policy. For monetary policymakers, it is thus crucial to assess whether the observed decline in pass-through in recent years is temporary or permanent in nature. Taylor (2000) argues that as long as the monetary policy regime ensures low and stable inflation, the pass-through will remain low. This implies a permanent effect. On the other hand, if globalisation is the main reason for the decline in pass-through, we are likely to witness a temporary phenomenon. The globalisation argument relies on the assumption of substantial markups by monopolistically-competitive firms prior to the introduction of higher competition. Downward pressures on the pass-through are then a temporary phenomenon only, marking a transition phase characterised by eroding markups. As soon as markups have levelled out at a lower and more competitive level, the degree of exchange rate pass-through rises again as tighter margins restrict the capacity of firms to absorb cost increases.

6. Conclusions

As compared to other empirical studies on the pass-through issue, this study uses an approach featuring several aspects that are worthy of note. First, it explicitly focuses on the Swiss case, instead of carrying out a cross-country analysis. Second, the data set comprises monthly data. Using monthly data appears to be appropriate, as this frequency better accounts for real-world price-level stickiness. As a consequence, the analysis is likely to uncover short-run pass-through dynamics that remain hidden in quarterly data. This is of particular interest for monetary policy authorities, which depend on information that is relevant for short-term inflation forecasts. Third, the degree of pass-through is estimated by means of impulse response functions from VARs. As such evidence may be very dependent on the specification of the empirical model, we apply a battery of robustness tests, including

---

[19]   Cf. the discussion at the end of Section 2.

different identification schemes and data transformations. Fourth, a thorough investigation of the changes in pass-through mechanisms over time is carried out, thereby giving special attention to the possible role of the inflation environment as a determinant of the degree of pass-through to consumer prices.

The empirical investigation yields several interesting results. Evidence from a full-sample analysis, covering data from 1976.01 through 2004.12, suggests that exchange rate changes are passed through quickly to import prices. In the long run, the related pass-through is substantial, but incomplete. Furthermore, the transmission of import price shocks to consumer prices is surprisingly strong. When looking at consumer prices for imported goods only, it is virtually complete in the long run. These findings are important when interpreting the weak exchange rate pass-through to consumer prices. In fact, the transmission of exchange rate changes to consumer prices seems to be blocked primarily by rigid import prices (i.e. by the incomplete exchange rate pass-through to import prices). On the other hand, there is no evidence that production or distribution processes exert any dampening effect on imported goods before they can be consumed.

The conclusions change, however, when results from a sub-sample analysis are considered. This perspective reveals that the magnitude of the pass-through at all stages decreased in the 1990s. Whereas this decrease is relatively limited (and not statistically significant) for the exchange rate pass-through to import prices, it is particularly pronounced for the transmission of import price shocks to consumer prices. As a consequence, the exchange rate pass-through to consumer prices has become virtually zero. Moreover, it is shown that the decline in the degree of pass-through to consumer prices coincided with a change in the inflation environment, i.e. a shift towards lower and more stable consumer price inflation. It is a hard task, and beyond the scope of this study, to disentangle the relative importance of monetary policy and globalisation as possible explanations for the changes in the exchange rate pass-through over time. Likewise, it is difficult to assess to what extent the observed decline in the exchange rate pass-through to consumer prices is temporary or permanent in nature. Notwithstanding this, it is sensible to argue that monetary authorities – by conducting a credible and efficient low-inflation policy – can contribute to the permanent component of low exchange rate pass-through to consumer prices.

A   Data appendix

A.1   Definitions

Exchange rate (EX): Nominal effective exchange rate of the Swiss franc versus 24 trading partners. The weights correspond to the export shares of the individual countries. Index: 1977.11 = 100. Inverted (i.e. a rising value indicates a depreciation of the Swiss franc). Not seasonally adjusted. Source: Swiss National Bank.[20]

Import prices (IPI): Import price index: 2003.05 = 100. Prices at the docks (exclusive value added tax). Seasonally adjusted by means of the Census-X-12 procedure. Source: Swiss Federal Statistical Office.

Gross domestic product (GDP): Monthly real GDP. In million Swiss francs. Seasonally adjusted (Census-X-12). The series is calculated in two steps. Firstly, quarterly GDP according to the ESVG95 (available from 1980 onwards) is linked with a discontinued GDP series from the former Nationale Buchhaltung. Secondly, the resulting series is transformed into a monthly series by means of the Chow-Lin procedure (Chow and Lin, 1971). This approach assumes a linear relationship between the unobservable series of interest (here: monthly GDP) and other series with more frequent recording (related series). Related series are chosen in the spirit of Cuche and Hess (2000), who suggest to take indicators for the expenditure side of GDP. Accordingly, exports of goods (to proxy for total exports), retail sales (for private consumption) and imports of investment goods (for both total imports and business investment) are used. Sources: State Secretariat for Economic Affairs (quarterly GDP), Federal Customs Administration (exports, imports), Swiss Federal Statistical Office (retail sales), own calculations (monthly GDP).

Output Gap (gap): Log deviation of real GDP from its Hodrick-Prescott trend ($\lambda = 14,400$). Source: own calculations.

Money (M): Broad money M3. In million Swiss francs. Seasonally adjusted (Census-X-12). Source: Swiss National Bank.
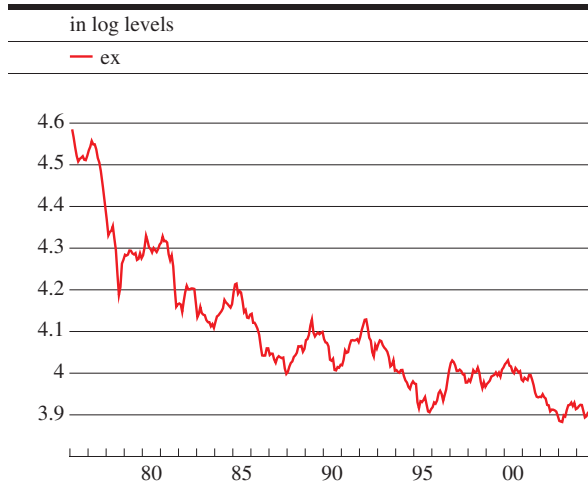
Consumer prices (CPI): Consumer price index: 2000.05 = 100. Seasonally adjusted (Census-X-12). Source: Swiss Federal Statistical Office.

Foreign consumer prices (CPIW): Weighted average of foreign national consumer price indices. The weights correspond to those applied to the effective exchange rate. The CPIW series is calculated indirectly by dividing the nominal effective exchange rate of the Swiss franc through the real effective exchange rate, and multiplying it with Swiss consumer prices. Index: 1977.11 = 100. Seasonally adjusted (Census-X-12). Source: Swiss National Bank and own calculations.
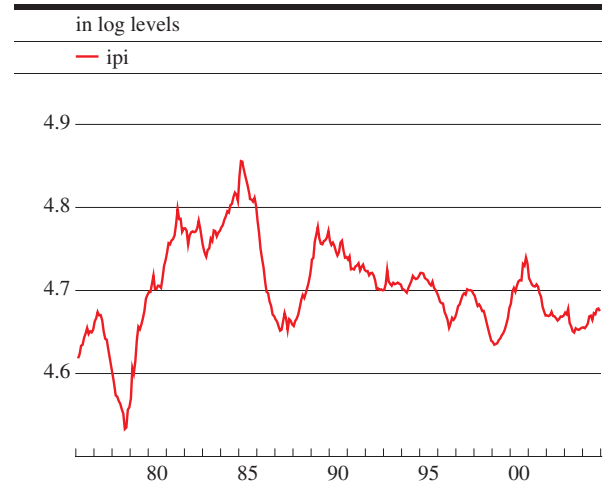

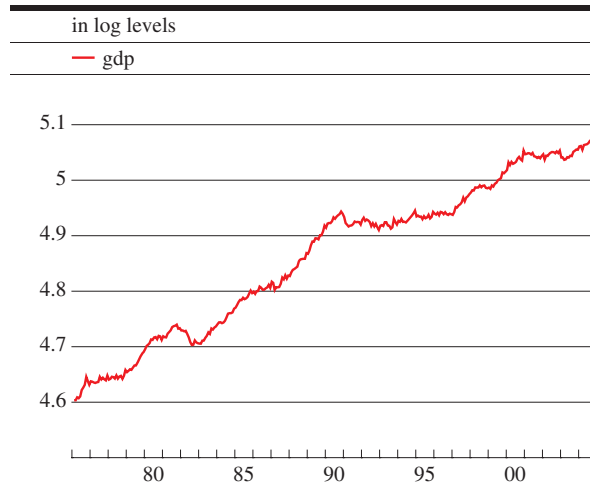[20]   For details, cf. Fluri and Müller (2001).
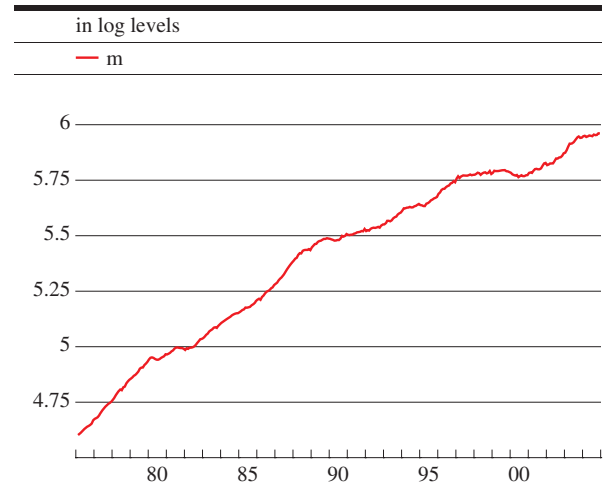
A.2 Graphs

Graph 12a: Exchange rate

in log levels
— ex

Graph 12b: Import prices

in log levels
— ipi

Graph 12c: Gross domestic product

in log levels
— gdp

Graph 12d: Money

in log levels
— m

Graph 12e: Consumer prices

in log levels
— cpi
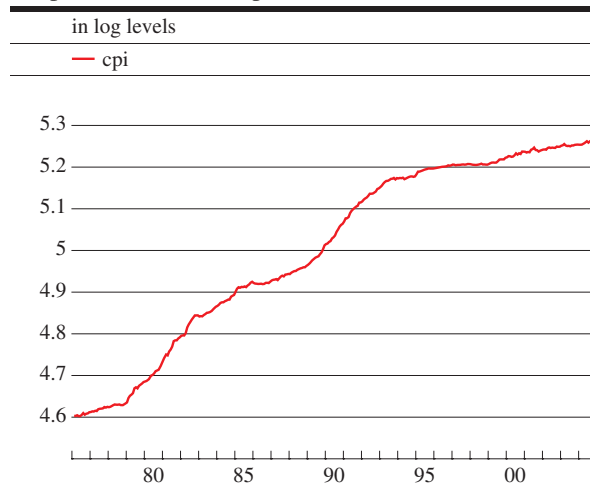
Graph 12f: Foreign consumer prices

in log levels
— cpiw
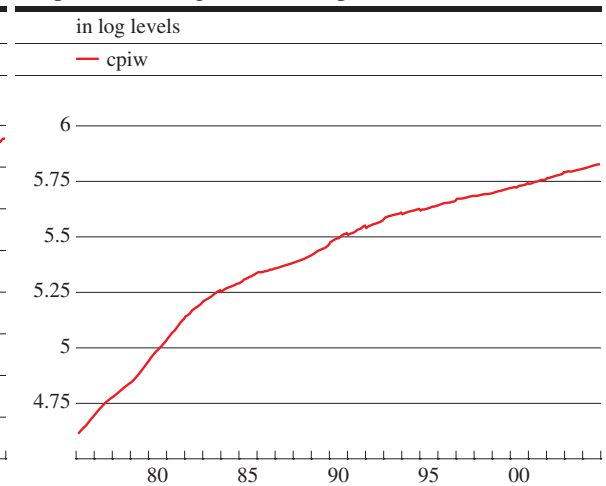
Graph 13a: Exchange rate

in log differences

— d(ex)
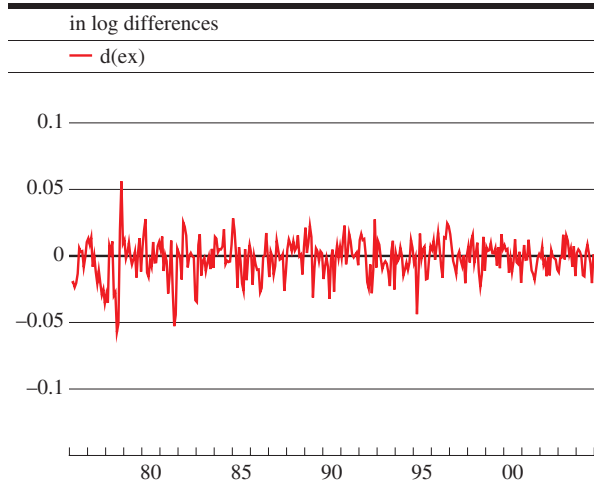
Graph 13b: Import prices

in log differences

— d(ipi)

Graph 13c: Output gap

in log deviations from trend
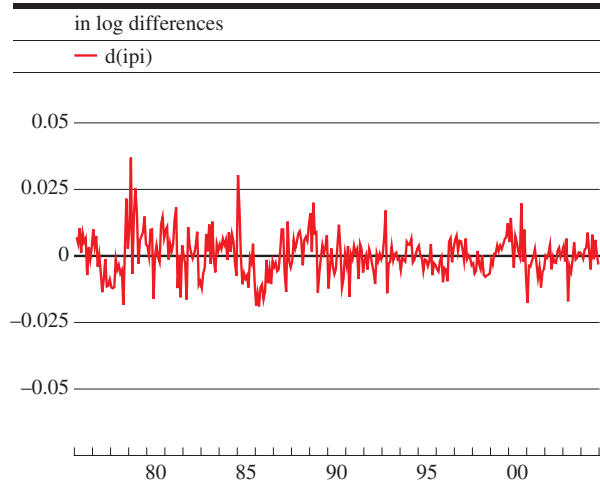
— gap

Graph 13d: Money

in log differences

— d(m)
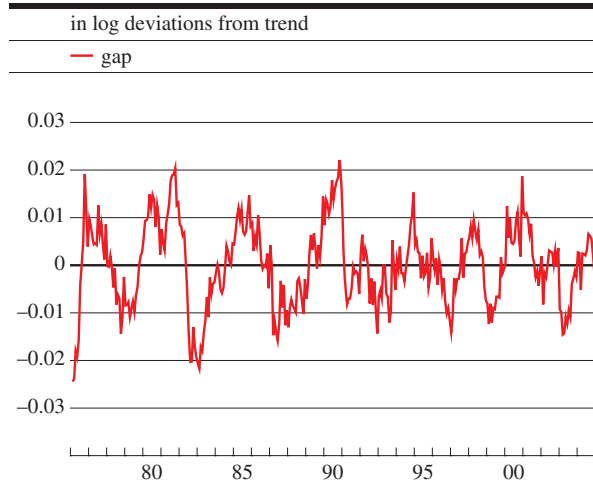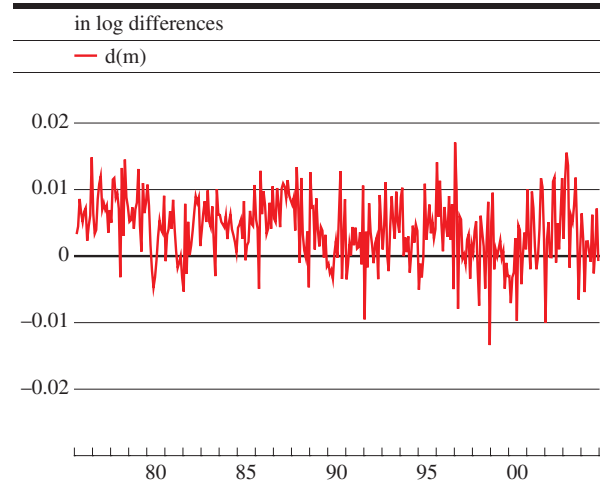
Graph 13e: Consumer prices

in log differences

— d(cpi)
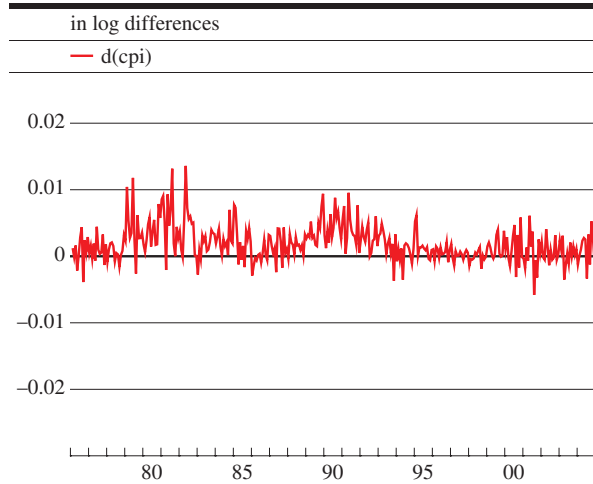
Graph 13f: Foreign consumer prices

in log differences

— d(cpiw)
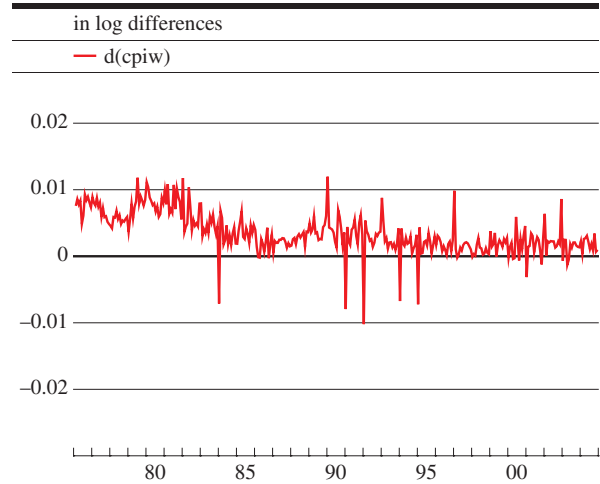
B   Results appendix

B.1   Models including total consumer prices

Table 1: Exchange rate pass-through to import prices

	Whole sample 1976.01–2004.12	High inflation period 1976.01–1993.04	Low inflation period 1993.05–2004.12
1	0.16	0.18	0.09
3	0.35	0.32	0.20
6	0.44	0.41	0.32
9	0.47	0.44	0.37
12	0.52	0.46	0.46
24	0.37	0.36	0.17

reported estimates are accumulated impulse responses

Table 2: Pass-through of import prices to consumer prices

	Whole sample 1976.01–2004.12	High inflation period 1976.01–1993.04	Low inflation period 1993.05–2004.12
1	0.16	0.14	0.21
3	0.29	0.30	0.24
6	0.35	0.42	0.25
9	0.43	0.54	0.28
12	0.47	0.63	0.31
24	0.45	0.69	0.13

reported estimates are accumulated impulse responses

Table 3: Exchange rate pass-through to consumer prices

	Whole sample 1976.01–2004.12	High inflation period 1976.01–1993.04	Low inflation period 1993.05–2004.12
1	0.03	0.03	0.00
3	0.09	0.07	0.03
6	0.14	0.12	0.03
9	0.15	0.12	0.03
12	0.17	0.13	0.05
24	0.18	0.13	0.02

reported estimates are accumulated impulse responses

B.2 Models including consumer prices for imported goods

Table 4: Pass-through of import prices to consumer prices for imported goods

	Whole sample 1976.01–2004.12	High inflation period 1976.01–1993.04	Low inflation period 1993.05–2004.12
1	0.54	0.54	0.54
3	0.99	1.09	0.78
6	0.96	1.08	0.84
9	0.98	1.11	0.87
12	1.01	1.21	0.87
24	1.02	1.26	0.53

reported estimates are accumulated impulse responses

Table 5: Exchange rate pass-through to consumer prices for imported goods

	Whole sample 1976.01–2004.12	High inflation period 1976.01–1993.04	Low inflation period 1993.05–2004.12
1	0.08	0.10	0.04
3	0.27	0.29	0.12
6	0.36	0.41	0.03
9	0.34	0.35	0.07
12	0.33	0.33	0.03
24	0.34	0.35	0.02

reported estimates are accumulated impulse responses

References

Amstad, Marlene and Andreas M. Fischer. 2005. Time varying pass-through from import prices to consumer prices: evidence from an event study with real-time data. Federal Reserve Bank of New York Staff Reports 228.

Andrews, Donald W. K. 1993. Tests for parameter instability and structural change with unknown change point. *Econometrica* 61(4): 821-856.

Bailliu, Jeannine and Eiji Fujii. 2004. Exchange rate pass-through and the inflation environment in industrialized countries: an empirical investigation. Bank of Canada Working Paper 21.

Bank of Canada. 2000. *Monetary Policy Report*. November. Ottawa.

Betts, Caroline and Michael B. Devereux. 1996. The exchange rate in a model of pricing-to-market. *European Economic Review* 40(3-5): 1007-1021.

Betts, Caroline and Michael B. Devereux. 2000. Exchange rate dynamics in a model of pricing-to-market. *Journal of International Economics* 50(1): 215-244.

BFS. 1993. Der neue Landesindex der Konsumentenpreise: Mai 1993 = 100: Methodenübersicht. Neuchâtel: Bundesamt für Statistik.

Campa, José M. and Linda S. Goldberg. 2005. Exchange rate pass-through into import prices. *Review of Economics and Statistics* 87(4): 679-690.

Cavaliere, Marco. 2007. How does exchange rate pass-through differ across countries and across price indices? Evidence from the industrialized countries. In *Exchange rate pass-through to prices: characteristics and implications*. Dissertation, Universität Bern and Studienzentrum Gerzensee.

Chen, Natalie, Jean Imbs, and Andrew Scott. 2004. Competition, globalization and the decline of inflation. Centre for Economic Policy Research Discussion Paper 4695.

Choudhri, Ehsan U., Hamid Faruqee, and Dalia S. Hakura. 2005. Explaining the exchange rate pass-through in different prices. *Journal of International Economics* 65(2): 349-374.

Chow, Gregory C. and An-loh Lin. 1971. Best linear unbiased interpolation, distribution, and extrapolation of time series by related series. *Review of Economics and Statistics* 53(4): 372-375.

Corsetti, Giancarlo and Luca Dedola. 2005. A macroeconomic model of international price discrimination. *Journal of International Economics* 67(1): 129-155.

Cuche, Nicolas A. and Martin K. Hess. 2000. Estimating monthly GDP in a general Kalman filter framework: evidence from Switzerland. *Economic and Financial Modelling* 7(4): 153-194.

Devereux, Michael B. and Charles Engel. 2003. Monetary policy in the open economy revisited: price setting and exchange-rate flexibility. *Review of Economic Studies* 70(4): 765-783.

Enders, Walter. 2004. *Applied econometric time series*. Second edition, New York: John Wiley & Sons.

Fluri, Robert and Robert Müller. 2001. Revision der Wechselkursindizes. Schweizerische Nationalbank *Quartalsheft 3*: 42-47.

Gagnon, Joseph E. and Jane Ihrig. 2004. Monetary policy and exchange rate pass-through. Board of Governors of the Federal Reserve System International Finance Discussion Papers 704 (revised version).

Goldberg, Pinelopi K. and Michael M. Knetter. 1997. Goods prices and exchange rates: what have we learned? *Journal of Economic Literature* 35(3): 1243-1272.

Greene, William H. 2003. *Econometric analysis*. Fifth edition, New Jersey: Prentice-Hall.

Hahn, Elke. 2003. Pass-through of external shocks to Euro area inflation. European Central Bank Working Paper 243.

Kim, Soyoung and Nouriel Roubini. 2000. Exchange rate anomalies in the industrial countries: a solution with a structural VAR approach. *Journal of Monetary Economics* 45(3): 561-586.

Krugman, Paul. 1987. Pricing to market when the exchange rate changes. *In Real-financial linkages among open economies*, eds. S. W. Arndt, and J. D. Richardson, 49-70. Cambridge: MIT Press.

Kugler, Peter and Sylvia Kaufmann. 2005. Does money matter for inflation in the Euro area? Oesterreichische Nationalbank Working Paper 103.

McCarthy, Jonathan. 2000. Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies. Federal Reserve Bank of New York Staff Reports 111.

Menon, Jayant. 1995. Exchange Rate Pass-Through. *Journal of Economic Surveys* 9(2): 197-231.

McCallum, Bennett T. and Edward Nelson. 1999. Nominal income targeting in an open-economy optimizing model. *Journal of Monetary Economics* 43(3): 553-578.

Mihailov, Alexander. 2005. Exchange rate pass-through on prices in US, German and Japanese macrodata. University of Essex.

Obstfeld, Maurice and Kenneth Rogoff. 1995. Exchange rate dynamics redux. *Journal of Political Economy* 103(3): 624-660.

Peersman, Gert and Frank Smets. 2001. The monetary transmission mechanism in the Euro area: more evidence from VAR analysis. European Central Bank Working Paper 91.

Scheffé, Henry. 1970. Practical solutions of the Behrens-Fisher problem. *Journal of the American Statistical Association* 65(332): 1501-1508.

Taylor, John B. 2000. Low inflation, pass-through, and the pricing power of firms. *European Economic Review* 44(7): 1389-1408.

Woo, Wing T. 1984. Exchange rates and the prices of nonfood, nonfuel products. *Brookings Papers on Economic Activity 2*: 511-536.