Exchange Rates and External Imbalances

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Abstract

This paper uses measures of external imbalances to forecast exchange rates, building on Gourinchas and Rey (2007), with three main contributions. First, we propose a linear approximation of the intertemporal budget constraint for net creditor countries which does not require the specification of trend shares for assets, liabilities, exports and imports. This avoids a potential source of measurement error and can make the approximation more accurate. Second, we use a measure of bilateral external imbalances, based on data on the currency denomination of assets and liabilities, to forecast bilateral exchange rates. Third, we take seriously the possibility that the relationship between exchange rates and external imbalances may be changing over time, using recently developed econometric techniques to efficiently account for time variation. We apply our methodology to Switzerland, a country with positive and large net foreign assets in the post-Bretton Woods period. Our measures of external imbalances have predictive power for Swiss franc nominal effective and bilateral exchange rates, both in-sample and out-of-sample.

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1 Introduction

This paper studies the predictive power of external imbalances for exchange rates. The recent literature[1] has emphasized that external adjustment can occur through both trade flows and valuation effects. For example, net creditor countries can satisfy their intertemporal budget constraint through some combination of future trade deficits and negative returns on their external portfolio. Because exchange rate movements are one component of portfolio returns, and because exchange rates affect trade flows, external imbalances should have predictive power for future exchange rate movements. In an important paper, Gourinchas and Rey (2007; henceforth GR) use a linear approximation of the intertemporal budget constraint to study the adjustment of US external imbalances. They derive a measure of cyclical external imbalances – a linear combination of deviations from trends in assets, liabilities, exports and imports – and show that this measure has predictive power for nominal effective US dollar exchange rate returns between one quarter and 4 years ahead.

This paper builds on GR's seminal paper and extends their analysis in three ways. First, we propose an alternative linear approximation to the intertemporal budget constraint, similar to the approximation of the domestic budget constraint suggested by Whelan (2008), that is valid for countries which have been net creditors (or net debtors) throughout the sample. This alternative approximation offers two key advantages. First, it does not require the specification of trend shares for assets, liabilities, exports and imports, which can be a source of measurement error. Second, the method can be applied to countries whose in-sample evolution of net foreign assets and net exports looks unsustainable. In the original GR approximation with constant trend shares, in-sample trends are used to specify the constant trend shares. For countries that are simultaneously net creditors and net exporters on average in the sample (or conversely, net debtors and net importers), extrapolating in-sample trends in this way leads to the conclusion that the intertemporal budget constraint is not satisfied. In contrast, our approach does not require the specification of trend shares and can therefore be applied to net creditor, net exporter countries with the usual assumption that the no-Ponzi condition is satisfied asymptotically.

In our empirical application we focus on Switzerland, a country with a strong growth in net foreign assets since 1970 and net exports which are positive for most of the post-Bretton Woods period. With net foreign assets of currently around 140 percent of GDP, the assumption underlying our approximation that net foreign assets are positive in-sample as well as for a sufficiently long out-of-sample period is reasonable. Our suggested measure of the Swiss external position is highly correlated with the original measure proposed by GR. However, the in-sample approximation error for the accumulation identity of the Swiss external position is less volatile for our measure than for the GR approximation. We find that both measures have strong predictive power for the Swiss franc nominal effective exchange rate, with the proposed new approximation explaining a larger share of the variation in Swiss franc returns. Our proposed approximation comfortably beats the random walk in forecasting Swiss franc returns out-of-

[1] See for example Lane and Milesi-Ferretti (2001, 2007), Lane and Shambaugh (2010), Gourinchas and Rey (2007), Gourinchas, Rey and Truempler (2012) and Evans (2012).

sample, and for the later part of the sample also shows a statistically significant improvement upon a random walk with drift.

Our second contribution is to propose a new measure of bilateral external imbalances, and to use it to forecast bilateral exchange rates. There is no theoretical link between external imbalances and bilateral exchange rates, because the intertemporal budget constraint holds only versus the rest of the world. Nevertheless, Gourinchas and Rey (2005) report that their measure of external imbalances also has predictive power for US dollar bilateral exchange rates. This is not surprising, especially for countries where the majority of trade and financial flows involves only a few currency pairs. Della Corte, Sarno and Sestieri (2012) develop a measure of bilateral US external imbalances, based on an instrumental variables approach, and use it to forecast bilateral US dollar exchange rates. In contrast to their paper we provide a direct measure of Swiss external imbalances versus the US, using data on the currency composition of Swiss assets and liabilities as well as data on bilateral trade flows. We show that this measure has predictive power for Swiss franc exchange rates versus the US dollar.

The third contribution of this paper is use recently developed econometric techniques to test for gradual time variation in the relationship between external imbalances and exchange rate returns. There is no reason why this relationship should be stable. In particular, as the currency denomination of external assets and liabilities changes the sensitivity of returns on the external portfolio to exchange rate movements will change also. Additionally, the elasticity of trade flows to exchange rates could change over time as well. We use the quasi-local-level test introduced by Elliott and Müller (2006) and Müller and Petalas (2010) to test for time variation in the link between external imbalances and subsequent exchange rate returns. This test has the advantage that it is efficient independent of the precise nature of the process for time variation. In particular, it is designed to detect gradual changes in coefficients. Perhaps surprisingly, we cannot reject the null hypothesis of parameter stability at conventional levels of significance.

The next section begins by reviewing the methodology introduced by GR. The objective is to highlight which assumptions can be problematic, in particular for countries such as Switzerland which have been net exporters and net creditors throughout most of the sample, and discusses how these assumptions can be relaxed. Then an alternative approximation is proposed. Section 3.1 compares alternative measures of external imbalances for Switzerland, and discusses their approximation accuracy. Section 3.2 then presents forecasts for exchange rates in- and out-of-sample. Section 3.3 reports estimates of bilateral external positions and studies their predictive power for bilateral exchange rates. Section 3.4 explores whether time variation is present in the relationship between Swiss franc exchange rates and Swiss external imbalances. Section 4 explores the robustness of our results for alternative approximations of Swiss external imbalances. Finally, section 5 concludes.

2 Empirical framework

2.1 The intertemporal budget constraint

Countries face an asset accumulation identity of the form

$$NFA_{t+1} = R_{t+1} \left(NFA_t + NX_t \right) \tag{1}$$

where NFA_t denotes net foreign assets, NX_t denotes net exports and R_t is the ex-post gross portfolio return. In (1) we follow the timing convention of GR, with assets and liabilities measured at the beginning of the period. For comparability with the setup in typical macroeconomic models it is common to divide by wealth W_t,

$$nfa_{t+1} = \frac{R_{t+1}}{\Gamma_{t+1}} \left(nfa_t + nx_t \right) \tag{2}$$

where $\Gamma_{t+1} \equiv W_{t+1}/W_t$ and small letters denote variables divided by wealth. Solving (2) forward and assuming that the no-Ponzi condition holds produces the intertemporal budget constraint,

$$nfa_t = -\sum_{j=0}^{\infty} R_{t,t+j} nx_{t+j} \tag{3}$$

where $R_{t,t+j} \equiv \left(\Gamma_{t+1} \times \Gamma_{t+2} \times ... \times \Gamma_{t+j} \right) / \left(R_{t+1} \times R_{t+2} \times ... \times R_{t+j} \right)$ with $R_{t,t} \equiv 1$. Since (3) holds ex-post and ex-ante it will also hold under rational expectations, taken conditional on information available in period t:

$$nfa_t = -\mathbb{E}_t \left(\sum_{j=0}^{\infty} R_{t,t+j} nx_{t+j} \right) \tag{4}$$

The implication of (4) is that positive net foreign assets should predict either trade deficits or negative portfolio returns, or both. Moreover, because exchange rate changes are one determinant of the portfolio return, net foreign assets should also predict movements in exchange rates.

The problem with using equation (4) as a starting point for the empirical analysis is that the relationship between net foreign assets, net exports and portfolio returns is non-linear. This is the case because $R_{t,t+j}$ is the product of individual one-period growth-adjusted portfolio returns, each of which depends on portfolio weights, returns on individual types of assets and liabilities, and exchange rate changes. The contribution of GR was to suggest a linear approximation of (4), following Campbell and Shiller (1988), Campbell and Mankiw (1989) and Lettau and Ludvigson (2001). The next subsection reviews the approach introduced by GR and discusses alternative ways of implementing it.

2.2 Linear approximations to the intertemporal budget constraint

A linear approximation of the accumulation identity. To log-linearize, GR first disaggregate net foreign assets and net exports in equation (2) to work only with variables which are positive by definition:

$$\Gamma_{t+1}\left(\hat{A}_{t+1}-\hat{L}_{t+1}\right)=R_{t+1}\left(\hat{A}_{t}-\hat{L}_{t}+\hat{X}_{t}-\hat{M}_{t}\right) \tag{5}$$

where $\hat{A}_t - \hat{L}_t = nfa_t$, $\hat{X}_t - \hat{M}_t = nx_t$ and $\hat{Z}_t \equiv Z_t/W_t$ for $Z_t \in \{A_t, L_t, X_t, M_t\}$. For US data GR note that the ratios of assets, liabilities, exports and imports to wealth are trending over time. They argue that these trends are for the most part unrelated to the cyclical adjustment of exchange rates, and therefore focus on the implications of trend deviations for external adjustment. Let $\overline{Z}_t$ denote the trend of $\hat{Z}_t$ for $Z_t \in \{Z_t, L_t, X_t, M_t\}$, with $\overline{R}_t$ and $\overline{\Gamma}_t$ denoting the trends of R_t and Γ_t, and define trend deviations as

$$\begin{aligned}\epsilon_t^z &\equiv \ln \hat{Z}_t - \ln \overline{Z}_t\\ \epsilon_{t+1}^{\Delta w} &\equiv \ln \Gamma_{t+1} - \ln \overline{\Gamma}_{t+1}\\ \hat{r}_{t+1} &\equiv \ln R_{t+1} - \ln \overline{R}_{t+1}\end{aligned}$$

The following assumption allows GR to log-linearize (5) around the trends.

Assumption 1 *The trend deviations* $\epsilon_t^z, \hat{r}_t$ *and* $\epsilon_t^{\Delta w}$ *are stationary and small:* $|\epsilon_t^z|$, $|\hat{r}_t|$ *and* $\left|\epsilon_t^{\Delta w}\right| \ll 1$ *for* $z \in \{a, l, x, m\}$.

With this assumption a first-order Taylor series expansion of (5) around the point where $\epsilon_t^a = \epsilon_t^l = \epsilon_t^x = \epsilon_t^m = 0$ gives

$$\begin{aligned}&\ln\left(\overline{\Gamma}_{t+1}\right)+\epsilon_{t+1}^{\Delta w}+\ln\left(\overline{A}_{t+1}-\overline{L}_{t+1}\right)+na_{t+1}\\ \approx\ &\ln\left(\overline{R}_{t+1}\right)+\hat{r}_{t+1}+\ln\left(\overline{A}_t-\overline{L}_t+\overline{X}_t-\overline{M}_t\right)+\frac{1}{\rho_t}na_t+\left(1-\frac{1}{\rho_t}\right)nx_t\end{aligned} \tag{6}$$

where

$$na_t \equiv \mu_t^a \epsilon_t^a - \mu_t^l \epsilon_t^l \tag{7}$$

$$nx_t \equiv \mu_t^x \epsilon_t^x - \mu_t^m \epsilon_t^m \tag{8}$$

$$\rho_t \equiv 1 + \frac{\overline{X}_t - \overline{M}_t}{\overline{A}_t - \overline{L}_t} \tag{9}$$

and

$$\mu_t^a \equiv \frac{\overline{A}_t}{\overline{A}_t - \overline{L}_t},\ \ \mu_t^x \equiv \frac{\overline{X}_t}{\overline{X}_t - \overline{M}_t},\ \ \mu_t^l \equiv \mu_t^a - 1,\ \ \mu_t^m \equiv \mu_t^x - 1$$

With the next assumption the trend terms in (6) drop out.

Assumption 2 *The trends satisfy the accumulation identity:*

$$\overline{\Gamma}_{t+1}\left(\overline{A}_{t+1}-\overline{L}_{t+1}\right)=\overline{R}_{t+1}\left(\overline{A}_{t}-\overline{L}_{t}+\overline{X}_{t}-\overline{M}_{t}\right) \tag{10}$$

After using assumption 2 and rearranging (6) simplifies to

$$\left(na_{t+1}-nx_{t+1}\right)\approx\hat{r}_{t+1}+\frac{1}{\rho_{t}}\left(na_{t}-nx_{t}\right)-\left(nx_{t+1}-nx_{t}+\epsilon_{t+1}^{\Delta w}\right) \tag{11}$$

Now we would like to solve (11) forward to obtain a linear approximation of the intertemporal budget constraint (3). This requires that $\rho_t<1$, at least in the limit as $t\rightarrow\infty$. From (9) this is the case if, as $t\rightarrow\infty$, the trend shares μ_t^a and μ_t^x have opposite signs: in the long run net creditor countries run trade deficits, while conversely net debtor countries run trade surpluses.

Time varying trend shares. Define

$$\begin{aligned} nxa_{t} &\equiv na_{t}-nx_{t} &(12)\\ \Delta nx_{t+1} &\equiv nx_{t+1}-nx_{t}+\epsilon_{t+1}^{\Delta w} &(13)\end{aligned}$$

Then we can write (11) as

$$nxa_{t+1}\approx\hat{r}_{t+1}+\frac{1}{\rho_{t}}nxa_{t}-\Delta nx_{t+1} \tag{14}$$

Assumption 3 *nxa_t satisfies the no-Ponzi condition* $\lim_{j\rightarrow\infty}\rho_{t+j}nxa_{t+j+1}=0$ *with probability one.*

With this assumption we can solve (14) forward to obtain

$$nxa_{t}\approx\sum_{j=1}^{\infty}\hat{\rho}_{t+j-1}\left(\Delta nx_{t+j}-\hat{r}_{t+j}\right) \tag{15}$$

where $\hat{\rho}_{t+j}\equiv\rho_{t}\times\rho_{t+1}\times...\times\rho_{t+j}$. In equation (15) nxa_t and Δnx_t are computed using time-varying trend shares $\mu_t^a,\mu_t^l,\mu_t^x,\mu_t^m$. In practice these weights may be imprecisely measured. In particular, the trend shares will exhibit extreme non-linear movements around points in the sample where $\overline{A}_t\approx\overline{L}_t$ and $\overline{X}_t\approx\overline{M}_t$. In the empirical implementation this problem could be dealt with by replacing the trend shares by their (time-varying) long term trends, obtained from HP-filtering $\mu_t^a,\mu_t^l,\mu_t^x,\mu_t^m$. Thus, to compute (for example) μ_t^a one would first filter $\hat{A}_t$ and $\hat{L}_t$ to obtain their trends $\overline{A}_t$ and $\overline{L}_t$, and then filter $\overline{A}_t/\left(\overline{A}_t-\overline{L}_t\right)$ to obtain a smoothed path for μ_t^a.

Constant trend shares. GR simplify by assuming that $\hat{A}_t,\hat{L}_t,\hat{X}_t,\hat{M}_t$ share a common trend, which allows them to work with constant trend shares.

Assumption 4 *The trend components $\overline{Z}_t$ for $Z_t\in\{A_t,L_t,X_t,M_t\}$ admit a common, possibly time-varying growth rate: $\overline{Z}_t=\overline{Z}\mu_t$.*

With this assumption the trend shares are constant:

$$\mu_t^a = \frac{\overline{A}}{\overline{A}-\overline{L}} \equiv \mu^a \tag{16}$$

$$\mu_t^x = \frac{\overline{X}}{\overline{X}-\overline{M}} \equiv \mu^x \tag{17}$$

$$\rho_t = 1+\frac{\overline{X}-\overline{M}}{\overline{A}-\overline{L}} \equiv \rho \tag{18}$$

To solve the accumulation identity forward we require that $\rho < 1$. From (18) and (2) we see that this is the case if

$$\rho = \frac{\overline{\Gamma}_{t+1}}{\overline{R}_{t+1}}\frac{\mu_{t+1}}{\mu_t} < 1$$

This is ensured (asymptotically) by the following assumption.

Assumption 5 *The deterministic economy eventually settles into a balanced growth path:*

a. Asymptotically, $\lim_{t\to\infty}\mu_t = 1$.

b. The trend return $\overline{R}_{t+1}$ *and growth rate* $\overline{\Gamma}_{t+1}$ *converge to* R *and* Γ *such that* $R > \Gamma$.

If $\rho < 1$ then μ^a and μ^x have opposite signs, and (11) simplifies to

$$nxa_{t+1} \approx \frac{1}{\rho} nxa_t + r_{t+1} + \Delta nx_{t+1} \tag{19}$$

where

$$nxa_t \equiv |\mu^a|\epsilon_t^a - |\mu^l|\epsilon_t^l + |\mu^x|\epsilon_t^x - |\mu^m|\epsilon_t^m \tag{20}$$

$$\Delta nx_{t+1} \equiv |\mu^x|\Delta\epsilon_{t+1}^x - |\mu^m|\Delta\epsilon_{t+1}^m - \epsilon_{t+1}^{\Delta w} \tag{21}$$

$$r_{t+1} \equiv \frac{\mu_t^a}{|\mu_t^a|}\hat{r}_{t+1} \tag{22}$$

Under assumption 3 we can then solve forward to obtain an approximation of the intertemporal budget constraint,

$$nxa_t \approx -\sum_{j=1}^{\infty}\rho^j\left(r_{t+j} + \Delta nx_{t+j}\right) \tag{23}$$

The use of constant trend shares mitigates the problem of measurement error, which could magnify the volatility of the trend shares.[2] In their empirical application GR therefore calculate

[2] The variable nxa_t in equation (20) can equivalently be expressed as

$$nxa_t = |\mu^m|\epsilon_t^{xm} + |\mu^l|\epsilon_t^{al} + \epsilon_t^{xa}$$

where ϵ_t^{xm}, ϵ_t^{al} and ϵ_t^{xa} are the trend deviations of the stationary ratios $\hat{X}_t/\hat{M}_t$, $\hat{A}_t/\hat{L}_t$ and $\hat{X}_t/\hat{A}_t$. Gourinchas and Rey (2005) and Cardarelli and Konstantinou (2007) construct nxa_t from this alternative formulation, using cointegration methods to estimate ϵ_t^{xm}, ϵ_t^{al} and ϵ_t^{xa}. See also Corsetti and Konstantinou (2012) for a related approach.

$\overline{Z}$ in (16)-(18) as the in-sample average of $\overline{Z}_t$, which is valid if assumption 4 holds in-sample.[3] In particular, this approach makes sense for US data where assets, liabilities, exports and imports do exhibit similar trends. For many countries, however, the assumption of a common in-sample trend in $\hat{A}_t, \hat{L}_t, \hat{X}_t, \hat{M}_t$ may not be a good description of the data. Often a more reasonable assumption may be that assets and liabilities exhibit a common trend, and that similarly exports and imports share a common trend. In this case one can follow Evans (2012) and rewrite the accumulation identity (5) as

$$\Gamma_{t+1}\left(\hat{A}_{t+1}-\hat{L}_{t+1}\right)=R_{t+1}\left(\hat{A}_t-\hat{L}_t+\hat{X}_t^*-\hat{M}_t^*\right) \tag{24}$$

where $\hat{X}_t^* \equiv \hat{X}_t+\tau_t$ and $\hat{M}_t^* \equiv \hat{M}_t+\tau_t$, and τ_t is chosen such that $\hat{X}_t^*, \hat{M}_t^*$ and $\hat{A}_t, \hat{L}_t$ exhibit a common trend. While τ_t cancels out in (24), this is not the case in its first-order approximation. On the one hand the introduction of τ_t adds some additional noise to the approximation; on the other hand, it may make the assumption of a common trend more reasonable.

A more serious problem is that the constant trend shares μ^a and μ^x identified in this way may have the same signs, so that $\rho > 1$. For example, countries such as Switzerland and Germany have been net exporters over the last decades, and as a result have built up large positive net foreign assets. For such countries, if in-sample trends are extrapolated the data would imply that the intertemporal budget constraint is not justified.

Predictive regressions without specification of the trend shares. The GR methodology can be used for forecasting without specifying the trend shares μ_t^x and μ_t^a. To do this, the trend deviations can be included as separate regressors in predictive regressions based on (15). Alternatively, note from (12) that nxa_t can be written as

$$nxa_t=\mu_t^a\left(\epsilon_t^a-\epsilon_t^l\right)-\mu_t^x\left(\epsilon_t^x-\epsilon_t^m\right)+\left(\epsilon_t^l-\epsilon_t^m\right)$$

where we used the fact that $\mu_t^l=\mu_t^a-1$ and $\mu_t^m=\mu_t^x-1$. Thus one could run predictive regressions using $\epsilon_t^a-\epsilon_t^l$, $\epsilon_t^x-\epsilon_t^m$ and $\epsilon_t^l-\epsilon_t^m$ as regressors. The advantage of this approach is that potential measurement error in the estimation of the trend shares is avoided. The disadvantages are that this approach does not use all available information, which makes it more difficult to identify a statistically significant relationship between the trend deviations and the variables on the right-hand side of (15). Also, without specification of μ_t^x and μ_t^a the approximation accuracy for the linearized accumulation identity can not be checked.

[3] Consider, for example, the calculation of μ^a. Under assumption 4 we have $\overline{A}_t=\overline{A}\mu_t$ and $\overline{L}_t=\overline{L}\mu_t$. Then $E\left(\overline{A}_t\right)=\overline{A}E\left(\mu_t\right)$ and $E\left(\overline{L}_t\right)=\overline{L}E\left(\mu_t\right)$, and hence

$$\mu^a=\frac{\overline{A}_t}{\overline{A}_t-\overline{L}_t}=\frac{E\left(\overline{A}_t\right)}{E\left(\overline{A}_t\right)-E\left(\overline{L}_t\right)}$$

2.3 An alternative approach for net creditor countries

This section introduces a linear approximation to the accumulation identity (2) which is valid for net creditor countries. The approximation is similar to that proposed in Whelan (2008) for consumers' budget constraints, but as in GR we log-linearize around the trends of net foreign assets and net exports.

Assumption 6 *Net foreign assets nfa_t are positive throughout the sample.*

Begin by defining net imports as $ni_t \equiv -nx_t$ and write (2) as

$$\Gamma_{t+1} nfa_{t+1} = R_{t+1} \left(nfa_t - ni_t \right) \tag{25}$$

Now the trick is to rewrite (25) as

$$\Gamma_{t+1} nfa_{t+1} = R_{t+1} \left(nfa_t^* - ni_t^* \right) \tag{26}$$

where

$$\begin{aligned} nfa_t^* &\equiv nfa_t + \tau_t \\ ni_t^* &\equiv ni_t + \tau_t \end{aligned}$$

and $\tau_t > 0$ is an adjustment factor which is sufficiently large to ensure that $ni_t^* > 0$ for all t. Clearly the accumulation identity is unaffected by the introduction of τ_t.

Following GR we allow for the possibility that the variables exhibit trends. Taking logs equation (26) then becomes

$$\ln \left(\overline{\Gamma}_{t+1} \right) + \epsilon_{t+1}^{\Delta w} + \ln \left(\overline{nfa}_{t+1} \right) + \epsilon_{t+1}^{nfa} = \ln \left(\overline{R}_{t+1} \right) + \hat{r}_{t+1} + \ln \left(nfa_t^* - ni_t^* \right) \tag{27}$$

Using assumption 1 we can take a first-order Taylor series expansion of the last term on the right-hand side around the point where $\varepsilon_t^{nfa*} = \varepsilon_t^{ni*} = 0$:

$$\ln \left(nfa_t^* - ni_t^* \right) \approx \ln \left(\overline{nfa}_t^* - \overline{ni}_t^* \right) + \frac{1}{\rho_t} \epsilon_t^{nfa*} + \left(1 - \frac{1}{\rho_t} \right) \epsilon_t^{ni*}$$

where

$$\rho_t \equiv 1 - \frac{\overline{ni}_t^*}{\overline{nfa}_t^*} \tag{28}$$

Substituting back into (27) we get

$$\ln \left(\overline{\Gamma}_{t+1} \right) + \epsilon_{t+1}^{\Delta w} + \ln \left(\overline{nfa}_{t+1} \right) + \epsilon_{t+1}^{nfa} \approx \ln \left(\overline{R}_{t+1} \right) + \hat{r}_{t+1} + \ln \left(\overline{nfa}_t^* - \overline{ni}_t^* \right) + \frac{1}{\rho_t} \epsilon_t^{nfa*} + \left(1 - \frac{1}{\rho_t} \right) \epsilon_t^{ni*} \tag{29}$$

Using assumption 2 applied to equation (26), the trends drop out and (29) simplifies to

$$\epsilon_{t+1}^{\Delta w} + \epsilon_{t+1}^{nfa} \approx \hat{r}_{t+1} + \frac{1}{\rho_t} \left(\epsilon_t^{nfa*} - \epsilon_t^{ni*} \right) + \epsilon_t^{ni*}$$

Subtracting ϵ_{t+1}^{ni*} and adding ϵ_{t+1}^{nfa*} on both sides and rearranging gives

$$nxa_{t+1}^{*} \approx \hat{r}_{t+1} + \frac{1}{\rho_t} nxa_t^{*} + \Delta nx_{t+1}^{*} + \varepsilon_{t+1}^{*} \tag{30}$$

where

$$nxa_t^{*} \equiv \epsilon_t^{nfa*} - \epsilon_t^{ni*} \tag{31}$$

$$\Delta nx_{t+1}^{*} \equiv -\left(\epsilon_{t+1}^{ni*} - \epsilon_t^{ni*} + \epsilon_{t+1}^{\Delta w}\right) \tag{32}$$

$$\varepsilon_t^{*} \equiv \epsilon_t^{nfa*} - \epsilon_t^{nfa} \tag{33}$$

Here we have used stars to emphasize the difference to the variables introduced by GR in (20) and (21). Note that nxa_t and nxa_t^{*} are both increasing in shocks which increase exports and assets relative to their trends, and decreasing in shocks that increase imports and liabilities above their trends.

Since $\rho_t < 1$ we can solve forward, imposing assumption 3, to obtain an approximation of the intertemporal budget constraint (3),

$$nxa_t^{*} \approx -\sum_{j=1}^{\infty} \hat{\rho}_{t+j} \left(\Delta nx_{t+1+j}^{*} + \hat{r}_{t+1+j} + \varepsilon_{t+j+1}^{*}\right) \tag{34}$$

which has a similar form as (23).

There are alternative ways to implement approximation (34) in practice. First, one could set τ_t equal to a constant that is sufficiently large to ensure that ni_t^{*} is always positive. Second, one could choose $\tau_t = \theta nfa_t$, where $\theta > 0$ would again be a positive and sufficiently large constant.[4] This second approach is similar to the approximation suggested by Whelan (2008) for the domestic budget constraint. In this paper we mainly focus on the first approach, for two reasons. First, with τ_t equal to a constant the implications of the choice of τ for the out-of-sample validity of the approximation are straightforward. In contrast, the required value of θ to ensure that $ni_t^{*} > 0$ for a reasonably long out-of-sample period depends on the projected path for net foreign assets. Second, while both approximations have strong predictability for exchange

[4] In the empirical implementation of (20) and (31) we follow GR and detrend the log of the variables. For example, we calculate $\overline{nfa}_t$ not as the trend of nfa_t but as the exponential of the trend of the log of nfa_t. With this specification it is not difficult to see that setting $\tau_t = \theta nfa_t$ implies $\epsilon_t^{nfa*} = \epsilon_t^{nfa}$ and hence $\varepsilon_t^{*} = 0$ for all t. The trend of nfa_t^{*} is estimated as

$$\begin{aligned} \overline{nfa}_t^{*} &= \exp\left[\overline{\ln(nfa_t^{*})}\right] \\ &= \exp\left[\overline{\ln(1+\theta) + \ln(nfa_t)}\right] \\ &= \exp\left[\ln(1+\theta) + \overline{\ln(nfa_t)}\right] \end{aligned}$$

Therefore

$$\begin{aligned} \epsilon_t^{nfa*} &\equiv \ln(nfa_t^{*}) - \ln\left(\overline{nfa}_t^{*}\right) \\ &= \ln(nfa_t) - \overline{\ln(nfa_t)} \equiv \epsilon_t^{nfa} \end{aligned}$$

rate returns in-sample, the out-of-sample performance of nxa^* with a constant adjustment factor is more robust. We relegate results for nfa^* adjusted with $\tau_t = \theta nfa_t$ to the robustness checks in section 4.

To what extent does (34) represent a good approximation of the non-linear intertemporal budget constraint? In-sample the approximation accuracy of (30) can be checked directly. However, the derivation only makes sense if assumption 6 remains satisfied out-of-sample (or in practice, for a sufficiently long out-of-sample period). This is likely to be the case for countries which have sufficiently large net foreign assets at the end of the sample period. Also, if nxa_t^* is found to forecast Δnx_{t+1+j}^* and/or $\hat{r}_{t+1+j}$ this can be interpreted as indirect evidence that approximation (34) is valid. Finally, note that that (34) can be applied to countries which are both net creditors and net exporters throughout the sample (or vice versa, simultaneously net debtors and net importers).

3 Empirical results

3.1 Measuring Swiss external imbalances

In this section we compare alternative measures of Swiss external imbalances for the post-Bretton Woods period.[5] Figure 1 shows that Switzerland has been running persistent trade surpluses for most of the sample period, and has built up a large stock of net foreign assets as a result.[6] From the perspective of the present value relation (3) Switzerland will eventually begin to run trade deficits, or will have to incur losses on its foreign portfolio to satisfy its intertemporal budget constraint. Figure 1 also shows that the ratios of Swiss external assets, external liabilities, exports and imports, as well as net foreign assets and net exports to GDP have been trending upwards over time. GR argue that such long-term trends reflect structural changes in the economy, such as declining transport and transaction costs, which are unrelated to (cyclical) external adjustment. We therefore follow GR and focus on the implications of deviations in the trends of external imbalances for exchange rate movements. Of course, to the extent that the observed trends themselves are inconsistent with the intertemporal budget constraint they would have additional implications for exchange rates. However it is difficult to quantify these additional effects because they would not reflect empirical patterns already observed in the sample.

In the following we denote by nxa the GR measure of cyclical imbalances computed using constant trend shares in equation (20).[7] Recall from section 2.2 that the approximation of the accumulation identity using nxa_t in (19) is only valid if μ^a and μ^x have opposite signs.

[5] See the appendix for details on data sources. In contrast to GR we use nominal GDP, rather than household wealth, as a deflator in equation (2). For Switzerland GDP data is available for a longer period, and is of better quality than data on household net worth. However, our results are robust to using household net worth as a measure of wealth instead, and to approximating the accumulation identity (1) directly in levels without dividing by wealth.

[6] The increase in Switzerland's net foreign assets has been smaller than what is implied by the size of current account surpluses. This is because of valuation changes, as discussed in Stoffels and Tille (2007).

[7] We follow GR and detrend all variables using an HP filter with $\lambda = 2400000$, filtering out only long-term trends. Our results are unchanged if we use a linear trend instead.

For Switzerland, however, we find $\mu^x \approx 10.97$, $\mu^a \approx 3.26$ and $\rho \approx 1.01$. This also implies that assumption 3 is not satisfied for Switzerland. This is not surprising: as Figure 1 makes clear, if we extrapolate the in-sample trends of Swiss external imbalances we conclude that the intertemporal budget constraint is not satisfied. Despite these problems we report nxa for purposes of comparison with the alternative approximation suggested in section 2.3. In any case, as we show below nxa has strong predictive power for Swiss franc exchange rates, at least in-sample.

Based on the approximation suggested in (31) we compute nxa^* by setting τ_t equal to a constant. As discussed above, this approximation has two advantages for Swiss data relative to the GR measure. First, it is theoretically correct despite the fact that Switzerland has been simultaneously a net creditor and net exporter in-sample; and second, it does not require the specification of the trend shares μ_t^a and μ_t^x. In the empirical implication we set $\tau_t = \max(nx_t) + \tau$, where the maximum value of net exports in the sample is about 12 percent of (quarterly) GDP. In the baseline results reported in this section we use $\tau = 0.05$ as a compromise between minimizing the approximation error (which increases with a larger τ) and ensuring that adjusted net imports ni_t^* remain positive out-of-sample. With $\tau = 0.05$ the approximation remains valid out-of-sample even if net exports were to rise from below 10 percent of GDP at the end of the sample to 17 percent of GDP. Note that the logic of the intertemporal budget constraint implies that Switzerland should eventually start to run trade deficits. In section 4 we show that our main results are robust to alternative choices of τ. As reported there, nxa^* computed with adjustment factors as high as $\tau = 0.5$ – i.e., allowing net exports to rise to more than 60 percent of GDP – still result in an approximation with very strong in-sample predictive power for exchange rate returns. The out-of-sample performance, however, suffers as τ is increased beyond 0.1.

Figure 2 shows time series for nxa and nxa^*. For comparability the series have been normalized to have zero mean and unit standard deviation. The two measures move closely together. To understand better what shocks have been driving the series, Figure 3 compares the contributions of trend deviations in net exports and net foreign assets to the overall measures.[8] Figure 4 shows that the approximation error of nxa is much more volatile than that of nxa_τ^*. The standard deviation of the approximation error of the GR nxa approximation is about three times as large as that of nxa^*, while the mean square error of the GR approximation is similarly about three times as large as that of nxa^*. However, the approximation error of nxa^* shows much more persistence.[9]

[8] The trend deviations of net foreign assets are more volatile from 2000 onwards. This is an artifact of limited data availability. Quarterly data on Swiss external assets and liabilities are only available from the fourth quarter of 1999. For the earlier part of the sample we obtain quarterly data by linear interpolation.

[9] The adjustment term ε_t^* in (26) with a constant $\tau = 0.2$ is close to zero on average, with a standard deviation below 0.01.

3.2 Forecasting effective exchange rates

The intertemporal budget constraint implies that current external imbalances should predict either future net export growth or future returns on the external portfolio. Since exchange rate changes contribute to returns when some fraction of external assets or liabilities are denominated in foreign currency, and because exchange rates affect trade flows, current external imbalances should also have predictive power for exchange rate movements. Here we explore whether this is the case for alternative approximations of the intertemporal budget constraint. We run regressions of the form

$$\Delta e_{t+k} = \beta_0 + \beta_1 X_t + \varepsilon_t^e \tag{35}$$

where $\Delta e_{t+k} \equiv \ln(E_{t+k}/E_t)/k$ is the log return of the Swiss franc nominal effective (export-weighted) exchange rate between quarters t and $t+k$, defined such that an increase corresponds to a Swiss franc appreciation, and $X_t \in \{nxa_t, nxa_t^*\}$ is a measure of external imbalances (normalized to have a standard deviation of one). We run regressions with data up to 2011 Q2 in the regressions to exclude the most recent period after the introduction of the Swiss franc minimum rate against the euro in September 2011. For the baseline results the sample starts in 1973 Q1, the first quarter for which data on the effective exchange rate is available (data on Swiss external assets and liabilities is available from 1971 Q1).

The expected sign of β_1 depends on the share of assets and liabilities denominated in foreign currency. For Switzerland, SNB data shows that between 1983 and 2011 the share of external assets denominated in foreign currency rose from 60 to about 80 percent, while the share of external liabilities denominated in foreign currency was much lower, fluctuating between 30 and 50 percent (see Figure 5). Since Swiss net foreign assets were also positive throughout the sample period this implies that a Swiss franc appreciation corresponds to a negative return on the external portfolio over the period that we study. Based on the currency decomposition of the Swiss external position we would therefore expect a positive coefficient for β_1, i.e. above-trend external imbalances should forecast an appreciation of the Swiss franc effective exchange rate (a negative return on the external portfolio). The expectation that we should find $\beta_1 > 0$ is reinforced by the effect of an appreciation on net exports.

The results are reported in Table 1, for forecast horizons k up to 16 quarters. The numbers in parentheses are Newey-West standard errors with $k-1$ lags to account for the serial correlation of the residuals induced by forecasting overlapping returns. Both measures of Swiss external imbalances exhibit a strong relationship with subsequent Swiss franc returns, with the expected positive coefficient. In particular, the link between nxa^* and future Swiss franc returns is statistically significant at the 1 percent level for forecast horizons between 1 and 16 quarters ahead. The strongest effects occur within the first year: a one standard deviation increase in nxa^* is associated with a 0.7 percent per quarter appreciation of the Swiss franc effective exchange rate in the first four quarters. The strength of the effect gradually declines for longer forecast horizons. The adjusted R^2 is always higher for the regressions with nxa^* than for nxa, peaking at 0.27 for the 10-11 quarters ahead regressions.

Next we ask whether trend deviations in external imbalances also have predictive power for

Swiss franc returns out-of-sample. We proceed as follows. Let T_0 and T_2 denote the initial and last observations in the sample, and choose T_1 such that $T_0 < T_1 < T_2$. First, we construct nxa and nxa^* and estimate regression (35) for the initial "in-sample" from T_0 to T_1. We then use the last in-sample observations nxa_{T_1} and $nxa^*_{T_1}$ together with the estimated coefficients to predict the first out-of-sample non-overlapping Swiss franc return, i.e. the return between T_1 and $T_1 + k$. Next we roll-over the in-sample by one quarter, so that the new in-sample runs from $T_0 + 1$ to $T_1 + 1$. We repeat the same steps as above, constructing nxa and nxa^*, performing the in-sample regression and using the nxa and nxa^* from period $T_1 + 1$ to predict Swiss franc returns between $T_1 + 1$ and $T_1 + 1 + k$. Continuing in this fashion we compute forecasts for $T_1 + 1$ to T_2. As the cutoff for the initial in-sample (T_1) we choose 1990 Q4 which gives an equal number of observations for the in-sample and out-of-sample periods. We end out-of-sample forecasts with the exchange rate return up to 2011 Q2, before the introduction of the Swiss franc minimum rate against the euro in September 2011.[10]

Table 2 presents the results. Because the constants in the regressions reported in Table 1 are highly significant – the Swiss franc has appreciated on average over the sample period –, we compare forecasting power of external imbalances against both a driftless random walk (as is standard in the literature) and against a random walk with drift. A ratio $MSPE_{nxa}/MSPE_{rw}$ and $MSPE_{nxa}/MSPE_{rwd}$ below one indicates that regression model (35) has a smaller mean square prediction error than the random walk without/with drift in forecasting Swiss franc returns out-of-sample. Since regression (35) nests the random walk models we report the Clark and West (2006) statistic, $\Delta MSPE$-adjusted, to test whether any improvement in the mean square prediction error due to the inclusion of approximated external imbalances is statistically significant. For the comparison with a random walk with drift the distribution of the test statistic is non-standard (because the null model relies on the estimation of the mean exchange rate return), but close to the standard normal distribution. Therefore significance levels are reported based on the standard normal distribution. The null that trend deviations in external imbalances do not have predictive power is rejected if $\Delta MSPE$-adjusted is sufficiently large.

The empirical models with external imbalances comfortably beat the standard random walk benchmark when forecasting Swiss franc effective returns out-of-sample. For the 1973-2011 sample, however, they do not seem to provide better forecasts than a random walk with drift. This could be interpreted as evidence for parameter instability in the relationship between Swiss external imbalances and exchange rates. In particular, this link could be weak in the first 10 years of the sample during which the Swiss franc appreciated strongly following the break-up of the Bretton Woods system. We therefore estimate the model from 1980 Q1 onwards, starting the out-of-sample period in 2000 Q1 to leave a sufficient number of observations to estimate the parameters accurately. The results are reported in Table 3. With this specification the Clark-West test statistic indicates that the model with nxa^* as explanatory variable beats the random walk with drift for 2-7 and 10-11 quarters ahead Swiss franc returns. The improvement upon the random walk with drift model is weaker with an earlier break date. For example, with

[10] Unlike Meese and Rogoff (1983) we test ex-ante forecasting power and do not compute forecasts using realized values.

1995 Q4 as the initial out-of-sample period – ensuring an equal number (62) of observations in the in- and out-sample – the nxa^* model beats the random walk with drift only for forecast horizons of 5-7 quarters ahead. We do not report additional results for the model with the GR nxa measure, which does not seem to improve upon the random walk with drift.

We conclude that theoretically well specified approximations of external imbalances exhibit a statistically significant and economically important relationship with subsequent Swiss franc returns. Given the well-documented difficulty of outperforming the random walk when forecasting exchange rate returns out-of-sample – demonstrated initially by Meese and Rogoff (1983), and confirmed in a large number of studies – the predictive power of trend deviations in external imbalances is impressive.

3.3 External imbalances and bilateral exchange rates

The intertemporal budget constraint holds versus the rest of the world, and therefore there is no direct theoretical connection between external imbalances and any particular bilateral exchange rate. For example, country A could run a current account surplus with country B and a deficit with country C in steady state without violating its intertemporal budget constraint. Nevertheless, Gourinchas and Rey (2005) report that their measure of US cyclical external imbalances has predictive power for one-quarter ahead US dollar exchange rate returns versus the British pound, the Swiss franc, the Japanese yen and the euro (DM before 1999). Indeed, it is intuitive that such a relationship may still exist especially for economies where a small number of trading partners account for the bulk of international trade and financial flows. For example, for Switzerland the great majority of trade and financial transactions occurs versus the euro and the US dollar. Therefore, if a measure of external imbalances forecasts the Swiss franc effective exchange rate it should also forecast Swiss franc exchange rates versus the euro and the US dollar.

Della Corte, Sarno and Sestieri (2012) argue that using external imbalances versus the rest of the world to forecast bilateral exchange rates may lead to an error-in-variables problem because these global imbalances contain information unrelated to the bilateral exchange rate that is being explained. As an alternative they propose to measure US bilateral external imbalances using an instrumental variable approach. To forecast the bilateral US dollar exchange rate versus currency i, in a first step they compute nxa_t from equation (20) for both the US and country i. In a second step they regress US nxa_t on a constant, on country i's nxa_t and on detrended bilateral net exports between the US and country i. In a third step the predicted value from this regression is then taken as a measure of bilateral external imbalances between the US and country i and used to forecast the corresponding bilateral exchange rate. They find that measures of bilateral exchange rates derived in this way successfully forecast US dollar exchange rates versus the Canadian dollar, the euro/DM, the British pound and the Japanese yen. Moreover, they find that their measure of bilateral external imbalances has greater predictive power for US dollar bilateral exchange rates than nxa_t.

Here we propose an alternative approach based measuring bilateral external imbalances directly using data on bilateral trade flows and bilateral portfolio holdings. To do so we make use of data collected by the SNB on the currency denomination of Swiss external assets and liabilities. Because this data is for the most part based on the same surveys that are used to compute Swiss foreign assets and liabilities versus the rest of the world, there is little reason to expect this data to be of poorer quality than the data on the aggregated Swiss external position. This direct measure of bilateral external imbalances can thus be expected to be more accurate that the estimate based on an IV-approach. We focus on the US dollar because data on Swiss external portfolio positions in euro is available only from 1999.

Figure 6 shows that Swiss net foreign assets denominated in US dollar have been positive and rising over the sample period, so that we can use approximation (**??**). The Figure also shows that Swiss net exports to the US have mostly fluctuated between plus and minus 1 percent of (quarterly) GDP over the sample period, peaking briefly around 3 percent of GDP in 1983. Because there is no obvious trend in net exports – which became negative at the end of the sample – we set the constant adjustment factor to be small, $\tau_t = \max(nx_t) + 0.0001$, to minimize the approximation error. Figure 7 compares the resulting nxa^{*CH-US} for $\tau = 0.0001$ against nxa^* with $\tau = 0.05$ for Swiss external imbalances versus the rest of the world. The series move together for most of the sample, before diverging with the onset of the global financial crisis in 2007.

We again run predictive regressions of the form

$$\Delta e_{t+k}^{CHF/USD} = \beta_0 + \beta_1 X_t + \varepsilon_t^e \tag{36}$$

with the nominal Swiss franc return versus the US dollar on the left-hand side and $X_t \in \left\{nxa_t^*, nxa_t^{*CH-US}\right\}$ including alternatively the approximated trend deviation of Swiss external imbalances versus the rest of the world, nxa_t^*, and our measure of Swiss bilateral external imbalances versus the US, nxa_t^{*CH-US}. Bilateral exchange rate returns are defined such that $\Delta e_{t+k}^{CHF/USD} < 0$ corresponds to an appreciation of the Swiss franc appreciation against the dollar. Since Swiss dollar-denominated assets are larger than dollar denominated liabilities throughout the sample period (see Figure 6), a Swiss franc appreciation versus the dollar corresponds to a negative return on the Swiss dollar portfolio. Consequently we expect $\beta_1 < 0$ in regression (36). The sample period is from 1983 Q4 (the first quarter for which data on Swiss external positions in US dollar is available) to 2011 Q2. The results are reported in Table 4. Bilateral external imbalances versus the US have predictive power for Swiss franc-US dollar exchange rate returns, with the strongest effects observed in the short run. For external imbalances versus the rest of the world we also find the expected negative coefficient, but the relationship with Swiss franc-dollar returns is statistically significant only for longer forecast horizons.

3.4 Time variation

There is no reason why we should expect the coefficients in regression (35) to be stable. First, β_1 could change over time as the discount rate $\hat{\rho}_{t+j}$ in the approximation of the intertemporal budget constraint varies, reflecting changing trends in ex-post growth-adjusted returns $\overline{R}_t/\overline{\Gamma}_t$ and trends in assets, liabilities, exports and imports. Second, β_1 could change because the currency decomposition of assets and liabilities changes over time. This would imply that a given change in exchange rates has a varying impact on portfolio returns $\hat{r}_t$. Finally, the elasticity of net exports with respect to the exchange rate could also change over time.

To test whether the relationship between external imbalances and subsequent exchange rate returns is stable over time we employ the quasi-local-level (qLL) test developed by Elliott and Müller (2006) and Müller and Petalas (2010). These papers show that the qLL test is asymptotically equivalent to the optimal tests for wide range of processes for time variation. Therefore we do not need to make specific assumptions about the particular process governing the time variation of coefficients. The null hypothesis of parameter stability, jointly for β_0 and β_1 in regression (35), is rejected if the test statistic is smaller (more negative) than the critical values, which are tabulated in Elliott and Müller (2006). This test has so far been applied in only few applied papers, including Goldberg and Klein (2010) and Grisse and Nitschka (2012).

The results are reported in Table 5. Perhaps surprisingly, as panel (a) of the table shows, we find no evidence for time variation in the link between Swiss external imbalances versus the rest of the world and effective exchange rate returns: for both nxa and nxa^* (computed again with the baseline value of $\tau = 0.05$), the null hypothesis of parameter stability cannot be rejected at conventional levels of statistical significance. One conclusion is that movements in trade weights employed in the effective exchange rate index are a good approximation for movements in portfolio weights across currencies. Panel (b) of the table similarly shows that the relationship between trend deviations in Swiss external imbalances (nxa and nxa^* with $\tau = 0.0001$) and Swiss franc-US dollar exchange rate movements appears to be stable over time.

4 Robustness

The previous section used approximation nxa^* in (31) with a constant adjustment factor $\tau_t = \max(nx_t) + \tau$ to predict exchange rate movements. The constant $\tau > 0$ was chosen as small as possible to minimize approximation error, while at the same time large enough to reasonably guarantee $ni_t^* > 0$ out-of-sample. In this section we explore the properties of nxa^* for various choices of τ_t, and discuss the robustness of our results for these alternative approximations. We focus on $\tau_t = \max(nx_t) + \tau$ with τ ranging from 0.0001 (as small as possible for the approximation to remain valid in-sample) to 0.4, which would allow net exports as percent of GDP to rise 40 percent of GDP above their largest in-sample value. We also explore an alternative choice of $\tau_t = \theta nfa_t$ for a range of possible values for the constant $\theta > 0$, beginning with $\theta = 0.03$ which is just large enough to ensure the approximation is valid.

Figure 8 shows paths of nxa^*, approximating trend deviations in Swiss external imbalances versus the rest of the world. The alternative measures move together closely. For τ_t very small nxa^* shows strong movements, as small absolute deviations from trends close to zero translate into large log deviations from trends. Figure 9 reports the corresponding in-sample approximation errors to the linearized accumulation identity (30). For both specifications the approximation errors are very persistent, but much less volatile than those from the GR measure. The approximation based on θ is less volatile again than that based on τ. Table 6 reports results for coefficient β_1 in our baseline regression (35) for Swiss franc effective returns. The results for alternative values of τ are robust, with β_1 positive and strongly statistically significant across specifications and forecast horizons. For the alternative aproximation with $\tau_t = \theta nfa_t$ we also find the expected positive coefficient across specifications, but the relationship between this alternative measure and exchange rate returns appears to be weaker except for small values of θ.

5 Conclusion

Appropriately defined measures of trend deviations in external imbalances provide useful information about exchange rate movements, as expected based on the intertemporal budget constraint. This paper has provided evidence supporting this claim, first advanced by Gourinchas as and Rey (2007), for Switzerland.

We propose a new approximation for the accumulation identity of the external portfolio that is valid for countries which are simultaneously net creditors and net exporters over the sample period. This approximation does not require the specification of trend shares for trade flows and portfolio positions. We apply this approximation to Swiss external imbalances and find that it has strong predictive power for nominal effective Swiss franc returns. We also show that measures of bilateral external imbalances, computed using data on bilateral trade flows and external positions, can be useful for predicting bilateral exchange rates. Finally, perhaps surprisingly, we find no evidence for time variation in the relationship between external imbalances and exchange rate movements.

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Appendix: data sources

Our sample covers the post-Bretton Woods period, 1973-2012. We run regressions only up to and including 2012 Q2 to account for the introduction of the Swiss franc exchange rate floor versus the euro by the SNB in September 2012.

Foreign assets and liabilities: data is from the SNB (quarterly from 1999, annual from 1983), available at `http://www.snb.ch/de/iabout/stat/statpub/iip/stats/iip`. We extend this data backwards using annual data from Lane and Milesi-Ferretti (2007).[11] Where quarterly data is not available we use linear interpolation to obtain quarterly data.

Currency denomination of assets and liabilities: The SNB provides data on the currency denomination of Swiss external assets and liabilities. Data for Swiss positions denominated in US dollar is available annually from 1983 and quarterly 1999; data for positions in euro is available quarterly from 1999. Alternatively we use annual data compiled by Lane and Shambaugh (2010) for the period 1990-2004.

Exports and imports of goods and services: quarterly seasonally adjusted data in current prices is obtained from the IMF IFS database for Swiss trade with the rest of the world, and from the IMF DOTS database for bilateral trade flows.

Swiss franc nominal effective exchange rates: from the SNB, obtained via Datastream. The effective exchange rate covers Switzerland's 24 most important trading partners.

Bilateral nominal exchange rates: Quarterly data corresponds to the last day of the month. We use exchange rate data from the SNB, obtained via Datastream.[12]

Wealth: quarterly data on seasonally adjusted nominal GDP is obtained from the IMF IFS database (via Datastream). Alternatively we use annual data on household wealth compiled by the SNB, available at `http://www.snb.ch/en/iabout/stat/statpub/vph/stats/wph`.

[11] We thank Philip Lane for providing us with an updated version of this dataset. For the time period 1983-2011 where annual data from both the SNB and Lane and Milesi-Ferretti (2007) are available, data on Swiss assets and liabilities from two datasets are extremely close together.

[12] All results are robust to using quarterly averages of exchange rates instead.

Tables and figures

Table 1: Predictive regressions for nominal effective Swiss franc returns

	Forecast horizon k (quarters)						
	1	2	3	4	8	12	16
(a) nxa							
β_0	0.80***	0.78***	0.77***	0.77***	0.73***	0.70***	0.65***
	(0.20)	(0.20)	(0.20)	(0.19)	(0.18)	(0.18)	(0.19)
β_1	0.52**	0.57**	0.56***	0.54***	0.38**	0.32**	0.19**
	(0.21)	(0.22)	(0.21)	(0.20)	(0.17)	(0.15)	(0.09)
$\overline{R}^2$	0.04	0.08	0.11	0.13	0.12	0.14	0.07
Observations	153	152	151	150	146	142	138
(b) nxa^*, $\tau = 0.05$							
β_0	0.82***	0.81***	0.80***	0.81***	0.79***	0.76***	0.71***
	(0.20)	(0.20)	(0.19)	(0.19)	(0.17)	(0.17)	(0.17)
β_1	0.61***	0.66***	0.68***	0.69***	0.56***	0.48***	0.35***
	(0.19)	(0.20)	(0.19)	(0.17)	(0.15)	(0.14)	(0.10)
$\overline{R}^2$	0.06	0.11	0.16	0.20	0.22	0.25	0.16
Observations	153	152	151	150	146	142	138

Notes: This table reports results from regressions $\Delta e_{t+k} = \beta_0 + \beta_1 X_t + \varepsilon^e_{t+k}$, where $\Delta e_{t+k} = ln(E_{t+k}/E_t)/k$ is the per-quarter log return of the Swiss franc nominal effective (export-weighted) exchange rate and X_t represents alternative measures of Swiss franc external imbalances. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Newey-West standard errors in parentheses. A positive coefficient $\beta_1 > 0$ implies that above-trend Swiss external imbalance are associated with an appreciation of the Swiss franc. The regressions use quarterly data from 1973 Q4 to 2011 Q2.

Table 2: Tests for out-of-sample predictability of nominal effective Swiss franc returns: 1973-2011

	Forecast horizon k (quarters)						
	1	2	3	4	8	12	16
(a) nxa							
$MSPE_{nxa}/MSPE_{rw}$	1.01	1.01	1.03	1.00	1.07	1.16	1.25
$\Delta MSPE_{rw}$-adjusted	0.61**	0.72**	0.71**	0.75**	0.49*	0.41*	0.32*
	(1.66)	(1.94)	(1.81)	(1.82)	(1.45)	(1.42)	(1.62)
$MSPE_{nxa}/MSPE_{rwd}$	1.07	1.11	1.17	1.16	1.37	1.60	1.85
$\Delta MSPE_{rwd}$-adjusted	-0.02	0.07	0.06	0.10	-0.04	-0.05	-0.05
	(-0.08)	(0.34)	(0.27)	(0.44)	(-0.20)	(-0.34)	(-0.44)
T_{out}	81	80	79	78	74	70	66
T_{in}	81	80	79	78	74	70	66
(b) nxa^*, $\tau = 0.05$							
$MSPE_{nxa^*}/MSPE_{rw}$	1.04	1.10	1.16	1.14	1.11	1.12	1.22
$\Delta MSPE_{rw}$-adjusted	0.84**	1.04**	1.14***	1.32***	0.76**	0.47*	0.33**
	(1.92)	(2.27)	(2.35)	(2.53)	(1.98)	(1.62)	(1.68)
$MSPE_{nxa^*}/MSPE_{rwd}$	1.10	1.20	1.32	1.32	1.43	1.54	1.79
$\Delta MSPE_{rwd}$-adjusted	0.02	0.14	0.19	0.34	0.07	-0.03	-0.05
	(0.09)	(0.49)	(0.67)	(1.09)	(0.30)	(-0.20)	(-0.47)
T_{out}	81	80	79	78	74	70	66
T_{in}	81	80	79	78	74	70	66

Notes: This table reports tests of out-of-sample predictive power, comparing regression model (35) against a random walk (rw) and a random walk with drift (rwd). $MSPE_{rw}/MSPE_{nxa}$ and $MSPE_{rwd}/MSPE_{nxa}$ denote the ratios of out-of-sample mean-square-errors of the null model versus regression model (35). ΔMSPE-adjusted is the Clark-West (2006) adjusted difference of mean square errors. t-statistics in parentheses. ***, ** and * indicate that the null that a random walk with/without drift outperforms model (35) is rejected at the 1%, 5% and 10% level, respectively (one-sided test). T_{out} is the length of the out-of-sample period, T_{in} is the length of the in-sample period. The initial in-sample begins in 1973 Q4 and ends in 1990 Q4, the end of the out-of-sample predictions is 2011 Q2.

Table 3: Tests for out-of-sample predictability of nominal effective Swiss franc returns: 1980-2011

	Forecast horizon k (quarters)						
	1	2	3	4	8	12	16
(a) nxa							
$MSPE_{nxa}/MSPE_{rw}$	0.86	0.76	0.73	0.67	0.70	0.70	0.68
$\Delta MSPE_{rw}$-adjusted	0.70***	0.82***	0.73***	0.81***	0.44**	0.29**	0.21***
	(3.34)	(3.57)	(2.75)	(2.50)	(2.13)	(1.82)	(2.55)
$MSPE_{nxa}/MSPE_{rwd}$	1.06	1.01	1.05	0.98	1.14	1.14	1.16
$\Delta MSPE_{rwd}$-adjusted	0.08	0.19	0.15	0.22	0.03	-0.01	-0.01
	(0.30)	(0.86)	(0.68)	(1.07)	(0.17)	(-0.06)	(-0.13)
T_{out}	45	44	43	42	38	34	30
T_{in}	80	79	78	77	73	69	65
(b) nxa^{*}, $\tau = 0.05$							
$MSPE_{nxa^{*}}/MSPE_{rw}$	0.83	0.74	0.70	0.61	0.67	0.64	0.69
$\Delta MSPE_{rw}$-adjusted	1.14***	1.37***	1.41***	1.69***	0.87**	0.42**	0.22***
	(3.32)	(3.58)	(2.99)	(2.89)	(2.32)	(1.80)	(2.37)
$MSPE_{nxa^{*}}/MSPE_{rwd}$	1.01	0.99	1.01	0.90	1.10	1.05	1.18
$\Delta MSPE_{rwd}$-adjusted	0.17	0.28**	0.30**	0.50***	0.13	0.02	-0.02
	(0.73)	(1.76)	(1.83)	(2.39)	(1.09)	(0.45)	(-0.35)
T_{out}	45	44	43	42	38	34	30
T_{in}	80	79	78	77	73	69	65

Notes: This table reports tests of out-of-sample predictive power, comparing regression model (35) against a random walk (rw) and a random walk with drift (rwd). $MSPE_{rw}/MSPE_{nxa}$ and $MSPE_{rwd}/MSPE_{nxa}$ denote the ratios of out-of-sample mean-square-errors of the null model versus regression model (35). ΔMSPE-adjusted is the Clark-West (2006) adjusted difference of mean square errors. t-statistics in parentheses. ***, ** and * indicate that the null that a random walk with/without drift outperforms model (35) is rejected at the 1%, 5% and 10% level, respectively (one-sided test). T_{out} is the length of the out-of-sample period, T_{in} is the length of the in-sample period. The initial in-sample begins in 1980 Q1 and ends in 1999 Q4, the end of the out-of-sample predictions is 2011 Q2.

Table 4: Predictive regressions for nominal Swiss franc returns versus the US dollar

	Forecast horizon k (quarters)						
	1	2	3	4	8	12	16
(a) global, 1971-2011							
β_0	-0.99**	-0.97**	-0.96**	-0.96**	-0.97***	-0.93***	-0.91***
	(0.40)	(0.40)	(0.39)	(0.39)	(0.37)	(0.34)	(0.33)
β_1	-0.73*	-0.76**	-0.83**	-0.97***	-0.93***	-0.78***	-0.59***
	(0.37)	(0.38)	(0.38)	(0.35)	(0.27)	(0.23)	(0.21)
$\overline{R}^2$	0.02	0.03	0.06	0.10	0.15	0.16	0.12
Observations	161	160	159	158	154	150	146
(a) global, 1983-2011							
β_0	-0.96**	-0.95*	-0.95*	-1.01**	-1.09**	-0.96***	-0.88***
	(0.48)	(0.48)	(0.48)	(0.47)	(0.45)	(0.36)	(0.30)
β_1	-0.60	-0.61	-0.62	-0.78*	-0.68*	-0.47**	-0.39
	(0.49)	(0.50)	(0.47)	(0.40)	(0.36)	(0.21)	(0.24)
$\overline{R}^2$	0.01	0.02	0.03	0.06	0.07	0.05	0.04
Observations	110	109	108	107	103	99	95
(c) CH-US, 1983-2011							
β_0	-0.83*	-0.81*	-0.82*	-0.82*	-0.82*	-0.73*	-0.63*
	(0.47)	(0.47)	(0.47)	(0.46)	(0.43)	(0.39)	(0.35)
β_1	-1.12***	-0.77***	-0.81***	-0.79***	-0.50***	-0.23*	-0.29**
	(0.26)	(0.29)	(0.26)	(0.26)	(0.18)	(0.14)	(0.12)
$\overline{R}^2$	0.05	0.04	0.06	0.07	0.06	0.02	0.06
Observations	109	108	107	106	102	98	94

Notes: This table reports results from regressions $\Delta e_{t+k}^{CHF/USD} = \beta_0 + \beta_1 X_t + \varepsilon_{t+k}^e$, where $\Delta e_{t+k}^{CHF/USD} k$ is the per-quarter log return of the Swiss franc versus the US dollar and $X_t = nxa_t^*$ represents measures of Swiss global and bilateral (versus the US) external imbalances. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Newey-West standard errors in parentheses. A negative coefficient $\beta_1 < 0$ implies that above-trend Swiss external imbalances are associated with an appreciation of the Swiss franc versus the US dollar. The regressions in panels (a) and (b) use nxa^* versus the rest of the world as explanatory variable, computed with $\tau = 0.05$. The regressions in panel (c) use nxa^* versus the US, computed with $\tau = 0.0001$.

Table 5: Tests for gradual time variation

	Forecast horizon k (quarters)						
	1	2	3	4	8	12	16
(a) CHF effective returns							
nxa	-9.99	-9.13	-8.84	-9.39	-11.36	-11.29	-10.94
nxa^*	-8.59	-7.99	-8.00	-8.61	-11.05	-11.14	-10.70
(b) USDCHF returns							
global, 1971-2011	-8.20	-9.01	-9.84	-12.00	-12.83*	-12.37	-11.72
global, 1983-2011	-7.43	-8.09	-8.94	-9.21	-9.83	-10.57	-9.14
versus US, 1983-2011	-11.61	-8.59	-8.26	-8.37	-9.80	-10.99	-12.21

Notes: This table reports test statistics for the quasi-local-level test proposed by Elliott and Müller (2006). The null hypothesis of parameter stability (jointly for β_0 and $beta_1$ in regression (35) is rejected if the test statistics are sufficiently negative. The critical values with two regressors are -17.57, -14.32 and -12.8 for the 1%, 5% and 10% level, respectively. Panel (a) reports tests for the regression specifications in Table 1. Panel (b) reports tests for the regression specifications in Table 4.

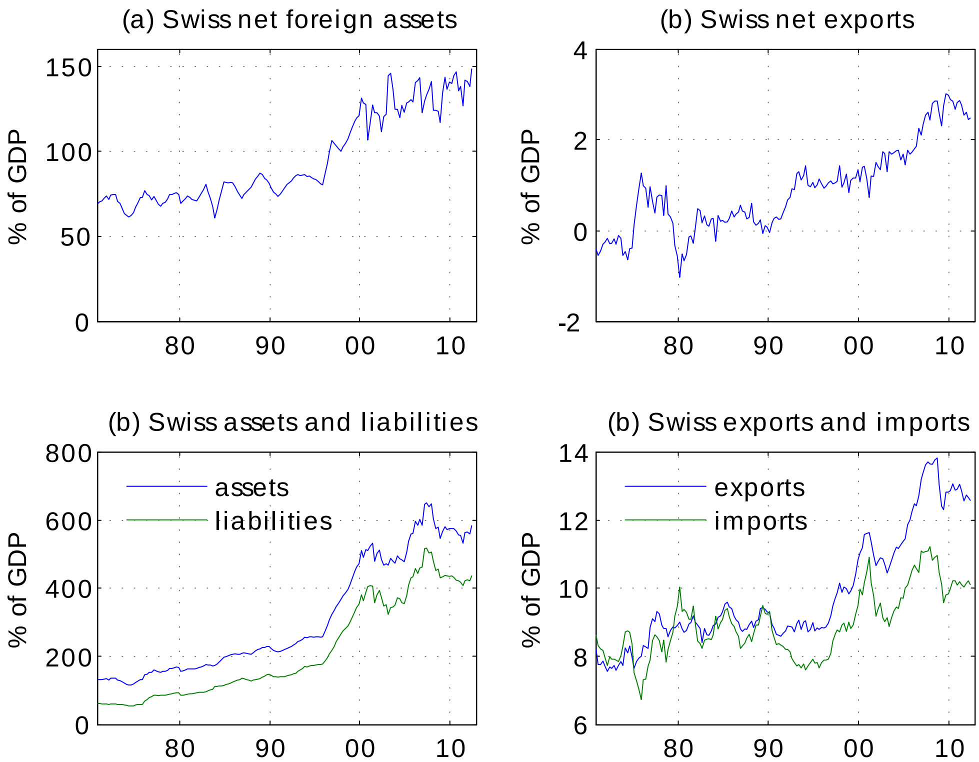

Figure 1: Swiss external imbalances. Data are percentages of annual GDP. Sources: SNB, IMF IFS database and Lane and Milesi-Ferretti (2007).

Table 6: Predictive regressions for nominal effective Swiss franc returns

	Forecast horizon k (quarters)						
	1	2	3	4	8	12	16
			(a) nxa^* with $\tau_t = \max(nx_t) + \tau$				
$\tau = 0.0001$							
β_1	0.47**	0.49*	0.50*	0.54**	1.02***	1.00***	0.88***
$\overline{R}^2$	0.04	0.06	0.09	0.13	0.27	0.35	0.29
$\tau = 0.1$							
β_1	0.57***	0.62***	0.63***	0.65***	0.50***	0.42***	0.28***
$\overline{R}^2$	0.05	0.09	0.14	0.18	0.19	0.21	0.12
$\tau = 0.2$							
β_1	0.50**	0.54***	0.57***	0.60***	0.44**	0.36**	0.23**
$\overline{R}^2$	0.04	0.07	0.11	0.15	0.15	0.16	0.09
$\tau = 0.3$							
β_1	0.45**	0.50**	0.53***	0.56***	0.41**	0.33**	0.21*
$\overline{R}^2$	0.03	0.06	0.09	0.13	0.13	0.14	0.08
$\tau = 0.4$							
β_1	0.40**	0.44**	0.48**	0.51***	0.37**	0.30*	0.19
$\overline{R}^2$	0.02	0.05	0.08	0.11	0.11	0.11	0.06
			(b) nxa^* with $\tau_t = \theta \times nfa_t$				
$\theta = 0.03$							
β_1	0.47**	0.52**	0.49**	0.47***	0.31*	0.27	0.15
$\overline{R}^2$	0.04	0.07	0.09	0.10	0.08	0.09	0.04
$\theta = 0.1$							
β_1	0.38	0.43*	0.40*	0.38*	0.21	0.17	0.07
$\overline{R}^2$	0.02	0.05	0.06	0.07	0.04	0.04	0.01
$\theta = 0.2$							
β_1	0.36	0.41*	0.39*	0.37*	0.19	0.16	0.06
$\overline{R}^2$	0.02	0.04	0.05	0.06	0.03	0.04	0.01
$\theta = 0.3$							
β_1	0.36	0.40*	0.39*	0.36*	0.19	0.16	0.06
$\overline{R}^2$	0.02	0.04	0.05	0.06	0.03	0.03	0.01
$\theta = 0.4$							
β_1	0.35	0.40	0.38*	0.36*	0.18	0.15	0.05
$\overline{R}^2$	0.02	0.04	0.05	0.06	0.03	0.03	0.01

Notes: This table reports results from regressions $\Delta e_{t+k} = \beta_0 + \beta_1 X_t + \varepsilon^e_{t+k}$, where $\Delta e_{t+k} = ln(E_{t+k}/E_t)/k$ is the per-quarter log return of the Swiss franc nominal effective (export-weighted) exchange rate and X_t represents alternative measures of Swiss franc external imbalances. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Newey-West standard errors in parentheses. A positive coefficient $\beta_1 > 0$ implies that above-trend Swiss external imbalance are associated with an appreciation of the Swiss franc. The regressions use quarterly data from 1973 Q4 to 2011 Q2.

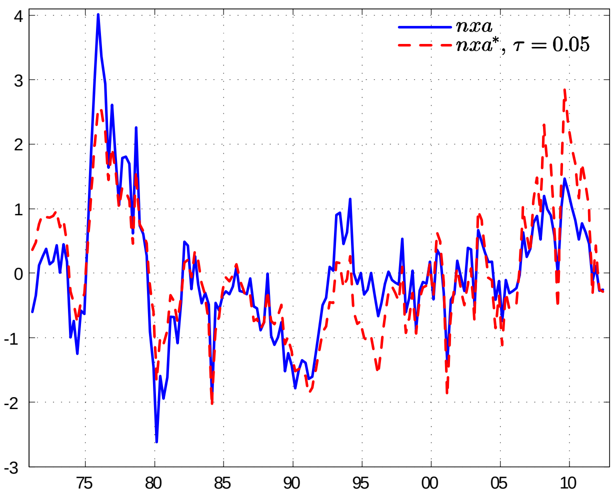

Figure 2: Alternative measures of Swiss external imbalances, normalized to have a mean of zero and a standard deviation of one. nxa is the Gourinchas-Rey (2007) approximation, equation (20), nxa^*_τ is the approximation proposed in (31) with $\tau_t = \max(nx_t) + 0.05$.

Figure 3: Composition of alternative measures of Swiss external imbalances. The blue solid line is the contribution from detrended net foreign assets, the red dashed line is the contribution from detrended net exports. The sum of the two contributions gives the approximation of the trend deviation of Swiss external imbalances.

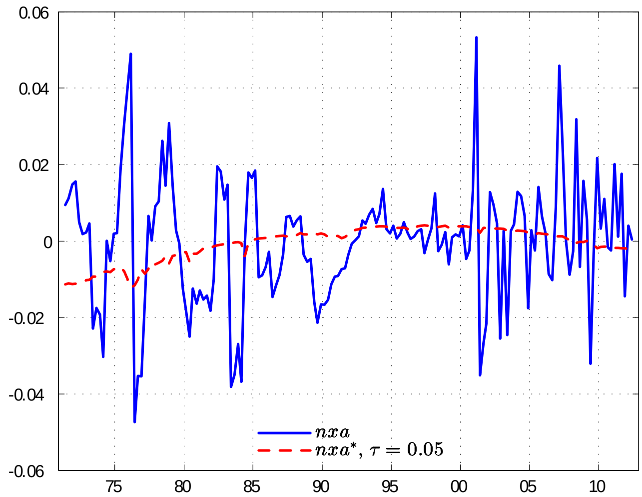

Figure 4: In-sample accuracy of alternative approximations of the accumulation identity for Swiss net foreign assets. This Figure shows the error from equations (19) for the GR nxa measure and (30) for nxa^*_τ (with $\tau = 0.2$) and nxa^*_θ (with $\theta = 0.03$), obtained by subtracting the right-hand side of the equation from the left-hand side.

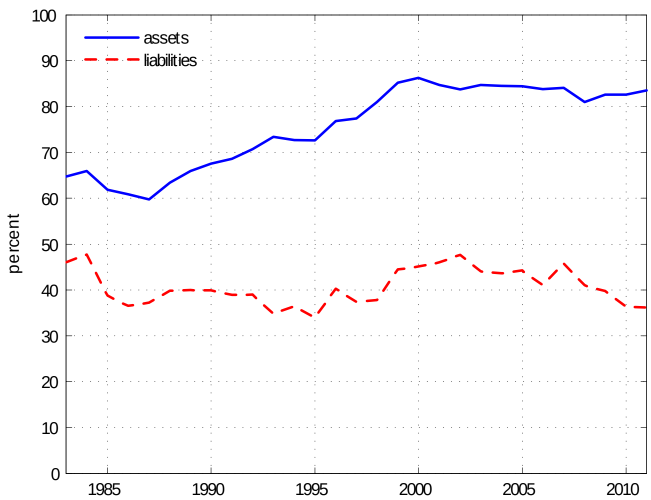

Figure 5: Share of Swiss external assets and liabilities denominated in foreign currency. Source: SNB.

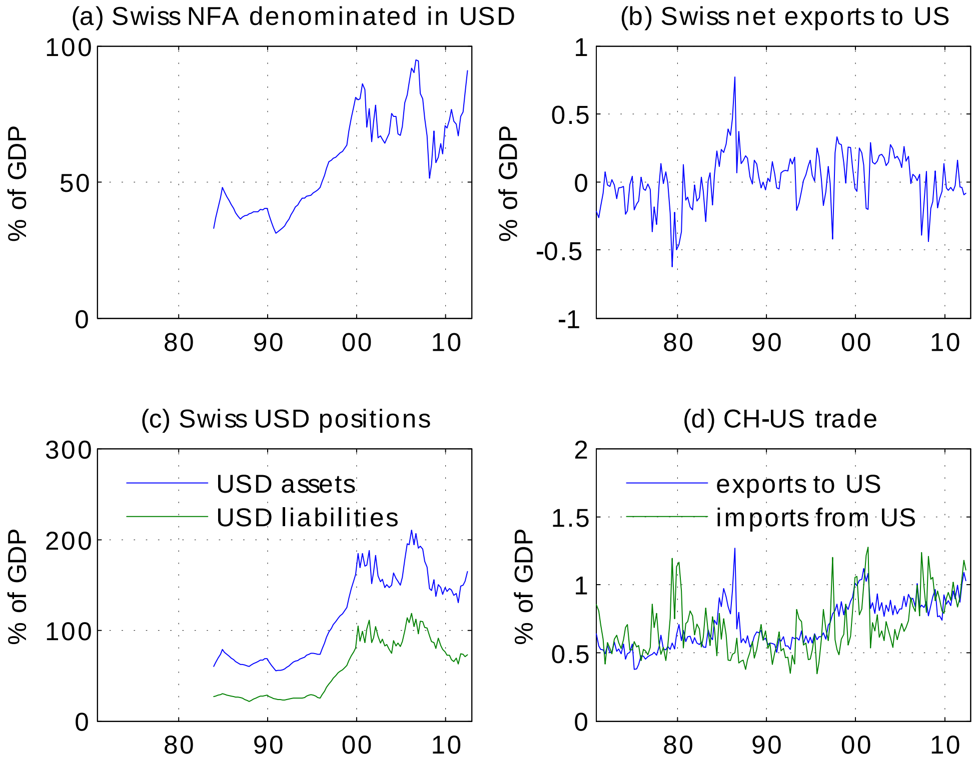

Figure 6: Swiss external imbalances versus the US. Data are percentages of annual GDP. Sources: SNB and IMF IFS and DOTS databases.

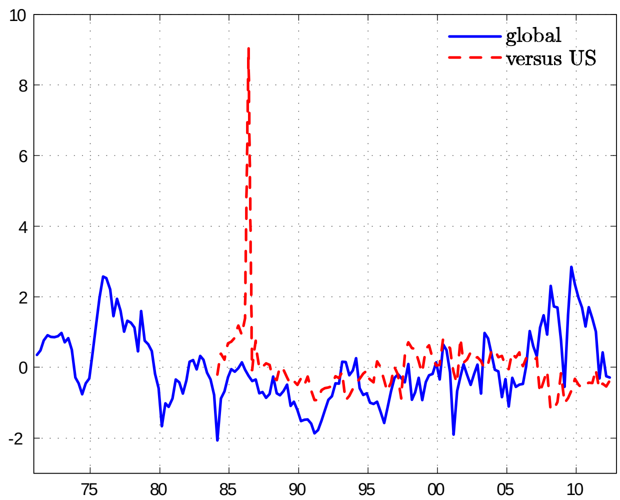

Figure 7: Measures of Swiss external imbalances versus the rest of the world (nxa^* with $\tau_t = \max(nx_t) + 0.05$) and versus the US ($nxa^{*,CH-US}$ with $\tau_t = \max\left(nx_t^{CH-US}\right) + 0.0001$).

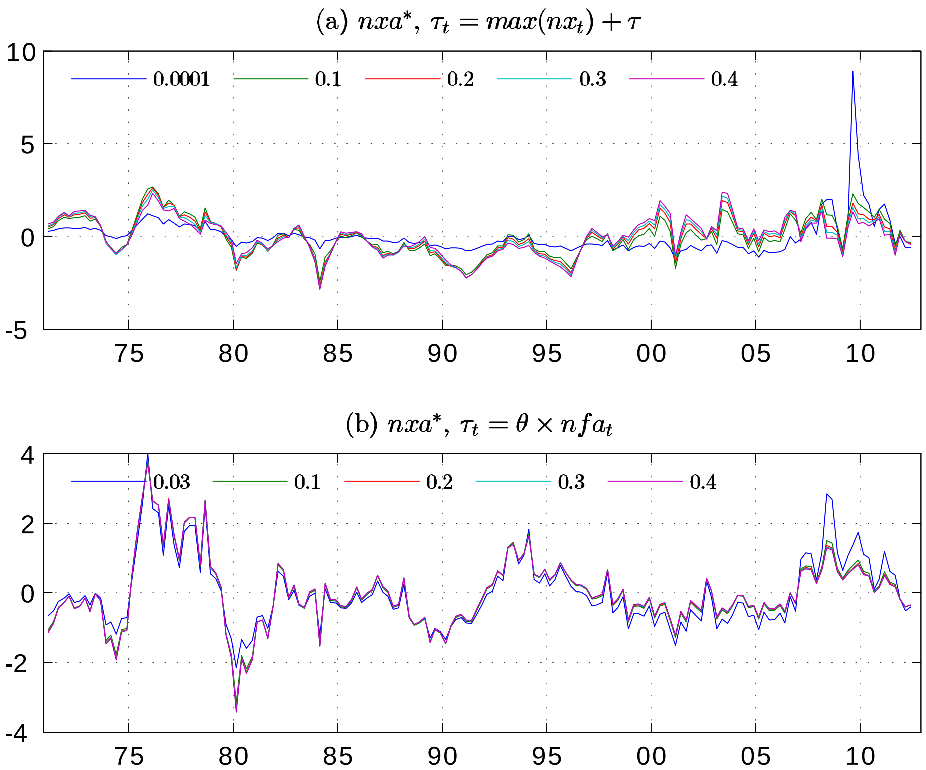

Figure 8: Alternative approximations to trend deviations in Swiss external imbalances, computed according to equation (31), for alternative specifications of τ_t. Panel (a) shows nxa^* with $\tau_t = \max(nx_t) + \tau$ for alternative values of τ. Panel (b) shows nxa^* with $\tau_t = \theta nfa_t$ for alternative values of θ.

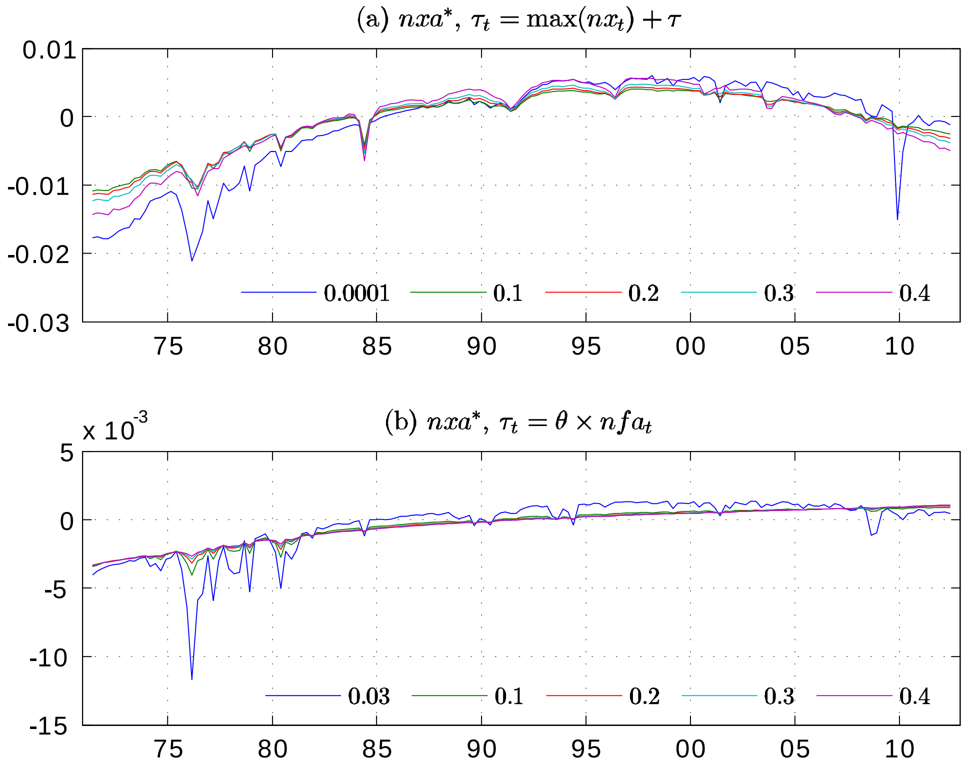

Figure 9: In-sample errors in the approximation of the accumulation identity for Swiss net foreign assets for alternative specifications of τ_t. Panel (a) shows the approximation error for nxa^* with $\tau_t = \max(nx_t) + \tau$ for alternative values of τ. Panel (b) shows the approximation error for nxa^* with $\tau_t = \theta nfa_t$ for alternative values of θ.