On the fundamental determinants of the Swiss franc exchange rate for the D-mark[1]

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Introduction

The reaction patterns of the foreign exchange markets are macroeconomic phenomena of great concern to central banks and other economic policy makers as well as to important parts of the financial and business community. Unfortunately, economists have, in the past, not done well in reliably tracing and quantifying these reaction patterns of exchange rates. As a consequence they have become rather pessimistic in regard to the development of successful econometric exchange rate models based on fundamental determinants; i.e. standard macroeconomic variables. Out-of-sample predictions of such fundamental models have usually been either not much better, no better or – in most cases – still more inaccurate than the no-change predictions of the unpretentious simple random walk model, even when the actually realised rather than forecasted values of the fundamental explanatory variables were used. This predictive failure justifies a sceptical attitude in regard to the theoretical and practical relevance of much of existing exchange rate theory. It appears that economists do not yet understand the determinants of short to medium-run movements in exchange rates.[2] This paper attempts to bring optimism back to this issue by presenting – as an alternative to the established but empirically unsuccessful monetary models – a behavioural type of fundamental exchange rate model which clearly beats the no-change predictions of the random walk time series model for a relatively wide range of time horizons.

1. Specification of an alternative fundamental model

In developing the fundamentals-based behavioural model of the Swiss franc exchange rate for the D-mark the focus was on a set of variables from the financial and goods markets which economic agents might actually use as relevant signals. The univariate stationarity properties of the chosen data set provided essential information for model construction. Stationarity tests, the results of which are summarised in footnote 4, suggest that the level form of the stochastic data series are all individually integrated of order one. This led, in particular, to the specification of a relationship between the levels – rather than the changes – of the exchange rate and the interest rate differential between the countries concerned. Moreover, on the basis of preponderant observed reaction patterns in the foreign exchange markets, the model envisages, on balance, a positive – rather than negative – partial relationship between the domestic level of interest rates and the external value of the domestic currency (given by the inverse of the exchange rate, defined as the domestic price of foreign currency). Both of these features are contrary to the uncovered-interest-parity framework, which economists continue to use as a guiding principle in their monetary exchange rate models in spite of its poor empirical record.[3] Apparently, the risk-neutral arbitrage behaviour under rational

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[1] Revised and updated version of Ettlin (1995a).

[2] This conclusion is drawn, for example, by Meese (1990, p. 132), after reviewing the empirical performance of monetary exchange rate models based on the asset market approach, which have been dominant in the literature for most of the last two decades.

[3] For negative empirical results regarding the application of that framework to the implied relationship between Swiss and German interest rates, as well as the presentation of an alternative approach, see Ettlin and Bernegger (1994).

expectations, on which uncovered interest parity builds, is not decisive for the movements of the foreign exchange markets in general.

The specification of the single-equation behavioural model of the nominal Swiss franc exchange rate for the D-mark (represented in the model by the mnemonic symbol *LSFDM*) contains two interest rate differentials among its explanatory variables. These are the differential between the official discount rates in Switzerland and Germany *(RDISD)* as well as the differential between the three-month Swiss franc and D-mark Eurodeposit rates *(R3MSD)*. The former variable serves as a robust current indicator of relative monetary policy while the latter represents a key measure of relative market interest rates. There is also a term structure differential *(R3YSD - R3MSD)* regarding the relative steepness of the yield curve between three-year and three-month Euromarket rates for the two currencies. This variable contains information on forward, i.e. expected future short-run interest rate differentials and thus also on the relative stance of future monetary policy. It should be observed that in contrast to most fundamental exchange rate models in the recent literature, no measure of relative money supply is included among the relevant fundamentals, since the discount rate differential provides a more autonomous and econometrically much more reliable measure of the relative stance of monetary policy.

Furthermore, the natural logarithm of the ratio of the consumer price indices in the two countries concerned *(LPCSD)* is generally recognised as a representative measure of the relative purchasing power of the two currencies. The logarithm of the (lagged) ratio of industrial capacity utilisation *(LCUSD)* is intended to serve as an indicator of the comparative cyclical state of real economic activity. A positive difference of the current account balance to GDP percentage ratio *(CAGSD)* is interpreted by the foreign exchange market as a sign of relative strength of the local currency. The implied larger relative capital outflow or smaller inflow apparently requires a differential foreign exchange risk premium on account of imperfect substitutability between (changes in) domestic and foreign assets. Finally, the logarithm of the lagged US-dollar exchange rate for the D-mark *(LUSDM)* is also included as a fundamental signal. The choice of this variable derives from the fact that US-dollar investments are a substitute for D-mark or Swiss franc investments, whereby it is empirically observed that the Swiss franc tends to be proportionately more affected than the D-mark by fund flow pressure out of or into US-dollars. This can be attributed to the relatively smaller liquidity in the Swiss financial market.

2. Estimation procedure and results

The econometric exchange rate model based on the above-mentioned set of fundamental determinants is estimated for the sample period 1979Q2 – 1991Q2. The starting point coincides with the beginning of the institutional framework of the Exchange Rate Mechanism of the European Monetary System, in which Germany participates. The early termination of the in-sample period in 1991Q2 allowed the inclusion of four quarters of observations following the structural break related to the German unification in mid-1990, while still leaving up to 19 calendar quarters for extended post-sample prediction tests. Regarding methodology, the single equation two-step ordinary least squares procedure developed by Engle and Granger (1987) is applied.[4]

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[4] This requires, as a preliminary task, the testing of the univariate time-series properties of the data used in the study. It was done by means of augmented Dickey-Fuller tests, with the critical values derived from MacKinnon (1991). For none of the stochastic level variables in the model was the null-hypothesis of the presence of a unit root rejected at the 1% size of a one-tail test, whereas for all the corresponding first differences the unit root hypothesis was rejected by the same criteria. This implies that the individual data series should be treated as being I(1), i.e. integrated of order one; they need to be differenced once to become stationary.

Table 1

Cointegration equation

$$
\begin{aligned}
LSFDM* = {} & 3.177 + 1.026 LPCSD - 0.025 RDISD - 0.012 M2R3MSD - 0.018 [R3YSD - R3YSD] \\
& - 0.493 M2LCUSD_{-3} - 0.061 LUSDM_{-1} - 0.009 \{ M2CCAGSD_{-1} [1 - D90UNIF] \} \\
& + 0.021 D89WALL - 0.050 D90UNIF + 0.008 \{ SD24 [1 - D90UNIF] \}
\end{aligned}
$$

Sample period	**1979Q1 – 1991Q2**
Cointegration regression Durbin-Watson statistic	1.889
Standard error of regression	0.009

Note: Because of non-standard distribution, the standard t-values are not reported.

The cointegration equation in Table 1 shows – as the first of the two main steps of the estimation procedure – the equilibrium relationship between the logarithm of the nominal exchange rate and the chosen set of fundamental variables. The estimated coefficient of the discount rate differential is -0.025. This implies that the Swiss franc will, ceteris paribus, ultimately strengthen by 2½ percent when the Swiss discount rate is raised by 1 percentage point, or when the German discount rate is lowered that much. The response parameter of the three-month Euromarket rate differential is -0.012, i.e. about half of the one related to the discount rates. Finally, the relative term structure between three-year and three-month Euromarket rates affects the logarithm of the exchange rate with a coefficient of -0.018.

The estimated coefficient for the logarithm of the ratio of consumer prices is 1.026; it practically coincides with unity. Thus, as the equilibrium nominal exchange rate adjusts fully to the relative price level, the real exchange rate is by implication not influenced, ceteris paribus, by such aggregate price movements.

The logarithm of the lagged ratio of industrial capacity utilisation captures the influence of the comparative cyclical state of real activity. The coefficient of -0.49 indicates that for each percentage point of relatively higher (lower) capacity utilisation in Switzerland than in Germany the Swiss franc will appreciate (depreciate) by 0.5 percent. At this time, it remains undetermined by which potential path this cyclical effect mainly arises. It could be, for example, via profitability, share prices, or anticipated monetary policy reaction.

The logarithm of the lagged US-dollar exchange rate for the D-mark has a long-run coefficient of -0.061. This implies, for example, that a 10 percent increase in that exchange rate, i.e. a corresponding depreciation of the US-dollar, will lead to an appreciation of the Swiss franc vis-à-vis the D-mark by 0.6 percent. As already explained, both the D-mark and the Swiss franc tend to appreciate (depreciate) when the effective dollar weakens (strengthens), but the relative impact on the Swiss franc is usually somewhat larger. On account of simultaneity problems, the presumably larger unlagged response within a calendar quarter would be traceable only with a system of at least two equations, in which the reaction patterns of the US-dollar vis-à-vis the D-mark are also modelled.

The difference between Switzerland and Germany regarding the current account to GDP ratio shows a response parameter of -0.009. This means, for example, that with a +7 percent ratio for Switzerland and a +2 percent ratio for Germany the Swiss franc would on that account alone be some 4½ percent [i.e. -0.009 (7-2)=-.045] stronger vis-à-vis the D-mark.

The economic and monetary unification of Germany in 1990 introduced a large structural break into the German current account data. Because of that break the relative current account variable in the model is considered reliable only until April 1990. After that date only the mean impact of the relative current account balance is included in the form of the negative coefficient of the level dummy variable *D90UNIF*.[5] If the entire value of that coefficient of -0.05 is attributed to the mean of the difference between the scaled current account balance of Switzerland and Germany, then this would correspond to a pre-unification effect of an average excess of the Swiss current account to GDP ratio of some 5½ percentage points, whereas the actual data for the period 1990Q3 – 1996Q1 show an average excess of more than 7 percentage points. The German current account data for the 1990s are subject to some further problems as the introduction of interest rate taxation led to large-scale tax evasion which induced considerable outflows of capital and inflows of interest income. It seems that the latter type of interest receipts has so far not been adequately registered in the German current account data. This implies a corresponding downward bias in the latter during the most recent years.

The transitory dummy variable *D89WALL* is intended to capture the temporary appreciation of the D-mark in connection with the international euphoria created by events symbolised by the fall of the Berlin wall. This is estimated to have resulted in a depreciation of some 2 percent of the Swiss franc vis-à-vis the D-mark in the last quarter of 1989 and the first quarter of 1990. Finally, the model contains a seasonal shift which is related to the current account variable, the seasonal adjustment of which is not appropriate for the current purpose.

The equation shows a cointegration regression Durbin-Watson statistic of 1.89. This result is close to the ideal value of the Durbin-Watson statistic for a stationary white-noise stochastic process, and it is obviously very significantly different from zero, which is the expected value of this statistic under the null hypothesis of non-cointegration. As the latter hypothesis is thus rejected, the estimated relationship can be considered as stationary and to have a valid error-correction representation according to Engle and Granger (1987). The null hypothesis of non-cointegration seems also rejected by an Engle-Granger unit root test on the cointegration residual, but in this case the critical values can only be derived by approximate extrapolation from MacKinnon (1991), as criteria for potential cointegration equations with more than six stochastic variables are not provided.

The estimated error-correction equation for the first differences of the logarithm of the Swiss franc exchange rate for the D-mark ($\Delta LSFDM$), which represents the second step of the estimation procedure, is summarised in Table 2. The last variable listed in this equation is the lagged error-correction term ($LSFDM_{-1} - LSFDM^*_{-1}$). Its coefficient of -1.147 implies that any difference between the actual level of the exchange rate and its equilibrium value according to the cointegration equation in Table 1 will practically be fully corrected after one calendar quarter.[6] Both the large absolute magnitude and the high t-value of the error correction coefficient confirm the stationary character of the cointegration equation and the validity of the error-correction representation. Moreover, the summary statistics of this equation suggest a good approximation to the unknown data generation process. The standard error of the regression is 0.007, i.e. about 0.7 percent of the exchange rate level. The adjusted R-square of 0.86 indicates that only 1/7 of the total variance of the exchange rate changes in the sample period remains unexplained. The Durbin-Watson statistic of 1.84 lies close to the ideal value of 2.0 for a stationary white-noise residual.

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[5] It seems that, in fact, after about two years of transition following unification, the pre-unification type of sensitivity to the changing current account situation was re-established. Pursuing that line of approach in the present paper, however, would have left much fewer observations for the following post-sample prediction tests, which are a crucial part of the paper.

[6] Actually, the point estimate, which is in excess of unity in absolute value, suggests some initial overcorrection. The difference to -1 is, however, not significant according to all standard test criteria. In any case, as the feedback is negative, only a coefficient value of -2 or smaller for the error correction term would imply an unstable adjustment process. It can also be observed that the quarterly unit period of the estimated model is relatively long for the fast reacting foreign exchange markets; this may tend to lead to a large absolute value of the error-correction coefficient, provided also that the cointegration equation is quite well specified.

Table 2
Error-correction equation*

$$
\begin{aligned}
LSFDM \approx{} & \underset{(3.78)}{1.002}\Delta LPCSD - \underset{(5.52)}{0.019}\Delta RDISD - \underset{(5.78)}{0.015}\Delta M2R3MSD - \underset{(9.53)}{0.019}\Delta\left[R3YSD - R3MSD\right] - \underset{(4.51)}{0.457}\Delta M2LCUSD_{-3} \\
& - \underset{(2.33)}{0.055}\Delta LUSDM_{-1} - \underset{(4.87)}{0.011}\Delta\left\{M2CCAGSD_{-1}\left[1 - D90UNIF\right]\right\} - \underset{(4.07)}{0.029}\Delta D89WALL - \underset{(2.51)}{0.030}\Delta D90UNIF \\
& + \underset{(6.32)}{0.09}\Delta\left\{SD24\left[1 - D90UNIF\right]\right\} - \underset{(6.82)}{1.147}\left[LSFDM_{-1} - LSFDM*_{-1}\right]
\end{aligned}
$$

Sample period	**1979Q2 – 1991Q2**
Durbin-Watson statistic	1.838
Standard error of regression	0.007
Adjusted R-square	0.864

Note: Absolute values of the standard t-statistic are shown below the coefficients.
* Estimation method: Two-step OLS according to Engle and Granger (1987).

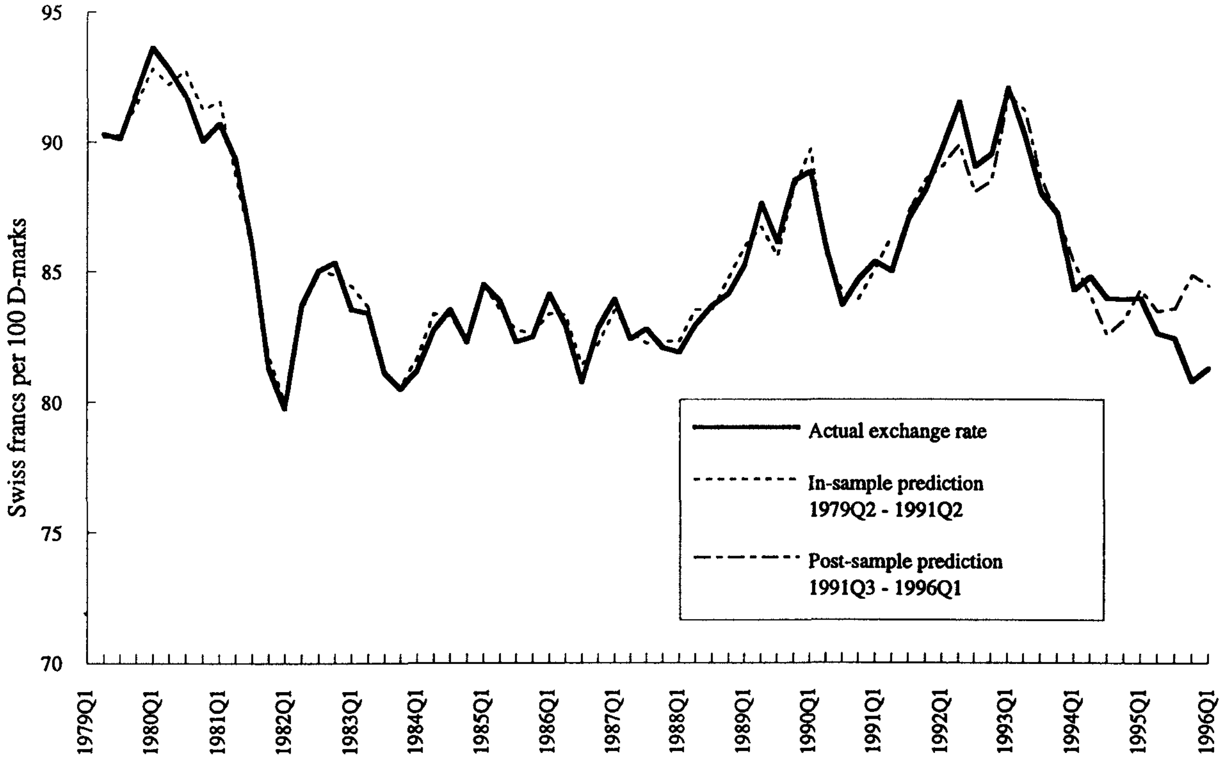
The short-run response coefficient of the nominal exchange rate with regard to price level changes is unity, i.e. the same as in the cointegration equation. This means that even in the short run the real exchange rate remains, ceteris paribus, unaffected by changes in relative consumer prices between Switzerland and Germany. It does not, however, imply a constant real exchange rate in agreement with purchasing power parity, since the other explanatory variables affect the nominal and real exchange rate in equal proportions, both in the short and longer run. The estimated immediate responses to changes in those other explanatory variables do not differ in sign but to some extent in magnitude from the corresponding equilibrium responses in the cointegration equation. Any remaining difference will be almost fully corrected after one calendar quarter via the lagged error correction term.

The in-sample period of the model was chosen to go only to the second quarter of 1991. The choice of this early endperiod left up to 19 calendar quarters for post-sample testing, which is crucial for determining the validity of an empirical exchange rate model.

3. Tests of the accuracy of post-sample predictions

Figure 1 visually illustrates the quarterly development of the Swiss franc/D-mark exchange rate for the period 1979Q2–1996Q1 as a thick solid line and the corresponding model-based in-sample predictions for the period 1979Q2–1991Q2 as a broken line. The tracking performance looks rather good. The post-sample predictions for the period 1991Q3–1996Q1 are indicated by a dash-dotted line. They correspond to the post-sample projection values from the cointegration equation. These predictions are somewhat less accurate than the in-sample results. But their overall tracking performance can be judged as quite satisfactory considering that in this case the post-sample horizon extends over 19 calendar quarters and that no information on the actual exchange rate between 1991Q3 and 1996Q1 was used for these out-of-sample predictions. The largest prediction errors appear in 1995Q4 and 1996Q1, after the Swiss franc appreciated on account of a much discussed speculative surge away from the D-mark. The surge which began in the second half of 1995Q3 related to fears concerning price stability and interest rate levels in the future European Monetary Union. Although the present version of the model is not sufficiently complete to endogenously explain this speculative movement, it does permit to derive an ex post estimate of around 5 percent for the magnitude of this appreciation.

Figure 1
Quarterly development of the Swiss franc exchange rate for the D-mark



In agreement with the well-known type of prediction tests for exchange rates originally associated with Meese and Rogoff (1983a, 1983b), the out-of-sample predictions of the estimated model are based on actual rather than on predicted values of the fundamental explanatory variables. As no data on the dependent variable from within the respective prediction horizon were to be used, the results shown in Table 3 neglect the error-correction equation and thus are done with the cointegration equation only.[7] The post-sample predictions for 1991Q3–1996Q1 illustrated in the graph on the preceding page provide the first set of fundamental-model predictions. They are based on the parameters of the cointegration equation estimated to 1991Q2. Then the observations for 1991Q3 are added to the in-sample data and the cointegration equation is re-estimated to generate predictions for 1991Q4–1996Q1. After successively adding one quarter to the in-sample period until the latter extends to 1995Q4 a total of 19 rolling cointegration regressions are estimated from which a set of predictions for the respective post-sample time periods is calculated. These predictions are compared with the naive (no change) forecasts of the random walk model.

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[7] The neglect of not only the error-correction term but also the short-run dynamics incorporated in the error-correction equation can be expected to decrease the accuracy of the fundamental model predictions. But since the quarterly unit period of the present empirical application is relatively long in comparison with the fast reactions of the foreign exchange market to fundamental news, there are only minor differences in the response coefficients between the cointegration equation, which was used, and the error-correction equation, which was not used for the predictions.

Table 3

Out-of-sample prediction statistics for the level of the Swiss franc exchange rate of the D-mark

1991Q3 – 1995Q2 (1991Q3 – 1996Q1)

Horizon (quarters)	**Number of prediction samples (rolling regressions)**	**Root mean square error of**	
		Random walk (percent)	**Fundamental model (percent)**
1	16 (19)	1.9 (1.8)	1.0 (1.8)
4	13 (16)	4.4 (4.2)	1.2 (2.2)
8	9 (12)	6.7 (6.6)	0.9 (2.2)
12..	5 (8)	6.3 (8.3)	1.1 (2.8)
16..	1 (4)	2.9 (7.6)	1.5 (3.2)

The latter uses no information on the fundamental variables but sets the exchange rate forecast for any period equal to the actual exchange rate value preceding the beginning of the forecast period. Despite the very naive character of the random walk model used as a benchmark for comparison, predictions of fundamental exchange rate models (generally some variants of the monetary asset market approach) using the actual future values of the fundamentals have, in the past, mostly failed to dominate the simplistic random walk forecasts for different time horizons. The corresponding prediction comparisons regarding the exchange rate model of this paper show, however, a clear dominance of the fundamental model over the random walk scheme.

In Table 3, the prediction results for the quarterly level of the Swiss franc rate for the D-mark are summarised for horizons of 1, 4, 8, 12 and 16 quarters. The table gives averages for predictions ending in 1995Q2 as well as, in brackets, for predictions which also include the subsequent three quarters, when the Swiss franc was subject to the above-mentioned speculative appreciation surge. The out-of-sample prediction statistic used for comparison is the root mean square error (RMSE), i.e. the square root of the average of the squared forecast errors. Except for the one-quarter horizon predictions extending to 1996Q1, which indicate a draw, the fundamental model has much smaller RMSE values than the random walk model. The differences range from 0 for the one-calendar-quarter horizon predictions ending in 1996Q1 to 6.2 percentage points for the twelve-quarter horizon predictions ending in 1995Q2. The random walk model's RMSEs are preponderantly several times as large as those of the fundamental model.

Conclusion

Of course, actual forecasting with this fundamentals-based model will be less accurate than out-of-sample prediction, because the explanatory variables themselves have to be forecasted as well. It still remains to be shown that the random walk can be beaten also in an actual forecasting context for short as well as longer-run horizons. Nevertheless, even without proof of such superior forecasting ability the model presented should be quite helpful for developing much improved scenarios for past and future developments of the Swiss franc exchange rate of the D-mark.

Corresponding sets of macroeconomic fundamentals to the ones chosen to model the Swiss franc/D-mark exchange rate from the late 1970s to the mid-1990s will not necessarily be sufficient for other exchange rate contexts. But they may still prove to form an essential part of similarly successful fundamental-based models of other flexible exchange rates as well.

The results of the fundamental model of the Swiss franc rate for the D-mark also provide some suggestions about the potency of monetary policy for exchange rate developments. For example, if the Swiss National Bank lowers its average discount rate in comparison with the discount rate of the Bundesbank by one percentage point, the average Swiss franc rate will, as a direct effect, depreciate by almost 2 percent in the same quarter and by about another ½ percent in the following quarter. The cut in the discount rate (accompanied by a similar reduction in the day-to-day rate of interest) could exert some additional depreciation pressure indirectly via its effects on the market rates of interest. When previously estimated reaction patterns of three-month and three-year Swiss franc interest rates[8] are also taken into account, this indirect effect turns out to be negligible on balance. The initial exchange rate depreciation will, at first, be re-enforced and later weakened via changes in the current account balance.[9] It will, after some delay, be reduced also on account of improvements in industrial capacity utilisation in Switzerland.[10]

In conclusion, the present behavioural type of exchange rate model seems to be a promising alternative fundamental approach. Its success in the post-sample prediction tests of this paper stands in marked contrast to the experiences with applied monetary models based on the asset market approach, which by now have been dominant in the literature for almost two decades. But the single-equation specification in this paper should in the future be succeeded by a multi-equation system. Thereby, problems arising from simultaneity and dynamic interdependence among the variables could be taken into account more effectively. In the present model such issues were dealt with only partially by lagging some regression variables and by excluding, in particular, any measure of relative money supply in favour of the more autonomous discount rate differential. In future applications it should also be worthwhile to shorten the unit period of the empirical model to one month or less, since, as already mentioned, the quarterly unit period seems long in comparison with the speed of reaction to fundamental news in the foreign exchange market.

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[8] Ettlin and Bernegger (1994).

[9] See footnote 5.

[10] For an attempt at a comprehensive quantitative assessment of the effects of a change in central-bank interest rates in Switzerland, see Ettlin (1995b).

List of variables

LSFDM	Natural logarithm of the Swiss franc exchange rate for the D-mark; quarterly average of daily spot rates.
*LSFDM**	Equilibrium level of LSFDM according to the cointegration equation.
LPCSD	Logarithm of the ratio of the consumer price index of Switzerland to that of Germany; quarterly average of monthly data.
RDISD	Difference between the official discount rate in Switzerland and Germany; quarterly average of beginning and end-of-month rates expressed as percentage points per annum.
R3MSD	Difference between the three-month Euromarket deposit rate for the Swiss franc and the D-mark; quarterly average of daily data expressed as percentage points per annum.
R3YSD	Difference between the three-year Euromarket deposit rate for the Swiss franc and the D-mark; quarterly average of daily data expressed as percentage points per annum.
LCUSD	Logarithm of the ratio of industrial capacity utilisation in Switzerland to that in Germany; once-per-quarter observations.
LUSDM	Logarithm of the US-dollar exchange rate for the D-mark; quarterly average of daily spot rates.
CAGSD	Difference between the current account to nominal GDP ratio of Switzerland and that of Germany; percentage points based on seasonally adjusted quarterly data.
D89WALL	Dummy variable related to the fall of the Berlin wall; one for 1989 Q4 and 1990 Q1 and zero otherwise.
D90UNIF	Dummy variable related to the German Economic and Monetary Unification in 1990; zero until 1990 Q1, two-thirds for 1990 Q2 and one thereafter.
SD24	Dummy variable with the value 1 in the second quarter and -1 in the fourth, implying a seasonal shift between the second and the fourth quarter.
M2...	Two-period moving average of the subsequently indicated variable.
M2C...	Centred two-period moving average of the subsequently indicated variable.
Δ	First backward difference of the indicated variable.

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Comments on paper by Franz Ettlin by G. Galati (BIS)

The objective of this paper is to build a model of the Swiss franc-DM exchange rate based on economic fundamentals that performs well as predictor of short- and medium run future exchange rate movements. It tries to improve on the poor forecasting performance of exchange rate models based on fundamentals compared to a simple random walk model, as documented in the literature (Meese and Rogoff, 1983).

The Swiss franc-DM exchange rate is represented by a single equation which has on the right hand side variables that economic agents might plausibly look at when they form their views on future exchange rate movements. These variables include two interest rate differentials (between discount rates, 3-month Eurorates) and a yield curve differential, the ratio of the CPI in the two countries, the ratio of capacity utilisation, the current account-GDP ratio, and the DM-US dollar exchange rate lagged one period. Furthermore, two dummies are included - one to capture the "international euphoria" following the collapse of the Berlin wall in 1989, and the other to capture the German monetary unification in 1990. The presence of two interest rate differentials is dubious on grounds of multicollinearity, while the inclusion of two dummies makes this approach more difficult to extend to other exchange rates. It would be interesting to see how well this approach can work for other exchange rates.

The model is estimated in error correction form using the Engle-Granger two step procedure with quarterly data from 1979.II (the start of the ERM) to 1991.II. All the coefficients turn out to be significant and the fit of the error-correction equation is judged to be good. However, the number of explanatory variables (eleven in the error-correction equation and ten in the cointegration equation) looks high compared with the number of observations. It would be useful (as the author admits) to estimate the model with data of monthly or higher frequency.

The model is then used to compute in-sample predictions as well as rolling out-of-sample forecasts over different horizons. The out-of-sample predictions are computed using actual values for the explanatory variables and only past values of the exchange rate (consistent with the approach followed by Meese and Rogoff). They are based on the cointegration equation only, whereas the whole error correction model should be used. Using the root mean square error as a criterion, the model is found to dominate the random walk model over all horizons beyond one quarter, and especially over longer horizons. The model, however, performs poorly during periods of tension in European markets and dollar weakness, for example in the fourth quarter of 1995.

An interesting finding of the paper is that even after controlling for macroeconomic and financial variables and indicators of monetary policy, changes in the Swiss franc-DM exchange rate are influenced by changes in the dollar-DM exchange rate: a 10% depreciation of the dollar vis-à-vis the DM leads to a 0.6% appreciation of the Swiss franc vis-à-vis the DM. This is consistent with BIS (1996) which estimates the elasticity of dollar exchange rates of different European currencies, the Australian and the Canadian dollar with respect to the dollar-DM exchange rate from bivariate regressions. Using daily data for rolling samples of 125 days over the period 1994 to 1996, it finds a differentiated response to dollar-DM exchange rate changes: at one side of the currency spectrum, the Swiss franc appreciates by 1.1% with respect to the dollar following a 1% appreciation of the DM with respect to the dollar. The coefficients of other European exchange rates lie between 0 and 1, with coefficients of currencies like the Dutch Guilder or the Belgian franc closer to 1 and those of the Italian lira and the British pound closer to 0. At the other side of the spectrum, the Australian and the Canadian dollar fall against the US dollar when it falls against the DM.

Moreover, the elasticities are not stable over time: periods of dollar weakness (strength) are associated with falling (rising) elasticities of the European currencies and a rising (falling) elasticity of the Canadian dollar. It would be interesting to see how the coefficient of the DM-dollar exchange rate in Ettlin's model changes in 1995.IV.

Although there are a number of studies that have looked at the links between exchange rates, these results are more recognised than understood in the literature. The author's view can be identified with what is known as the *moka Tasse* effect, i.e. shifts in asset demand having larger effects on the exchange rate the larger the size of the shift relative to the underlying asset stock. Earlier work on this interpretation by Giavazzi and Giovannini (1989) looks at the offshore market size by currency of denomination and compares it with the economic importance of a country (proxied by its GNP share). They argue that in countries that have relatively small financial markets because of transaction costs arising from capital controls, the DM (dollar) exchange rate is more (less) exposed to movements in the value of the dollar. Ongoing research at the BIS finds that the order of sensitivities of each dollar exchange rate is significantly correlated with the order of international banking intensity as measured by the ratio of international and Eurodeposits to GDP.

However, there are other possible explanations of the observed exchange rate links. The same factors used by the author to explain the Swiss franc-DM exchange rate may also drive the correlation coefficients of the Swiss franc-DM or other DM exchange rates with the DM-dollar rate. These include the relative cyclical position of the home country, Germany and the US, and the relative stance of monetary policy. Another interpretation looks at the structure of trade as a determinant of exchange rate links (Brown, 1979).

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