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In 2004 all publications will carry a motif taken from the €100 banknote.

1 The opinions expressed in this paper are those of the author only and do not reflect the views of the European Central Bank or the European System of Central Banks. The work has benefited from comments by Peter Christoffersen, Stelios Makrydakis, Stefano Mazzotta and seminar participants at an internal ECB seminar, as well as useful discussions with Richard Lyons and Kenneth Froot. All remaining errors are mine.

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Abstract: This paper assesses the contemporaneous, leading and lagging indicator properties of financial market variables relative to movements in six major developed country currency pairs. As indicator variables changes in various relative asset prices, short-term portfolio flows and currency options data are used. We find that changes in equity index differentials, short-term speculative flows and risk reversals on currency options prices exhibit consistent contemporaneous indicator properties and leading indicator properties for several currency pairs. Since 1999, changes in short-term interest rate differentials have gained importance as indicators. The best indicator variables explain over 50% of monthly returns of the USD/EUR and GBP/USD exchange rates and over 60% of the appreciation and depreciation episodes of the USD/EUR and JPY/EUR currency pairs.

JEL classification: F31, F32, G15

Keywords: Exchange rates, asset prices, capital flows, leading and lagging indicators, market microstructure.

Non-technical summary

Recent advances in theoretical research in exchange rate determination have provided important new insights to short-term exchange rate determination. Moreover, improved access to data, in particular on cross-border financial flows, has facilitated empirical research in the area. In this paper we provide an evaluation of the indicator properties of a large set of financial market variables vis-à-vis monthly exchange rate returns. The particular questions we ask are: do financial market news convey information about future economic fundamentals that are capable of moving exchange rates? Are some indicators more relevant than others, and do they work consistently for all currencies? Are episodes of appreciation and depreciation symmetrically called?

In our investigation, we focus on the main euro bilateral exchange rates, namely the USD/EUR, JPY/EUR and GBP/EUR, as well as the JPY/USD, USD/GBP and CHF/USD currency pairs. The set of indicators encompasses variables used in earlier studies, as well as factors frequently quoted by financial market participants and financial press as “determinants” of short-term currency movements. To that end, we consider variables such as options prices and short-term speculative flows whose properties have not yet been extensively investigated in the context of exchange rate models.

Within the sample period considered (August 1986-March 2003), our estimations unearth strong evidence of contemporaneous and leading indicator relationships between changes in a number of financial market variables and exchange rate returns over the monthly horizon. In terms of explanatory power, the “best” contemporaneous indicators are risk reversals on currency options prices, net speculative flows, equity index differentials and, after 1999, short-term interest rate differentials. These variables produce adjusted R^2 values in excess of 50%, or explain over 60% of episodes, in the main bilateral euro exchange rates. Most of these variables also exhibit good leading indicator properties vis-à-vis several exchange rates. Net equity flows almost consistently dominate net bond flows in explaining exchange rate fluctuations. When incorporated in multivariate models, the relative ranking of the individual variables tends to be confirmed. The estimations also revealed interesting differences as to the ability of indicator variables to explain fluctuations in various currency pairs. In particular, the rather poor results obtained for short-term interest rate differentials in explaining movements in the Japanese yen exchange rates could be related to the fact that throughout a significant part of the sample period, short-term interest rates in Japan were close to zero. The increased importance of short-term interest rate differentials in explaining the euro exchange rates since the launch of the single currency could, in turn, suggest that the relationship between the interest rates and exchange rates might have been temporarily distorted by the EMU convergence process throughout the 1990s. Net equity flows work as a rather good indicator for contemporaneous movements for many US dollar exchange rates, whilst net bond flows scored markedly worse. This finding is likely to reflect different trading practices. Cross-border transactions in bonds tend to be hedged against currency risk that counters any impact on exchange rates, whereas equity transactions are not hedged. This asymmetry is a result of the different risk characteristics of the underlying assets, whereby the currency risk component is more dominant relative to the own market risk component for bonds and *vice versa* for equities.

The results using euro area data prior to 1999 are also in line with results obtained using corresponding data from the largest euro area economy. We conclude that news in financial asset prices and financial flows are useful indicators for monitoring and analysing exchange rates in short horizons. To this end, they are likely to effectively convey information on future economic fundamentals.

1. Introduction

Effective monitoring of monthly exchange rate movements requires understanding about the driving forces behind short- and medium term currency movements. To this end, the classic approach to short-term exchange rate determination is the uncovered interest rate parity (UIP) condition. However, the empirical problems frequently encountered with the UIP have prompted a search for factors that could better account for the fluctuations in exchange rates. This task has been intensified by the vast expansion of volumes in international financial flows over the past decade, as well as the almost world-wide surge in equity prices witnessed in the second half of the 1990s. These phenomena typically reflect the increased ability of international investors to exploit arbitrage opportunities across the globe, following the abolition of barriers to capital mobility. As a by-product, exchange rates have become increasingly driven by asset prices rather than trade transactions.

Recent advances in theoretical research have provided important new insights to short-term exchange rate determination. On the other hand, improved access to data in particular on cross-border financial flows has facilitated empirical research in the area. The contribution of this paper is to provide an evaluation of the indicator properties of a large set of financial market variables vis-à-vis monthly exchange rate returns. The particular questions we ask are: do financial market news convey information about future economic fundamentals that are capable of moving exchange rates? Are some indicators more relevant than others, and do they work consistently for all currencies? Are episodes of appreciation and depreciation symmetrically called? In our investigation, we focus on the main euro bilateral exchange rates, namely the USD/EUR, JPY/EUR and GBP/EUR, as well as the JPY/USD, USD/GBP and CHF/USD currency pairs. The set of indicators encompasses variables used in earlier studies, as well as factors frequently quoted by financial market participants and financial press as "determinants" of short-term currency movements. To that end, we consider variables such as options prices and short-term speculative flows whose properties have not yet been extensively investigated in the context of exchange rate models.

Within the sample period considered (August 1986-March 2003), our estimations unearth strong evidence of contemporaneous and leading indicator relationships between changes in a number of financial market variables and exchange rate returns over the monthly horizon. In terms of explanatory power, the "best" contemporaneous indicators are risk reversals on currency options prices, net speculative flows, equity index differentials and, after 1999, short-term interest rate differentials. These variables produce adjusted R^2 values in excess of

50%, or explain over 60% of episodes, in the main bilateral euro exchange rates. Most of these variables also exhibit good leading indicator properties vis-à-vis several exchange rates. Net equity flows almost consistently dominate net bond flows in explaining exchange rate fluctuations. When incorporated in multivariate models, the relative ranking of the individual variables tends to be confirmed. Overall, the results are rather consistent across currency pairs. The results using euro area data prior to 1999 are also in line with results obtained using corresponding data from the largest euro area economy. We conclude that news in financial asset prices and financial flows are useful indicators for monitoring and analysing exchange rates in short horizons. To this end, they are likely to effectively convey information on future economic fundamentals.

The rest of this paper will proceed as follows. Section 2 discusses the theoretical approach and specifies the econometric model. Section 3 introduces the data. Section 4 reports the estimation results. Section 5 concludes.

2. Related research and theoretical considerations

The workhorse empirical model for short- and medium term exchange rate pricing is the uncovered interest rate parity condition (UIP). This relationship assumes that exchange rates instantaneously adjust to changes in relative interest rates between two economic areas so as to eliminate arbitrage opportunities. The change in relative interest rates, in turn, tends to reflect changes in expected future economic fundamentals that are associated with nominal and real exchange rate determination.

More recently, several researchers have attempted to extend the set of financial variables that incorporate information on future fundamentals and could thus be used for explaining short-term exchange rate movements. In this context, analysis of the role of equity prices and short-term financial flows (see for example Brooks et al, 2001, Hau and Rey 2002) has been motivated by the vast increase in cross-border financial flows and improved data availability on such transactions. These studies broadly argue that short-term equity flows could have an impact on exchange rates if market imperfections do not allow the transactions to be fully reflected in relative asset prices. On the theoretical side, the role of information aggregation and market composition in transmitting signals on expected future fundamentals has been brought forward by the research in market microstructure. Lyons (2001) and Evans and Lyons (2002) have shown that private information about the state of economic fundamentals, as incorporated in the order flow to the FX market, is only gradually aggregated in the market and can generate exchange rate volatility. Jeanne and Rose (2002) suggest that only a part of the market participants rely on "hard" data on fundamentals while the rest would form their expectations on currency prices mainly by extrapolating historical trends using technical trading rules. A predominance of non-fundamentalists can, in turn, contribute to protracted swings in exchange rates and asset prices due to herding behaviour and bandwagon expectations as suggested by Morris and Shin (2003). What these arguments also suggest is that financial market data could be related to exchange rates with varying lags. In other words, rather than adjusting instantaneously to restore the portfolio equilibria, some indicators might move prior to the exchange rate while others could move only after the change in the exchange rate has realised.

To analyse the properties of financial market variables in providing information on future fundamentals and explaining short-term exchange rate movements we model the exchange rate in the standard asset-pricing framework. In that context, the log exchange rate s_t reflects the discounted value of private agents' expectations about future economic fundamentals f_{t+i}:

$$s_t = (1-\delta)\sum_{i=0}^{\infty} \delta^i E_t(f_{t+i} | \Omega_t, I_{t+j}) \quad (i=0,1,2,\ldots\infty;\ j=-1,\ 0,\ 1) \tag{1}$$

In (1), δ denotes the discount factor, E the expectations operator, Ω_t the private agents' information set available at time t, and I_{t+j} captures the financial market news released at time $t+j$ that affects the time t information set about future expected fundamentals. In the case where $j=0$, the news in the financial market variable has a contemporaneous impact on the current information set and hence on the current exchange rate. When $j=-1$ the indicator shows leading indicator properties; yesterday's movement in the financial market data affects today's exchange rate. For example, asset prices or financial flows could lead exchange rate movements if the information is only gradually aggregated or if the FX market is dominated by traders who apply technical trading rules. Finally, $j=1$ means that financial data has lagging indicator properties as it moves one period after the exchange rate movement. An example of such indicator could be cross-border portfolio flows that are often triggered by expectations of near-term exchange rate appreciation.[2]

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[2] The formulation of (1) is rather general and as such it encompasses several theoretical formulations including UIP (with I replaced by the short-term interest rate differential), Frankel's (1979) monetary model (with I replaced by the long-term interest rate differential) and Evans and Lyons' (2002) order flow model (with I replaced by order flow).

A test of the hypothesis that financial market data at time *t+j* could provide valuable information about exchange rate movements at time *t* amounts to testing that

$$s_t = (1-\delta)\sum_{i=0}^{\infty}\delta^i E_t(f_{t+i}|\Omega_t, I_{t+j}) \neq s_t = (1-\delta)\sum_{i=0}^{\infty}\delta^i E_t(f_{t+i}|\Omega_t) \quad (2)$$

To test this hypothesis empirically, we specify an econometric model that estimates the impact of contemporaneous, leading or lagging changes in a set of *k* financial market variables on the current change in the log exchange rate as follows.

$$\Delta s_t = \alpha + \sum_{k=1}^{n}\beta_k \Delta I_{k,t+j} + \varepsilon_t \quad (3)$$

The aim of the regressions is to assess the fit of the model through the adjusted R^2 and to check how close the estimates of α are to zero and how close the estimates of β are to one. The estimations are first run as univariate regressions (indicator-by-indicator), followed by multivariate regressions where the combinations of right-hand side variables are specified according to particular model selection criteria. The purpose of the latter estimation is to establish the relative merit of the individual variables in explaining short-term exchange rate movements.

Our data set – that is described in more detail in section 3 below – consists of indicator variables that can be broadly divided into two sub-categories. First, we measure ΔI with asset price based indicators. In particular, it is assumed that the changes in the relative short-term interest rates, long-term interest rates or equity indices would be related to movements in exchange rates, with increasing relative returns in the home country being indicative of appreciation of the domestic currency vis-à-vis the foreign currency. This specification follows the spirit of the market microstructure literature where the short-term exchange rate determination follows the intuition of portfolio balance model. Second, ΔI is measured by a set of variables capturing changes in net portfolio capital flows between economic regions. The hypothesis is that an increase in net capital outflows from the home country would be associated with a depreciation of the home currency relative to the foreign currency. This would follow from the increased demand for foreign currency to finance the asset transactions, as suggested by Brooks et al (2001). Empirically, such transactions *per se* tend to be too small to affect exchange rates; however, in so far as the associated order flows generate information aggregation (as described by Lyons, 2001) the exchange rates could adjust. Finally, we also incorporate risk reversals on currency options as a measure of ΔI that reflects genuinely forward-looking characteristics. An increase in risk reversal, that measures the difference in implied volatility between similar put and call options, indicates expectations of appreciation of the base currency used in the quotation of the underlying option. If the market participants adjust their positions in view of expected future movements already today, changes in risk reversals could trigger also contemporaneous exchange rate effects.

3. Data sources

The data contains monthly observations from the last trading day of the month until March 2003. Due to the availability of data, the length of the sample period varies somewhat between indicators considered. In particular, for interest rates and equity market indices, the sample period starts in August 1986, while the period is somewhat shorter for capital flows (starting in January 1988) and risk reversals (starting in March 1992).

The sources of the various data are as follows. The bilateral currency pairs considered are USD/EUR, GBP/EUR, JPY/EUR, JPY/USD, USD/GBP and CHF/USD. These bilateral exchange rates are the ones most frequently used in international trade and financial transactions. Moreover, the bilateral euro exchange rates included in the sample together represent some 65% of the euro nominal effective exchange rate basket. The data for the bilateral euro exchange rates are the ECB reference rates, whilst the bilateral US dollar rates (apart from the USD/EUR) are obtained from the BIS. All exchange rates are expressed in log differences, *i.e.* monthly returns. Like in most related studies (see Brooks et al., 2001 and Froot and Ramadorai, 2003), we use the "synthetic" euro exchange rates prior to January 1999. This is consistent with our choice of indicator variables that use euro area wide measures already prior to January 1999.

Turning to the explanatory variables, the short-term interest rates we use are the 1-month euro-currency deposit rates for the euro, the US dollar, the UK pound sterling, the Japanese yen and the Swiss franc, all available from the BIS. The long-term interest rates are the secondary market 10-year nominal benchmark Treasury bond yields for the euro area, US, UK, Japan and Switzerland, that are also available from BIS. Stock market data consists of local currency denominated total return indices for the euro area, the US, the UK, Japan and Switzerland, obtained from Financial Times Actuaries. Prior to 1999 the euro area index is proxied by the Europe ex-UK index that closely tracks the euro area series. All returns are continuously compounded and expressed in monthly percentage changes. Regarding the capital flow variables, three distinct sources of data are used. Monthly figures on portfolio bond and equity flows for all individual euro area countries are obtained from the US Treasury TIC database and aggregated to yield a measure of euro area flows. Since all these flows are measured as net inflows to the US, no data is available for flows between the euro area and Japan or the UK. To partially compensate for this loss, we also consider the equity flows obtained from the Union Bank of Switzerland (UBS) proprietary trading data. While this database only covers the time period from January 1999 onwards, it includes data on cross-border transactions between all major economic regions. Data on the short-term speculative accounts consists of figures on the net positions taken on currency futures at the Chicago International Money Market that are downloaded from Bloomberg. Data on risk reversals are based on OTC trading figures, obtained from Citibank.

The descriptive statistics of the time series of the various monthly returns are reported in Appendix 1. For many return series considered, particularly the exchange rates, equity indices and most capital flow variables, the distributions are skewed and leptokurtotic which is a clear indication of non-normality. This is confirmed by the Jarque-Bera normality test that for the above mentioned variables often strongly rejects the hypothesis of normally distributed returns. On the other hand, the Ljung-Box test statistics reveal that autocorrelation is an issue particularly for the short- and long term interest rates, risk reversals and portfolio bond and equity flows. Such characteristics are not uncommon for financial time series, and need to be reflected in the choice of the estimation technique.

4. Estimation results

Our estimation strategy consists of two phases. First, we run estimations of exchange rates on various financial market indicators applying linear regression methods. Second, in order to measure the ability of the indicator variables to signal the probability of larger appreciation/depreciation episodes in a monthly horizon, we apply the binomial logit technique. In both linear and non-linear cases, the estimations are first run on univariate basis. We then specify a set of multivariate models on the basis of the performance of the individual indicators in the univariate regressions. The motivation for considering multivariate models as well is to assess the relative explanatory power of the individual indicators as well as to investigate whether the goodness-of-fit of the model can be improved by incorporating several variables. This “specific to general” model selection strategy is different than often applied in macroeconomic analysis where a general model is first specified and a specific model is arrived at by successively eliminating non-significant variables. Here, however, our focus is to assess the relative performance of the individual variables rather than searching for the "best" multivariate model combination. We therefore follow the avenue adopted in studies of volatility indicator performance where multivariate models serve as a complementary evaluation tool (see Christoffersen and Mazzotta, 2004, and Jorion, 1995).

4.1. Linear regressions

Because our data, as is often the case with financial market series, is characterised by heteroscedasticity and serial correlation, we invoke the generalised methods of moment (GMM) technique where the standard errors are corrected for such disturbances. More importantly, we choose GMM because of the simultaneity problems associated with endogeneity that complicate the assessment of the direction of causality between exchange rates and their financial determinants. Lagged explanatory variables are used as instruments throughout the analysis.

The estimations were run on two different time periods, from September 1986 (from January 1988 in the case of capital flows and March 1992 in the case of risk reversals) to March 2003, and from January 1999 to March 2003. Since the choice of the latter time period reflects the time since the launch of the euro, we also run tests to check whether the shift established structural breaks on relationships between exchange rates and their prospective financial market determinants.

4.1.1. Results from univariate analysis

The results regarding the leading and lagging indicator properties from the univariate linear estimations are summarised in Tables 2 and 3. The tables report those estimation outcomes where the slope coefficients both exhibit expected signs *and* are statistically significant. The R^2 values of the estimations on contemporaneous variables vary across indicator categories, with risk reversals and speculative flows showing generally high readings for financial market returns (in many cases between 0.3-0.5%) while the explanatory power of most other indicators is somewhat lower. The R^2s on estimations that use leading or lagging right-hand-side variables are, as could be expected, much lower and only in few cases exceed 0.1%. The constant terms tend to be very close to zeros throughout the regressions, while the slope coefficients show more variation. In the cases of short-term interest rate differentials and equity index differentials the coefficients are in most cases quite close to one. The coefficients are generally higher on the shorter sample period starting in January 1999. For the risk reversals the regression coefficients are smaller, and for the capital flow variables even more substantially so, but there is no marked difference in size across the sample periods.

When comparing the results across the various indicators and currency pairs, two general findings are worth pointing out. First, the results seem to be fairly consistent across the various exchange rates, thus indicating robust relationships and reducing the possibility of spurious regression. Second, in many cases, an indicator variable works both as contemporaneous and leading (or lagging) indicator for a currency pair. In the cases where the indicator variable works both as contemporaneous and leading indicator the exchange rate returns are likely to be characterised by persistence that could be indicative of trend-chasing behaviour in the FX market. When the variable exhibits both contemporaneous and lagging indicator properties vis-à-vis the exchange rate, it is the asset market that could be chasing the trend.

For the full sample period, changes in short-term interest rate differentials (STID) seem to work as a leading (and contemporaneous) indicator for the movements in the CHF/USD currency pair. The fact that news on the differentials in short-term interest rates do not explain the dynamics in the euro exchange rates could be related to ERM and the convergence to EMU that throughout the 1980s and 1990s dominated the developments in the euro area financial markets. Changes in long-term interest rate differentials tend to work as contemporaneous and lagging indicator for the JPY/EUR and as a lagging indicator for the GBP/EUR rate. This result suggests that a stronger pound could contribute to lower UK inflation expectations and lower long-term interest rates, although ERM related issues possibly complicate the conclusion here. Change in equity index differential (EID) is a rather consistent contemporaneous indicator for all major currency pairs, while higher domestic equity prices also seem to lag domestic currency appreciation in the case of the JPY/EUR.

Turning to the capital flow indicators, net portfolio bond flows (NBF) work as a contemporaneous and lagging indicator for the JPY/USD currency pair. The relationship suggests adaptive expectations among bond investors on further US dollar appreciation. Like relative equity prices, net equity flows (NEF) are a contemporaneous indicator for almost all US dollar currency pairs. Moreover, net speculative flows (NSF) work as a contemporaneous indicator for all currency pairs where data is available. They also exhibit leading indicator properties in the case of the USD/GBP exchange rate.

Table 1: GMM estimations using full samples

	Exchange rate					
Indicator	**USD/EUR**	**GBP/EUR**	**JPY/EUR**	**JPY/US dollar**	**USD/GBP**	**CHF/USD**
STID Lead						X
Contemp						X
Lag				X		
LTID Lead						
Contemp			X			
Lag		X	X			
EID Lead						
Contemp	X	X	X	X	X	
Lag			X			
NBF Lead						
Contemp		*N/A*	*N/A*	X		
Lag				X		
NEF Lead						
Contemp	X	*N/A*	*N/A*		X	X
Lag						
NSF Lead					X	
Contemp	X	*N/A*	*N/A*	X	X	X
Lag				X		
RR Lead				X	X	
Contemp	*N/A*	*N/A*	*N/A*	X	X	*N/A*
Lag						

Note: A cross indicates a statistically significant (at 5% level) estimator that is correctly signed. The start of the sample period is August 1986 for STID, LTID and EID; January 1988 for NBF and NEF; November 1992 for NSF; and March 1992 for risk reversals.

For risk reversals, data on euro currency options is available only after January 1999 (the D-Mark denominated data is covered below in subsection 4.3.). For the JPY/USD and USD/GBP exchange rates, risk reversals are a good contemporaneous indicator, and also show consistent leading indicator properties. Therefore, risk reversals derived from options with one-month horizon indeed exhibit forward-looking properties vis-à-vis exchange rate returns.

The results from the regressions using the shorter sample period (since January 1999) are reported in Table 3. The main difference to the longer sample is the increased explanatory power of changes in short-term interest rate differentials regarding contemporaneous movements in the USD/EUR and GBP/EUR currency pairs, and the general increase in importance of net capital flow variables. The increased role for short-term rates in exchange rate determination for USD/EUR and GBP/EUR exchange rates is most likely due to elimination of the above mentioned ERM related distortions. The improved properties of net capital flow variables in turn could reflect structural changes in the financial markets, with large capital flows associated with liberalisation of pension fund investment rules in many economic areas around the time of the change of the Millennium. Finally, the ability of short-term rates to predict future movements in the JPY/USD exchange rate has declined in the latter sample, and long-term rate interest rate spreads no longer work as an indicator for the JPY/EUR rate. The near-zero interest rates in Japan and the subsequent use of alternative channels of monetary policy, as well as occasional exchange rate intervention, could have contributed to the decline in explanatory power of interest rates regarding movements in the yen.

Table 2: GMM estimations using sample January 1999-March 2003

	Exchange rate					
Indicator	**USD/EUR**	**GBP/EUR**	**JPY/EUR**	**JPY/US dollar**	**USD/GBP**	**CHF/USD**
STID Lead	X	X				X
Contemp	X	X				X
Lag					X	
LTID Lead						
Contemp					X	
Lag		X				
EID Lead		X	X	X		
Contemp	X	X	X	X	X	X
Lag	X					
NBF Lead						X
Contemp		*N/A*	*N/A*		X	
Lag						
NEF Lead				X	X	
Contemp	X	*N/A*	*N/A*		X	X
Lag						
UBS Lead			X			
Contemp		X				*N/A*
Lag	X			X	X	
NSF Lead						
Contemp	X	*N/A*	*N/A*	X	X	X
Lag	X			X		
RR Lead			X	X	X	
Contemp	X	X	X	X	X	*N/A*
Lag	X					

Note: A cross indicates a statistically significant (at 5% level) estimator that is correctly signed.

To investigate whether the introduction of the euro in January 1999 constituted any structural breaks in the estimated relationships, we carry out Chow tests on parameter stability for all regressions. The results show that regarding the asset price variables only the contemporaneous relationship between the USD/EUR exchange rate and change in equity index differentials between the US and the euro area shows a significant structural break at 1999. This result is not entirely surprising given the increasing prominence of equities among international portfolio flows in the late 1990s and early 2000s. On the capital flow variables, only the contemporaneous relationship between the JPY/USD exchange rate and the speculative flows between the US and Japan show a break, a result that is also difficult to directly attribute to the introduction of the euro.

How do our findings compare with other related studies? Brooks et al. (2001), Rime (2000) and Hau and Rey (2002) all found that capital flow variables, and in particular equity flows, as well as changes in interest rate and equity index differentials work as contemporaneous explanatory factors for the USD/EUR and JPY/USD exchange rates. Our results seem to broadly confirm those findings, and suggest that the named variables also work for the USD/GBP and CHF/USD rates. Our main contribution is that we also find in many cases significant leading and lagging indicator properties vis-à-vis the exchange rates. In this context, the most important result from the univariate regressions could be the role played by equity markets and risk reversals in predicting short-term dynamics in several exchange rates.

4.1.2. Results from multivariate analysis

We now extend upon the univariate analysis by constructing multivariate models. The set of explanatory variables for the various currency pairs is selected according to following two-stage process. First, only those variables that in the univariate regressions received significant and correctly signed coefficients are considered. Second, the variables passing stage one are divided in two groups, "asset returns" and "financial flows", given the rather different channels the two types of variables take to affect the exchange rate. Hence, for each exchange rate, multivariate models can be constructed if at least two of the relative asset price variables or at least two of the net financial flow variables received significant coefficient estimates in the univariate regressions.[3] Given that more indicator variables received significant coefficient estimates in the post-January 1999 sample period and in the contemporaneous rather than the leading and lagging regressions, in the multivariate regressions we concentrate on the contemporaneous links in the post-euro period.

On the basis of results in Table 3, we arrive at the following 9 equations:

Model I:	$USD/EUR = \alpha + \beta_1 STID + \beta_2 EID + \beta_3 RR$
Model II:	$USD/EUR = \alpha + \beta_1 NEF + \beta_2 NSF$
Model III:	$GBP/EUR = \alpha + \beta_1 STID + \beta_2 EID + \beta_3 RR$
Model IV:	$JPY/EUR = \alpha + \beta_1 EID + \beta_2 RR$
Model V:	$JPY/USD = \alpha + \beta_1 EID + \beta_2 RR$
Model VI:	$USD/GBP = \alpha + \beta_1 EID + \beta_2 RR$
Model VII:	$USD/GBP = \alpha + \beta_1 NBF + \beta_2 NEF + \beta_3 NSF$
Model VIII:	$CHF/USD = \alpha + \beta_1 STID + \beta_2 EID$
Model IX:	$CHF/USD = \alpha + \beta_1 NEF + \beta_2 NSF$

The results from the multivariate regressions are summarised below in Table 3 (with *t*-values in parenthesis). As in the contemporaneous univariate regressions, the coefficient signs suggest that domestic currency appreciates when domestic interest rates and equity returns increase, when risk reversals move to predict future domestic currency appreciation and when capital flows register inflows to the domestic economy. Furthermore, while the coefficients of the individual explanatory variables are often slightly smaller than in the univariate regressions, the relative "ranking" seems broadly unchanged. In the "asset return equations" (models I, III, IV, V, VI and VIII), risk reversals tend to receive the highest coefficients apart from the US dollar/EUR currency pair where the change in relative equity returns have the highest sign. In the "financial flow" equations (models II, VII and IX), changes in net speculative flows receive systematically higher coefficients than net flows in bonds and equities. In fact, in the multivariate regressions the latter fail to receive statistically significant signs apart from the net equity flows in the case of the US dollar/GBP currency pair. The adjusted R^2s from the multivariate models tend to be higher than in the best univariate cases in the "asset return" equations. For the "financial flow" models, the R^2s are lower than in the univariate net speculative flow equations, and also generally lower than in the "asset return" equations.

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[3] As discussed above this strategy is different from the general-to-specific tradition but is more in line with work on short-term indicators for exchange rate volatility.

Table 3: Results from the contemporaneous multivariate linear regressions

	STID	EID	RR	NBF	NEF	NSF	Adj. R^2
Model I USD/EUR	0.304 (3.048)	0.517 (3.146)	0.447 (6.228)				0.533
Model II USD/EUR					0.132 (1.765)	0.346 (2.371)	0.108
Model III GBP/EUR	0.283 (3.690)	0.360 (3.288)	0.487 (4.075)				0.464
Model IV JPY/EUR		0.411 (2.464)	0.493 (6.059)				0.479
Model V JPY/USD		0.253 (1.650)	0.499 (4.997)				0.365
Model VI USD/GBP		0.321 (3.144)	0.564 (5.809)				0.455
Model VII USD/GBP				0.0059 (0.046)	0.230 (2.081)	0.356 (2.906)	0.129
Model VIII CHF/USD	0.292 (2.352)	0.238 (1.902)					0.116
Model IX CHF/USD					0.105 (1.371)	0.551 (2.953)	0.346

4.2. Non-linear regressions

We now invoke the binomial logit methodology to assess whether the news in various financial market variables might exhibit leading or lagging indicator properties relative to the appreciation or depreciation *episodes* in exchange rates. This approach also has the additional benefit that it allows us to investigate whether the indicators reliably signal movements in exchange rates in one direction rather than another.

For that purpose, we first need to define an "episode". In the current context, we consider an episode a period of appreciation or depreciation of the base currency of a currency pair that exceeds 3% on a month-on-month basis. This magnitude is close to one (annualised one-month) standard deviation for most major currency pairs, and a movement of a currency pair by more than 3% within one month's interval can thus be considered as "larger than pure noise". The binary logit technique then implies that the left-hand side variable is strictly limited to take two values only, 0 or 1. In the present context, we run two separate logit regressions where the binary dependent variable is specified as follows:[4]

$$Y_t^1 = \begin{cases} 1 & \textit{in periods of monthly appreciation of the base currency by more than } 3\% \\ 0 & \textit{in all other periods} \end{cases}$$

$$Y_t^2 = \begin{cases} 1 & \textit{in periods of monthly depreciation of the base currency by more than } 3\% \\ 0 & \textit{in all other periods} \end{cases} .$$

Given the specification of Y_t, the logit technique specifies the probability of Y_t occurring given an information set. Since the probability must lie between 0 and 1, a transformation function must be used that maps from the real values to the 0-1 interval. For the logit model, the transformation function takes the form of the logistic function

$$\Phi(x) \equiv (1+e^{-x})^{-1} = \frac{e^x}{1+e^x} .$$

The estimation itself is run by means of the maximum likelihood, and the estimated equation now takes the following form, that is slightly different from (3) given the binary left-hand side variable.[5]

$$Y_t^i = \alpha + \sum_{k=1}^{n} \beta_k I_{k,t+j} + \varepsilon_t , j = 0,1,-1.$$

We now proceed to report the results from regression estimations, starting again with univariate regressions and moving then on to multivariate models.

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4 The alternative would be to run a multinomial regression where all three regimes would be simultaneously included. However, the interpretation of coefficients in such "ordered logit" model is very tricky. Moreover, regarding the objectives of the present study, it is not obvious that the same variables and coefficient values would be optimal for both the appreciation and depreciation outcomes.

5 Note that since a non-linear method is used the estimated parameters do not measure the marginal effect on the dependent variable. It can be shown, however, that positive (negative) values of β always imply that a higher (lower) reading of the indicator variable X_t will increase (decrease) the probability of the appreciating or depreciating response in the dependent variable exchange rate. Therefore, although it is not straightforward to interpret the size of the coefficients, their sign nevertheless correctly indicates the direction of the relationship.

4.2.1. Results from univariate analysis

The results from the logit regressions are summarised in Tables 4 and 5. Since we now make a distinction between episodes in two different directions, we are also able to detect whether some of the variables work as leading/lagging/contemporaneous indicators for episodes of appreciation rather than depreciation, or vice versa. A good indicator would, of course, correctly signal movements in both directions in a consistent manner but there are reasons why signals could work in an asymmetric fashion. For example, if the exchange rate is subject to an underlying medium-term appreciation trend then signals for short-term depreciation may not be followed by a subsequent episode. In addition, the exchange rate might also be actively manipulated by policymakers who are willing to tolerate currency movements in one direction but not another. It could also be that movements in an indicator that signal exchange rate episodes in one direction are priced into the exchange rate faster than movements in the other direction. In the tables the outcomes where an indicator signals a probability of an appreciation of the base currency (the latter currency in a quote of a currency pair) are marked with *(+)* while indications for depreciation are denoted by a *(-)*.[6]

Looking at the full sample periods, it is worth noting that the outcomes in terms of leading indicator properties are not very different from the linear GMM estimations. This tends to confirm the general patterns of the data. The R^2 values of the estimations vary rather lot, with some regressions on contemporaneous indicators receiving values in excess of 0.5 while the power of the regressions on leading and lagging indicators is typically below 0.1.

The asymmetric properties of some indicator variables exhibit a number of interesting details. Changes in short-term interest rate differentials signal probabilities of contemporaneous and future episodes of US dollar appreciation against the Swiss franc. A possible explanation to why episodes of US dollar depreciation are not signalled could be related to the fact that episodes of US dollar depreciation against the CHF often result from short-term safe haven flows that are triggered by increased global risk aversion, independent on the relative interest rate positions.[7]

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[6] Recall that in the estimated equations, the left-hand side variable is always a 0-1 variable, where 1 indicates an episode of either appreciation or depreciation of the base currency. Therefore, when *correctly* measured, an increase in US net capital inflows, for example, should receive a negative coefficient in the regression where it is used as an indicator for probability of euro appreciation against the US dollar and a positive coefficient in the regression where it is used as an indicator for probability of euro depreciation.

[7] There is some evidence that in times of increased global risk aversion, currencies of countries with large current account surpluses, such as Switzerland and Japan, tend to benefit from safe haven inflows. This is because a large current account surplus provides an outlook for safe medium-term appreciation prospects that in periods of increased market volatility could be more highly regarded than uncertain returns from interest rate differentials.

Table 4: Logit estimations using full samples

	Exchange rate					
Indicator	**USD/EUR**	**GBP/EUR**	**JPY/EUR**	**JPY/USD**	**USD/GBP**	**CHF/USD**
STID Lead						(+)
Contemp						(+)
Lag						
LTID Lead			(+)	(-)		
Contemp			(-)			
Lag			(-)			
EID Lead				(+)		
Contemp	(+/-)	(-)	(+/-)	(+/-)	(+/-)	(-)
Lag						(+)
NBF Lead						
Contemp		*N/A*	*N/A*			
Lag						
NEF Lead						
Contemp		*N/A*	*N/A*		(+)	(+)
Lag					(+)	
NSF Lead				(-)		(-)
Contemp	(+/-)	*N/A*	*N/A*	(+/-)	(+/-)	(+/-)
Lag	(+)					
RR Lead				(-)		
Contemp	*N/A*	*N/A*	*N/A*	(+/-)	(+/-)	*N/A*
Lag						

Note: (+) and (-) refer to a correctly signed, statistically significant (at 5% level) estimator of an appreciation/depreciation episode of the base currency (the latter currency in the quote of a currency pair). The start of the sample period is August 1986 for STID, LTID and EID; January 1988 for NBF and NEF; November 1992 for NSF; and March 1992 for risk reversals.

An increase in Japanese long-term interest rates signals episodes of yen appreciation vis-à-vis the US dollar and leads episodes of yen depreciation against the euro. Changes in equity index differentials work as a rather consistent contemporaneous indicator across the board, with leading indicator properties regarding appreciating episodes of the yen against the US dollar.

Net equity flows are a contemporaneous but asymmetric indicator for CHF/USD and USD/GBP rates, signalling probability of appreciating episodes of the dollar and the pound, respectively. For the latter currency pair, equity flows also lag the exchange rate, suggesting that episodes of appreciation of the pound tend to attract portfolio equity inflows. Net speculative positions are a consistent and symmetric contemporaneous indicator of exchange rate episodes in all cases. They also lead episodes of depreciation of the US dollar against the yen and the Swiss franc, but not US dollar appreciation. The failure to capture episodes of US dollar appreciation against the yen could be related to the fact that such episodes are sometimes associated with yen-selling interventions that are aimed at squeezing the long yen positions of the speculative side of the market. Regarding the USD/EUR exchange rate, speculative flows show lagging indicator properties for episodes of euro appreciation. Consistent with the linear estimations, risk reversals send a (symmetric) contemporaneous signal of probability of exchange rate movement for JPY/USD and USD/GBP currency pairs. They also lead episodes of US dollar depreciation against the yen, but again episodes of yen depreciation are not captured.

Table 5 reports the estimation results using the sample starting in January 1999. In line with the linear estimation results, short-term interest rates have gained explanatory power vis-à-vis several exchange rates. Long-term rates, however, only work as a signal for JPY appreciation relative to the US dollar but no longer relative to the euro, while net flows in bonds from the UK to the US now signal the probability of a contemporaneous appreciation of the US dollar relative to the pound sterling. Net equity flows have become a leading indicator for probability of episodes of US dollar appreciation against the Japanese yen. The UBS data confirm that equity flows from Japan to the US tend to precede US dollar appreciation episodes. After the introduction of the euro, risk reversals explain contemporaneous appreciation episodes of the euro against the US dollar.

Table 5: Logit estimations using sample January 1999-March 2003

	Exchange rate					
Indicator	**USD/EUR**	**GBP/EUR**	**JPY/EUR**	**JPY/USD**	**USD/GBP**	**CHF/USD**
STID Lead	(+)					(+)
Contemp	(+/-)	(+)				(+/-)
Lag						
LTID Lead				(-)		
Contemp						
Lag						
EID Lead				(+)		
Contemp	(+)		(+/-)		(+)	(-)
Lag	(-)					(+)
NBF Lead						
Contemp		*N/A*	*N/A*		(+)	
Lag						
NEF Lead				(+)		
Contemp		*N/A*	*N/A*		(+)	
Lag						
UBS Lead				(+)		
Contemp						*N/A*
Lag			(-)			
NSF Lead				(-)		
Contemp	(-)	*N/A*	*N/A*	(-)		(+/-)
Lag						
RR Lead			(-)	(-)		
Contemp	(+)		(+/-)	(+/-)	(+)	*N/A*
Lag	(-)					

Note: (+) and (-) refer to a correctly signed, statistically significant (at 5% level) estimator of an appreciation/depreciation episode of the base currency (the latter currency in the quote of a currency pair). The start of the sample period is August 1986 for STID, LTID and EID; January 1988 for NBF and NEF; November 1992 for NSF; and March 1992 for risk reversals.

4.2.2. Effectiveness of indicators in signalling appreciation episodes

To assess the "goodness-of-fit" of the indicators in terms of sending correct signals on future exchange rate movements, we define a signal as the indicator departing from its mean beyond a given threshold level. Obviously, the determination of the threshold level is an important starting point. The lower the threshold is set, the more signals of episodes the model will send with the risk of "false alarms" (Type II errors) increasing. Raising the threshold level reduces the number of wrong signals but at the cost of increasing the number of missed episodes (Type I errors). This trade-off is illustrated in Table 6 below.[8]

Table 6: The tradeoff problem of choosing optimal threshold value

	Yt=0 (no episode)	Yt=1 (episode)
Indicator sends no signal	Correct call of a non-event	Missed signal (Type I error)
Indicator sends a signal	Wrong signal (Type II error)	Correct call of episode

Choosing a cut-off value therefore involves a judgement on the relative importance of Type I vs. Type II errors. To determine the "optimal" threshold values for the various indicators, we adopt the following strategy. For each indicator that in the post-January 1999 sample produced statistically significant signals, a set of *a priori* threshold probabilities ranging from 0.1 to 0.5 was applied. The indicator-specific optimal threshold was then determined as the level that minimised the total percentage of "failures" (Type I and Type II errors occurring).[9] The proportion of "failures" typically falls rather rapidly when the threshold is increased from a low level (say 0.1), as the probability of Type II errors decreases while the probability of Type I errors increases more slowly. A low optimal threshold level suggests that the risk of Type I errors (missed correct signal) dominates the risk of Type II errors (wrong signal sent) for a particular indicator variable, and *vice versa* with a high optimal threshold level. Table 7 summarises the calculated optimal threshold values for each indicator that in Table 5 was reported to have received a significant coefficient estimate.

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8 See Kaminsky and Reinhart (1999) for a more thorough discussion on type I vs. type II errors in binary regression models where the threshold selection is done by maximising the signal/noise ratio.

9 We also applied an alternative strategy where the percentages of Type I and Type II errors from the different threshold levels were incorporates in a linear loss function with equal weights for the two errors. The threshold level that minimised the loss function for a particular indicator was then chosen. The resulting choice of optimal threshold levels in all cases coincided with the choice from minimising the total percentage of "failures".

Table 7: Optimal threshold probabilities for indicator variables

	Exchange rate					
Indicator	**USD/EUR**	**GBP/EUR**	**JPY/EUR**	**JPY/USD**	**USD/GBP**	**CHF/USD**
STID Lead	0.3					0.4
Contemp	0.4	0.3				0.4
Lag						
LTID Lead				0.3		
Contemp						
Lag						
EID Lead				0.2		
Contemp	0.3		0.3		0.2	0.5
Lag	0.2					0.3
NBF Lead						
Contemp		*N/A*	*N/A*		0.2	
Lag						
NEF Lead				0.2		
Contemp		*N/A*	*N/A*		0.3	
Lag						
UBS Lead				0.2		
Contemp						*N/A*
Lag			0.3			
NSF Lead				0.3		
Contemp	0.3	*N/A*	*N/A*	0.4		0.4
Lag						
RR Lead			0.4	0.4		
Contemp	0.3		0.3	0.3	0.4	*N/A*
Lag	0.4					

Table 8 applies the estimated thresholds to calculate the average test statistics indicator-by-indicator. The goodness of fit of estimations is assessed against three criteria. (i) Ability of the estimations to produce significant gain compared to a benchmark model that involves running the regression with the constant term only. (ii) The probability of an event occurring given that the indicator sent a signal. (iii) The probability of an event occurring given that no signal was sent.

A general observation from the results in Table 8 is that while in most cases the estimates are able to beat the benchmark constant probability model, there are also cases where including explanatory variables actually worsens the results. Regarding the contemporaneous indicators, signals that are sent by net speculative flows and risk reversals produce the highest gains relative to the benchmark model. These two variables are also the ones that produce correct signals more than 60% of the time, although net equity flows also emit correct signals half of the time. Changes in equity index differentials and risk reversals provide leading indicator signals that are correct most of the time given the chosen threshold levels. The lagging indicator properties of the estimated signals are generally rather poor, however. Only risk reversals manage to improve upon the constant probability model and even there, the percentage of correct signals is low.

Table 8. The effectiveness of indicators given the optimal threshold levels

		Goodness of fit criteria		
Indicator	Significant estimates per total cases	Average gain to benchmark	Average % of episodes, signal issued	Average % of episodes, no signal issued
STID Lead	2/12	1.2%	26.0%	17.5%
Contemp	5/12	1.7%	28.1%	18.1%
Lag	0	-	-	-
LTID Lead	1/12	-2.16%	21.1%	9.4%
Contemp	0	-	-	-
Lag	0	-	-	-
EID Lead	1/12	6.2%	50.0%	5.3%
Contemp	5/12	3.6%	49.0%	11.6%
Lag	2/12	-2.0%	35.7%	5.6%
NBF Lead	0	-	-	-
Contemp	1/8	3.3%	25.0%	10.0%
Lag	0/8	0.0%	50.0%	0.0%
NEF Lead	1/8	1.6%	25.4%	3.5%
Contemp	1/8	1.8%	50.0%	8.5%
Lag	0	-	-	-
UBS Lead	1/10	4.9%	25.0%	9.7%
Contemp	0	-	-	-
Lag	1/10	-25.5%	15.8%	12.5%
NSF Lead	1/8	3.6%	27.9%	7.65%
Contemp	4/8	6.77%	63.3%	11.6%
Lag	0	-	-	-
RR Lead	2/10	7.4%	58.5%	9.7%
Contemp	6/10	5.4%	60.3%	8.75%
Lag	1/10	3.2%	33.3%	10.6%

Finally, for all the indicators where the logit regressions produced significant estimates the issued signals were, on average, "useful" in the sense that the number of episodes leading, coinciding or lagging a signal was higher than the number of episodes that took place when no signal was issued.

4.2.3. Results from multivariate estimations

The model selection criteria for the multivariate analysis follow the procedure used above in section 4.1.2. Concentrating again on the contemporaneous regressions using the post-euro sample we arrive at the following five equations.

Model I: $USD/EUR(+) = \alpha + \beta_1 STID + \beta_2 EID + \beta_3 RR$

Model II $JPY/EUR(+) = \alpha + \beta_1 EID + \beta_2 RR$

Model III: $JPY/EUR(-) = \alpha + \beta_1 EID + \beta_2 RR$

Model IV: $USD/GBP(+) = \alpha + \beta_1 STID + \beta_2 EID + \beta_3 RR$

Model V: $USD/GBP(+) = \alpha + \beta_1 NBF + \beta_2 NEF$

The endogenous variable is now the binary 0-1 variable, with (+) and (-) denoting appreciation/depreciation episodes of the base currency, respectively. The results are summarised in Table 9.

When included in multivariate models, the sizes of coefficients and statistical significance of several variables declines compared with the unilateral regressions. This is particularly the case with short-term interest rate differentials and net bond flows. The relative ranking among individual indicators remains rather consistent, however. Risk reversals tend to receive the highest and most significant coefficients, with changes in short-term interest rate differentials and and equity return differentials obtaining high scores as well. The R^2s of the multivariate models are generally higher than from the univariate regressions – suggesting that the explanatory power of the multivariate models is stronger.

Table 9: Results from the contemporaneous multivariate non-linear regressions

	STID	EID	RR	NBF	NEF	NSF	McF R^2
Model I USD/EUR (+)	0.725 (2.329)	1.376 (2.266)	1.375 (2.276)	-	-	-	0.234
Model II JPY/EUR (+)	-	0.896 (1.774)	1.608 (1.970)	-	-	-	0.301
Model III JPY/EUR (-)	-	0.486 (1.951)	1.700 (2.720)	-	-	-	0.337
Model IV USD/GBP (+)	1.886 (1.637)	0.278 (0.482)	4.036 (2.113)	-	-	-	0.538
Model V USD/GBP (+)	-	-	-	0.146 (0.245)	1.151 (1.926)	-	0.147

The latter finding is supported by threshold estimations reported in Table 10, showing that compared with the univariate regressions the multilateral models produce better results. The gains to the constant probability benchmark models are rather high in almost all cases. Moreover, all models produce at least 50% of the time correct signals about contemporaneous exchange rate episodes, while the percentage of false signals is lower than in the univariate cases.

Table 10. The effectiveness of models given the optimal threshold levels

	Goodness of fit criteria		
Model/ threshold level	Gain to benchmark	% of episodes, signal issued	Average % of episodes, no signal issued
I / 0.2	8.85%	50.0%	5.6%
II / 0.4	8.59%	71.4%	7.14%
III / 0.3	8.24%	62.5%	6.82%
IV / 0.3	2.51%	66.6%	6.52%
V / 0.3	8.6%	50.0%	7.7%

4.3. Robustness check: estimations using German data until December 1998

As a final matter, we run the estimations on both linear and non-linear models for the sample period finishing at December 1998 and comparing the results obtained from euro area data with results from using German data. While all data that is available for the euro area (in synthetic form) up until end-1998 is also available for Germany, for the pre-euro sample period risk reversals are available only on D-Mark currency pairs.

The results are summarised in Table 11. The left-hand side columns illustrate the results from GMM regressions, while the logit output is summarised in the right-hand side columns. Crosses (circles) indicate significant and correctly signed coefficients for the euro area (Germany). The results are rather consistent between the two data sets. The explanatory power of changes in long-term interest rate differentials is somewhat higher for the D-Mark exchange rates than for the corresponding euro exchange rates. In addition, changes in equity index differentials did not work for the DEM/GBP and DEM/JPY rates, possibly reflecting the more limited role played by equity transactions between Germany and the UK and Japan prior to 1999. Regarding risk reversals, they showed consistent contemporaneous and leading indicator properties for all three D-Mark exchange rates considered. This is broadly consistent with the results obtained for risk reversals on the JPY/USD and USD/GBP exchange rates prior to the launch of the single currency.

Table 11: Comparison of results with D-Mark until December 1998*

	GMM estimations			Logit estimations		
Indicator	**USD**	**GBP**	**JPY**	**USD**	**GBP**	**JPY**
STID Lead						
Contemp						
Lag						
LTID Lead		O	O			X(+)O(+/-)
Contemp		O	X/O			X(-)O(-)
Lag		X	X			X(-)
EID Lead	O			O(+)		
Contemp	X/O	X	X	X(+/-)O(+)	X(-)	X(+/-)
Lag			X			
NBF Lead						
Contemp		*N/A*	*N/A*		*N/A*	*N/A*
Lag						
NEF Lead						
Contemp	X/O	*N/A*	*N/A*	O(+/-)	*N/A*	*N/A*
Lag						
NSF Lead						
Contemp	X	*N/A*	*N/A*	X(+/-)	*N/A*	*N/A*
Lag				X(+)		
RR Lead	O	O	O		O(+)	O(+)
Contemp	O	O	O	O(+/-)	O(+/-)	O(+/-)
Lag						

**Note: Crosses (X) denote estimates using euro area data, circles (O) estimates using German data.*

5. Conclusions

This study used two distinct estimation techniques to assess the monthly indicator properties of a large set of financial market variables vis-à-vis monthly exchange rate returns. The estimations reveal significant links between several indicator variables and major exchange rate returns. Regarding the GMM estimations, using the full sample period going back to the mid-1980s, the overall "best" performing indicators were changes in equity index differentials, net speculative flows and risk reversals. The fit of the regressions, measured in terms of adjusted R^2, in many cases exceeded 50% that is rather good result for financial market data. The logit estimations underlined the ability of the named variables to correctly signal contemporaneous and, in many cases, also future exchange rate episodes; the best indicators were capable of capturing more than 60% of monthly appreciation and depreciation episodes for the major exchange rates. In general, since 1999, short-term interest rate differentials have gained contemporaneous and leading indicator properties for a number of bilateral euro exchange rates.

The estimations also revealed interesting differences as to the ability of indicator variables to explain fluctuations in various currency pairs. In particular, the rather poor results obtained for short-term interest rate differentials in explaining movements in the Japanese yen exchange rates could be related to the fact that throughout a significant part of the sample period, short-term interest rates in Japan were close to zero. The increased importance of short-term interest rate differentials in explaining the euro exchange rates since the launch of the single currency could, in turn, suggest that the relationship between the interest rates and exchange rates might have been temporarily distorted by the EMU convergence process throughout the 1990s. Net equity flows work as a rather good indicator for contemporaneous movements for many US dollar exchange rates, whilst net bond flows scored markedly worse. This finding is likely to reflect different trading practices. Cross-border transactions in bonds tend to be hedged against currency risk that counters any impact on exchange rates, whereas equity transactions are not hedged. This asymmetry is a result of the different risk characteristics of the underlying assets, whereby the currency risk component is more dominant relative to the own market risk component for bonds and *vice versa* for equities.

All in all, our findings tend to confirm the importance of financial variables as explanatory factors for short-term exchange rate dynamics. This is not entirely surprising given the expansion over the past decades in the “asset trade” segment of foreign exchange markets relative to the “real trade” segment of exchange in goods and services. Nevertheless, there are limits how far financial variables can explain exchange rate movements. As suggested by Froot and Ramadorai (2003), in longer horizons permanent movements in exchange rate returns tend to be driven by economic fundamentals while financial flows are likely to account for transitory fluctuations.

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Appendix 1: Descriptive statistics of the data

Table A.1.1.a Descriptive statistics for exchange rates data (returns)

	USD/EUR	JPY/EUR	GBP/EUR	USD/GBP	USD/JPY	CHF/US dollar
Mean	0.0002	-0.001	-0.00004	0.0003	-0.001	-0.0009
Min	-0.135	-0.136	-0.054	-0.152	-0.141	-0.084
Max	0.098	0.1311	0.084	0.067	0.088	0.058
Std. Dev	0.0299	0.033	0.0195	0.030	0.033	0.029
Skew.	-0.248	-0.444	0.4016	-0.976	-0.532	-0.235
Kurt.	4.9188*	5.192*	4.883*	6.633*	4.530*	2.631*
J-B	32.563*	46.372*	34.732*	141.01*	28.814*	1.652*

Table A.1.1.b Autocorrelations for exchange rates data (returns)

	USD/EUR	JPY/EUR	GBP/EUR	USD/GBP	USD/JPY	CHF/US dollar
ρ1	0.126	0.151	0.115	0.068	0.144	0.103
ρ2	-0.072	-0.039	-0.090	-0.120	0.051	-0.019
ρ3	-0.027	0.043	0.062	-0.014	0.017	0.047
ρ4	-0.090	0.059	0.020	-0.045	-0.126	-0.176
ρ6	-0.058	-0.052	-0.026	-0.070	-0.126	0.000
ρ12	-0.011	-0.070	-0.080	0.066	0.036	0.084
ρ36	-0.093	-0.174	0.008	-0.128	-0.136	0.057
L-B 36	36.599*	43.820*	45.306*	43.914*	69.165*	48.727*

Table A.1.2.a Descriptive statistics for data on euro area (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR (USD)
Mean	0.005	0.006	0.006	-34.73	3.806	165.1	165.42	0.228
Min	0.002	0.003	-0.247	-8396	-5453	-1660.9	-35290	-0.800
Max	0.011	0.010	0.119	9277	7020	1981	38554	1.500
Std. Dev	0.002	0.001	0.055	2855	1469	842.6	13223	0.4622
Skew.	0.461	0.003	-1.018	0.032	0.281	0.222	0.165	0.465
Kurt.	2.146*	1.858*	5.589*	3.679*	7.729*	2.848*	4.6211*	3.172*
J-B	13.15*	10.887	90.373	3.492*	170.1*	0.542*	6.956*	4.950*

Table A.1.2.b Autocorrelations for data on euro area (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR (USD)
ρ1	0.976	0.981	0.086	-0.462	-0.553	0.359	-0.263	0.441
ρ2	0.963	0.956	0.026	-0.036	0.301	0.359	-0.065	0.260
ρ3	0.946	0.932	0.023	0.021	-0.329	0.164	-0.087	0.213
ρ4	0.929	0.909	-0.027	-0.012	0.150	0.167	-0.087	0.096
ρ6	0.894	0.869	-0.057	0.035	0.073	0.036	-0.178	0.057
ρ12	0.780	0.780	0.063	0.051	0.368	-0.098	-0.010	0.053
ρ36	0.458	0.421	0.016	-0.143	-0.071	-0.220	-0.190	0.040
L-B 36	3975*	3883*	26.737*	76.328*	222.91	82.761*	30.883	114.35*

Table A.1.3.a Descriptive statistics for data on the US (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR (JPY)
Mean	0.004	0.005	0.008	-	-	-	-	-0.67
Min	0.001	0.003	-0.276	-	-	-	-	-3.20
Max	0.0079	0.007	0.164	-	-	-	-	1.50
Std. Dev	0.0016	0.001	0.057	-	-	-	-	0.897
Skew.	-0.142	0.259	-0.752	-	-	-	-	-0.570
Kurt.	2.667*	2.319*	5.422*	-	-	-	-	3.439*
J-B	1.599*	6.104*	67.73*	-	-	-	-	8.281*

Table A.1.3.b Autocorrelations for data on US (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR (JPY)
ρ1	0.975	0.979	0.166	-	-	-	-	0.589
ρ2	0.950	0.954	-0.012	-	-	-	-	0.370
ρ3	0.924	0.929	-0.055	-	-	-	-	0.188
ρ4	0.832	0.901	-0.066	-	-	-	-	0.110
ρ6	0.826	0.849	-0.005	-	-	-	-	0.014
ρ12	0.574	0.701	0.058	-	-	-	-	0.167
ρ36	-0.118	0.298	0.020	-	-	-	-	-0.046
L-B 36	1904*	3092*	31.712*	-	-	-	-	172.25*

Table A.1.4.a Descriptive statistics for data on Japan (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR (EUR)
Mean	0.002	0.0059	-0.001	23.967	1.85	-143.24	-68.81	-0.437
Min	-0.0005	0.001	-0.205	-29650	-2011	-910.17	-57710	-3.300
Max	0.007	0.007	0.215	34532	3383	620.79	73828	1.100
Std. Dev	0.002	0.002	0.072	6028	900.6	342.2	19502	0.816
Skew.	0.625	0.340	-0.010	0.326	0.443	-0.027	0.235	-1.266
Kurt.	20.89*	2.127*	2.927*	11.187*	3.858*	2.649*	4.640*	4.591*
J-B	19.936*	10.21*	0.048*	505.91*	11.41*	0.309*	15.037*	49.55*

Table A.1.4.b Autocorrelations for data on Japan (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR (EUR)
ρ1	0.990	0.981	0.108	-0.447	-0.273	0.094	-0.100	0.714
ρ2	0.982	0.960	0.027	0.019	0.009	-0.006	-0.159	0.589
ρ3	0.975	0.935	0.031	-0.108	-0.068	0.025	-0.091	0.491
ρ4	0.964	0.914	0.037	0.057	-0.059	0.143	0.022	0.419
ρ6	0.941	0.883	-0.055	0.157	0.043	0.023	-0.108	0.310
ρ12	0.854	0.801	-0.035	-0.106	0.299	0.029	-0.040	0.260
ρ36	0.443	0.447	-0.047	0.038	0.049	-0.089	-0.050	-0.166
L-B 36	4443.1*	4082*	32.373*	79.076*	85.367*	17.864*	38.100*	435.8*

Table A.1.5.a Descriptive statistics for data on UK (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR (EUR)
Mean	0.006	0.005	0.007	50.944	-14.60	30.492	52.774	0.213
Min	0.003	0.003	-0.287	-22669	-6728	28.0	-35161	-0.550
Max	0.012	0.008	0.131	21265	7189	35.0	37520	1.500
Std. Dev	0.002	0.001	0.054	7079.0	1778	3.380	13776	0.4166
Skew.	0.791	0.028	-0.927	0.2122	0.198	0.602	-0.059	0.592
Kurt.	2.457*	2.163*	6.522*	4.095*	5.712*	1.362*	3.549*	3.176*
J-B	23.31*	5.866*	132.01*	10.347*	56.323*	10.156*	1.628*	7.935*

Table A.1.5.b Autocorrelations for data on UK (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR (EUR)
ρ1	0.987	0.969	0.113	-0.523	-0.484	-0.536	-0.245	0.535
ρ2	0.970	0.932	-0.103	0.039	0.006	-0.175	-0.261	0.326
ρ3	0.951	0.899	-0.061	0.001	0.011	0.533	0.061	0.195
ρ4	0.932	0.864	0.055	-0.039	-0.054	-0.437	-0.102	0.152
ρ6	0.889	0.802	0.010	0.087	-0.041	0.336	0.023	0.071
ρ12	0.746	0.641	-0.005	0.046	0.039	0.163	0.021	-0.122
ρ36	0.222	0.334	-0.005	-0.054	0.052	-0.256	0.068	0.124
L-B 36	3178*	2805.2	35.098	104.28	103.5*	216.5*	60.291*	117.9*

Table A.1.6.a Descriptive statistics for data on Switzerland (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR
Mean	0.003	0.0036	0.0059	5.328	-3.394	-	87.984	-
Min	0.0002	0.0020	-0.196	-5371	-5717	-	-56311	-
Max	0.008	0.0056	0.254	4504	3623	-	44376	-
Std. Dev	0.002	0.0010	0.064	1203.5	915.2	-	15477	-
Skew.	0.712	0.425	-0.1566	-0.532	-1.494	-	-0.272	-
Kurt.	2.274*	2.323*	5.262*	7.176*	14.282*	-	4.663*	-
J-B	21.273*	9.840*	23.92*	139.3*	1021.6*	-	15.812*	-

Table A.1.6.b Autocorrelations for data on Switzerland (returns)

	S-R rates	L-R rates	Equity index	Bond flows	Equity flows	UBS flows	Spec. flows	RR (EUR)
ρ1	0.982	0.980	-0.105	-0.535	-0.445	-	-0.217	-
ρ2	0.964	0.955	-0.066	0.150	0.014	-	-0.144	-
ρ3	0.949	0.926	0.089	-0.097	0.050	-	0.029	-
ρ4	0.929	0.896	-0.006	-0.055	-0.188	-	-0.211	-
ρ6	0.890	0.836	0.001	-0.038	-0.080	-	-0.077	-
ρ12	0.740	0.669	-0.030	0.045	-0.176	-	0.043	-
ρ36	0.269	0.235	0.053	-0.137	0.014	-	-0.005	-
L-B 36	3189*	2885.1*	22.126*	87.910*	107.26*	-	57.945*	-

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