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EXPLAINING EXCHANGE RATE DYNAMICS

THE UNCOVERED EQUITY RETURN PARITY CONDITION

by Lorenzo Cappiello
and Roberto A. De Santis

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THE UNCOVERED EQUITY RETURN PARITY CONDITION [1]

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In 2005 all ECB publications will feature a motif taken from the €50 banknote.

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Abstract

By employing Lucas' (1982) model, this study proposes an arbitrage relationship – the Uncovered Equity Return Parity (URP) condition – to explain the dynamics of exchange rates. When expected equity returns in a country/region are lower than expected equity returns in another country/region, the currency associated with the market offering lower returns is expected to appreciate. First, we test the URP assuming that investors are risk neutral and next we relax this hypothesis. The resulting risk premia are proxied by economic variables, which are related to the business cycle. We employ differentials in corporate earnings' growth rates, short-term interest rate changes, annual inflation rates, and net equity flows. The URP explains a large fraction of the variability of some European currencies vis-à-vis the US dollar. When confronted with the naïve random walk model, the URP for the EUR/USD performs better in terms of forecasts for a set of alternative statistics.

JEL Classification: F31, G15, C22, C53

Keywords: foreign exchange markets; asset pricing; random walk; UIP; GMM

Non-technical summary

The need to understand the mechanics of exchange rates and their developments has generated a vast theoretical and empirical literature. The flexible price monetary model, which subsequently gave way to the overshooting or sticky-price model, the equilibrium and liquidity models as well as the portfolio balance approach have characterised three decades of research, from the 1960s to the 1980s. More recently, since the publication of Obstfeld and Rogoff's (1995) seminal "redux" paper, the new open-economy macroeconomics has attempted to explain exchange rate developments in the context of dynamic general equilibrium models that incorporate imperfect competition and nominal rigidities. Empirically, these theoretical developments have fared poorly at explaining exchange rate dynamics, at least over relatively short horizons, and several exchange rate puzzles have been highlighted.

The increasing role played by international financial markets in developed economies constitutes a persuasive argument to explore possible relationships between returns on risky assets and exchange rates dynamics. Recently, a new strand of research has investigated the interconnections between equity and bond returns, on one side, and exchange rate dynamics, on the other side, with promising results (see Brandt et al., 2001; Pavlova and Rigobon, 2003; Hau and Rey, 2004 and 2005).

In this paper, by employing the Lucas' (1982) consumption economy model, we introduce a new framework explaining exchange rate dynamics. We propose an arbitrage relationship between expected exchange rate changes and differentials in expected equity returns of two economies. Specifically, if expected returns on a certain equity market are higher than those obtainable from another market, the currency associated with the market that offers higher returns is expected to depreciate. A resident in the market which offers higher expected returns suffers a loss when investing abroad, and therefore she has to be compensated by the expected capital gain that occurs when the foreign currency appreciates. This ensures that no sure opportunities for unbounded profits exist and, therefore, the equilibrium is re-established. Due to the similarity with the Uncovered Interest Parity (UIP) condition, the equilibrium hypothesis proposed and tested here is baptised Uncovered Equity Return Parity condition (URP). There is, however, a key difference between the two arbitrage relations. In the UIP return differentials are known *ex ante*, since they are computed on risk-free assets, while in the URP are not.

Risk-averse agents investing in risky assets denominated in a foreign currency usually require a market and a foreign exchange risk premium, which can be time varying. We begin our study assuming that investors are risk-neutral, which implies that the URP does not include risk

premia. Next, we relax the risk-neutrality assumption and we enrich the URP by employing additional financial variables, which are related to the business cycle. We use differentials in corporate earnings' growth rates, short-term interest rate changes, and annual inflation rates, as well as net equity flows. In line with previous studies (see, for instance, Fama and French, 1989; Chen, 1991; and Ferson and Harvey, 1991b), these variables can be thought of as proxies for the risk premia. The URP with risk premia turns out to explain a large fraction of the variability of the European currencies, particularly of the euro, the British pound and the Swiss franc.

We also test the forecasting ability of the URP with time-varying risk premia and find that it beats the naïve random walk model with drift at two- and three-month ahead forecasts and always predicts about two thirds of directional changes for the EUR/USD exchange rate. The forecasting performances for the Swiss Franc are better in terms of mean square errors, but not in terms of the sign tests. The specification for the British pound does not beat the naïve random walk model, despite it predicts correctly more than 60% of its directional changes.

Similar specifications fail in explaining the evolution of the Japanese Yen and the Canadian dollar against the US dollar, possibly due to the systematic intervention policy of these countries in the foreign exchange market.

"My experience is that exchange markets have become so efficient that virtually all relevant information is embedded almost instantaneously in exchange rates to the point that anticipating movements in major currencies is rarely possible….. To my knowledge, no model projecting directional movements in exchange rates is significantly superior to tossing a coin."

FED Chairman Alan Greenspan, at the 21st Annual Monetary Conference, Washington, D.C., November 20, 2003.

1. Introduction

The need to understand the mechanics of exchange rates and their developments has generated a vast theoretical and empirical literature.[1] The flexible price monetary model, which subsequently gave way to the overshooting or sticky-price model, the equilibrium and liquidity models as well as the portfolio balance approach have characterised three decades of research, from the 1960s to the 1980s. More recently, since the publication of Obstfeld and Rogoff's (1995) seminal "redux" paper, the new open-economy macroeconomics has attempted to explain exchange rate developments in the context of dynamic general equilibrium models that incorporate imperfect competition and nominal rigidities. Empirically, these theoretical developments have fared poorly at explaining exchange rate dynamics, at least over relatively short horizons, and several exchange rate puzzles have been highlighted.[2] [3]

In this paper, by employing the Lucas' (1982) consumption economy model, we introduce a new framework explaining exchange rate dynamics. We propose an arbitrage relationship between expected exchange rate changes and differentials in expected equity returns of two economies. Specifically, we show that when expected returns on a certain equity market are lower than the returns that could be gained from another market, the currency associated with the market that offers lower average returns is expected to appreciate. This ensures that no sure opportunities for unbounded profits exist and, therefore, the equilibrium is re-established. Due to the similarity with

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[1] Surveys can be found for instance in Hodrick (1987), Frankel and Rose (1995), Taylor (1995), Engel (1996) and Lyons (2001).

[2] Progress has been recently made in the microstructure literature. Evans and Lyons (2002), for instance, explain above 60% of daily changes in log exchange rates, demonstrating that there is high correlation between net order flows from electronic brokerage systems and contemporaneous exchange rate changes. The downside of this research is that, ultimately, order flows do not reveal why investors approach a market-maker to execute their buy or sell orders, leaving exchange rate determinants quite obscure.

[3] The two most well-known puzzles are: (i) the determination puzzle, which points out that exchange rate movements cannot be explained by macroeconomic fundamentals; and (ii) the forward rate puzzle (or Uncovered Interest Parity condition – UIP – puzzle), which highlights that the forward exchange rate is a biased predictor of the future spot rate, or, put it differently, that short-term interest rate differentials fail to explain changes in spot exchange rates.

the UIP, the equilibrium hypothesis proposed and tested here is baptised Uncovered Equity Return Parity condition (URP).

Several studies have recently analysed the interaction between risky asset returns and exchange rates. Brandt *et al.* (2001) argue that exchange rates fluctuate less than the implied marginal rate of intertemporal substitution obtained from equity market premia. Pavlova and Rigobon (2003) describe a two-country two-good asset pricing model, where the same factors drive real exchange rates, equity and bond markets. Estimates suggest that demand shocks are twice as important as output innovations in explaining the dynamics of exchange rates and asset prices. Hau and Rey (2004, 2005) put emphasis to the inter-connections between dynamic asset allocation and exchange rate evolution, developing a theoretical model where exchange rates, equity market returns and equity flows are jointly and endogenously determined. Imbalances between the domestic and foreign dividend income, which are generated by differences in stock market performances, determine dynamic re-balancing of equity portfolios, which, in turn, initiate foreign exchange order flows and therefore exchange rate movements.[4]

Similarly to our findings, one of the implications of the model developed by Hau and Rey (2005) is that “higher returns in the home equity market (in local currency) relative to the foreign equity market are associated with a home currency depreciation”. The relationship between equity and foreign exchange markets allows them to talk about “uncovered equity parity”. The key difference with Hau and Rey is that, in our framework, the imbalances between dividend incomes are not the driving forces of exchange rate developments. The model that we propose tests a simple arbitrage condition. The analysis is carried out on the euro, the Japanese yen, the Pound sterling, the Swiss franc, the Canadian dollar, the French franc and the Deutsche Marc vis-à-vis the US dollar.[5] The results suggest that differentials in returns on equity prices exhibit explanatory power for the dynamics of all European currencies against the US dollar.

Risk-averse agents investing in risky assets denominated in a foreign currency usually require a market and a foreign exchange risk premium. As pointed out already by Fama (1984), risk premia can be time varying and linked to the business cycle. We begin our study assuming that investors

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[4] Additional studies linking risky assets to exchange rates have been developed by the international asset pricing literature. An example is the International Capital Asset Pricing Model (Solnik, 1974; Adler and Dumas, 1983), where risk averse international investors require a market premium to hedge against uncertain security returns, and an exchange rate risk premium to hedge against currency risks stemming from those assets denominated in foreign currency.

[5] Although French franc and Deutsche mark ceased to exist with the advent of the euro in January 1999, results on these two currencies are reported for robustness check with the sample period ending in December 1998.

are risk-neutral, which implies that the URP does not include risk premia. Next, we relax the risk-neutrality assumption and we enrich the URP by employing additional financial variables, which are related to the business cycle. We use differentials in corporate earnings' growth rates, short-term interest rate changes, and annual inflation rates, as well as net equity flows. In line with previous studies (see, for instance, Fama and French, 1989; Chen, 1991; and Ferson and Harvey, 1991b), these variables can be thought of as proxies for the risk premia. The URP with risk premia turns out to explain a large fraction of the variability of the European currencies, particularly of the euro, the British pound and the Swiss franc.

A financial variable usually monitored by private and institutional investors is the equities' earnings yield or the inverse of the price-earnings ratio, which indicates how much investors are willing to pay a stock per unit of earnings. As a complementary analysis to the URP, we investigate a relationship between exchange rates developments and growth rates of earnings yields across regions/countries. Indeed, the differentials in growth rates of earning yields, on the one hand, and the differentials in equity returns and growth rates of total earnings, on the other hand, are, under some mild assumptions, the two sides of the same coin. We find that the differential of earning yields' growth rates is a key variable to explain movements in the exchange rate of the euro, the Pound sterling and the French franc vis-à-vis the US dollar, and that the results are consistent with the URP condition.

The remainder of the paper is organised as follows: Sections 2 and 3 present the URP hypothesis and the empirical models, respectively. Section 4 describes the data utilised in the analysis. Section 5 discusses the empirical results. Section 6 tests the robustness of the model through predictive accuracy as well as directional change tests. Section 7 concludes the paper. Finally, Appendix A formally derives the URP.

2. The uncovered equity return parity condition

The equilibrium condition proposed in this paper relates the expected changes in exchange rates with differentials in the *expected* returns on equity securities. Exchange rates and equity returns would move simultaneously in order to guarantee equilibrium in international financial markets. The theoretical foundations of this arbitrage condition can be found in Lucas' (1982) consumption economy. Lucas develops a dynamic, two country, general equilibrium model, thanks to which we derive the URP enriched with risk premia. In Lucas' model the only risky assets traded are claims to countries' uncertain outputs, or, put it differently, shares of stocks in national economies. While the asset pricing literature has utilised Lucas' framework because it provides useful insights into the nature of risk premia in asset markets, we extend Lucas' model putting emphasis on the exchange rate dynamic as a function of differentials in expected returns on two regional equity markets.

Lucas' model is sketched in Appendix A, where the URP is also formally derived. Specifically, we show that the dynamics between returns on risky assets and exchange rate among two countries are linked by the following expression:

$$(1) \quad E\{(1+R_{x,t+1})|\Im_t\} = E\{(1+R_{y,t+1})|\Im_t\}E\left\{\frac{S_{ij,t+1}}{S_{ij,t}}|\Im_t\right\} + riskpremium_{t+1}$$

where $E\{(1+R_{x,t+1})|\Im_t\}$ and $E\{(1+R_{y,t+1})|\Im_t\}$ are expected gross total returns resulting from producing goods *x* in country *i* and goods *y* in country *j*, given the information set $\Im_t$; $S_{ij,t}$ is the nominal spot exchange rate of currency *i* with respect to currency *j*, that is the number of units of currency *i* exchanged for one unit of currency *j* (for instance euro per US dollars). Finally, the variable $riskpremium_{t+1}$ includes equity as well as foreign exchange risk premia.

For a given value of the risk premium term, the URP states that discrepancies in expected equity returns are re-equilibrated through contemporaneous adjustments in expected exchange rates. Specifically, if expected returns on a certain equity market are higher than those obtainable from another market, the currency associated with the market that offers higher returns is expected to depreciate. A resident in the market which offers higher expected returns suffers a loss when investing abroad, and therefore she has to be compensated by the expected capital gain that occurs when the foreign currency appreciates. The arbitrage mechanism characterising the URP is therefore similar to the one driving the UIP. There is, however, a key difference between the two arbitrage relations. In the UIP return differentials are known *ex ante*, since they are computed on risk-free assets, while in the URP are not.

3. Testing the uncovered equity return parity condition

To render the model described by (1) empirically tractable, we assume - for the time being - that agents are risk neutral. Taking logarithms of both sides of (1) yields: [6]

$$(2) \quad E\{s_{ij,t+1}|\Im_t\} - s_{ij,t} = -E\{r_{j,t+1} - r_{i,t+1}|\Im_t\},$$

[6] Notice that equation (2) is only an approximation because of Jensen's inequality, which implies that $ln\,E\{h_{t+1}|\Im_t\} > E\{ln(h_{t+1})|\Im_t\}$.

where $s_{ij,t+1} \equiv ln\left(S_{ij,t+1}\right)$, $r_{i,t+1} \equiv \ln\left(1+R_{x,t+1}\right)$ and $r_{j,t+1} \equiv \ln\left(1+R_{y,t+1}\right)$. Specifically, $E\left\{r_{i,t+1}\middle|\Im_t\right\}$ and $E\left\{r_{j,t+1}\middle|\Im_t\right\}$ are, respectively, the expected equity returns in country *i* and *j* given the information set $\Im_t$.[7]

Assume also that the vector process $\{\mathbf{y}_t\}_{t=1}^{T}$, $\mathbf{y}_t \equiv \left(s_{ij,t}, r_{j,t}, r_{i,t}\right)'$ is stationary and Gaussian, which implies that the conditional expectations in (2) have linear, time invariant representations and that the conditional variances are constant. Thanks to this assumption, once the projection $E\left\{r_{j,t+1} - r_{i,t+1}\middle|\Im_t\right\}$ is parameterized as a linear function of some predetermined variables, the parameters of (2) can be estimated by the Generalized Method of Moments (GMM) of Hansen (1982). Although developments in exchange rate changes might be determined by equity return differentials, investors may well exploit profit possibilities arising from the foreign exchange markets. For example, if euro area investors expected a decline in the US dollar, they would demand higher returns on US assets to compensate for the expected loss. This would induce a portfolio re-balance, which in turn would impact stock returns. This simultaneity problem justifies the use of GMM.

The econometric relationship for the conditional expectation of equity return differential reads as follows:

(3) $$r_{j,t+1} - r_{i,t+1} = \boldsymbol{\delta}'\left(\mathbf{Z}_{j,t} - \mathbf{Z}_{i,t}\right) + u_{t+1},$$

where $\mathbf{Z}_{j,t}$ and $\mathbf{Z}_{i,t}$ are $(f \times 1)$ vectors of instrumental variables, $\boldsymbol{\delta}$ is a $(f \times 1)$ vector of coefficients and u_{t+1} represents the forecast error which is orthogonal to the information variables.

The GMM procedure permits to estimate the following model:

(4) $$\Delta s_{ij,t+1} = \gamma + \alpha\left(r_{j,t+1} - r_{i,t+1}\right) + \varepsilon_{t+1},$$

where the f orthogonality conditions are given by $E\left\{\left(\mathbf{Z}_{j,t} - \mathbf{Z}_{i,t}\right)\varepsilon_{t+1}\right\} = \mathbf{0}$. The Newey-West covariance estimator is employed and is consistent in the presence of heteroskedasticity and autocorrelation of unknown form (Newey and West, 1987).

Under the hypothesis of market efficiency and risk neutrality, γ should not be statistically different from zero, while α should be equal to minus one. This would be in line with what the URP predicts to arbitrage away any profit possibilities. However, in the spirit of Fama's (1984) argument about the forward rate puzzle, if investors are risk averse, α could be negative but

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[7] Since in Lucas (1982) $R_{x,t+1}$ and $R_{y,t+1}$ are the returns resulting from producing gods *x* and *y*, respectively, for empirical applications the use of equity returns constitutes a natural proxy.

smaller than one in absolute value. The resulting risk premium could be time varying and affected by the business cycle. In line with earlier studies (Fama and French, 1989; Chen, 1991; Ferson and Harvey, 1991b), we assume that the risk premium is a function of a set of macroeconomic variables, such as the corporate earnings' growth rates, international equity flows, the annual inflation rates, and the changes in the short-term interest rates. In a two country/region context, we consider differentials in the two regional risk premia, which, in turn, are associated with differentials of country-specific economic variables. Since these variables are related to regional business cycles, their associated coefficients also possess economic content. Therefore, the model described by equation (4) can be extended and take the following specification:

(5) $$\Delta s_{ij,t+1} = \alpha_0 + \alpha_1 \left(r_{j,t+1} - r_{i,t+1} \right) + \alpha_2 \Delta \left(e_{j,t+1} - e_{i,t+1} \right) + \alpha_3 \Delta^2 \left(e_{j,t+1} - e_{i,t+1} \right) + \alpha_4 Q_{ij,t+1} + \alpha_5 \Delta \left(\pi_{j,t+1} - \pi_{i,t+1} \right) + \alpha_6 \Delta \left(i_{j,t+1} - i_{i,t+1} \right) + \alpha_7 \Delta s_{ij,t} + \zeta_{t+1}.$$

$\Delta e_{i,t+1}$ $\left(\Delta e_{j,t+1}\right)$ denotes the change in the log current corporate earnings associated with the equity price index *i* (*j*), which can approximate business cycle developments due to the pro-cyclical nature of corporate profits. When the growth rate of corporate earnings is relatively higher in one country/region, then its associated currency should appreciate vis-à-vis the other. Therefore, α_2 is expected to be positive. The change in the earnings growth differential, $\Delta^2\left(e_{j,t+1} - e_{i,t+1}\right)$, determines whether that differential is itself increasing or decreasing. If, for example, a positive widening in the differential induced a further appreciation of currency *j* vis-à-vis currency *i*, the pattern of the exchange rate $s_{ij,t+1}$ would be unsustainable. Therefore the coefficient α_3 is expected to be negative.

$Q_{ij,t+1}$ represents the net equity flows from country/region *i* to *j*, which can also approximate business cycle developments. Since a positive (negative) change in net equity flows from country/region *i* to *j* could generate appreciation (depreciation) of the currency *j* vis-à-vis the currency *i*, α_4 is expected to be positive. The inclusion of such variables could be criticized on the ground of an indeterminacy issue: if equity flows may have an impact on exchange rate developments, it is also true that exchange rate movements, in turn, may affect capital flow directions. However, this is the case only if there is a temporal lag between the two variables. If $\Delta s_{ij,t+1}$ were regressed on ΔQ_t, when investors decide in which market to allocate their funds, they would form expectations on possible evolutions of exchange rates. However, in equation (5), only a contemporaneous relationship between these two variables is explored.

$\Delta\left(i_{j,t+1} - i_{i,t+1}\right)$ and $\Delta\left(\pi_{j,t+1} - \pi_{i,t+1}\right)$ are the changes in differentials of the three-month interest rates and annual inflation rates, respectively. Both variables are key components of the business cycle literature. The differential in the changes of short-term interest rates is a variable which is borrowed from the microstructure literature (see, for instance, Evans and Lyons, 2001), which adopts it in the spirit of the Dornbush's (1976) model. More specifically, an increase in $\Delta i_{j,t+1}$ relative to $\Delta i_{i,t+1}$ should determine an appreciation of $s_{ij,t+1}$ (i.e. $\alpha_6 > 0$). Investors monitor the monthly changes in annual inflation rates, as inflation can undermine the purchasing power of their investments. If changes in inflation rates are higher in country *j* relative to country *i*, $s_{ij,t+1}$ is expected to depreciate (i.e. $\alpha_5 < 0$).

Finally, the term $\Delta s_{ij,t}$ captures a possible autoregressive component in the dependent variable.

We will also carry out a test to check whether the coefficients α_1 and α_2 are statistically the same, but of opposite sign, i.e. if $\alpha_1 = -\alpha_2 = \alpha$. If this were the case and if the rate of growth of the number of shares in each equity price index were relatively small or highly correlated, the term $\alpha_1(r_{j,t+1} - r_{i,t+1}) + \alpha_2\Delta(e_{j,t+1} - e_{i,t+1})$ would be approximately equal to the change in the price-earnings ratio, i.e. $\alpha\{\Delta ln(P_{j,t+1}/E_{j,t+1}) - \Delta ln(P_{i,t+1}/E_{i,t+1})\}$, where $E_{i,t+1}$ $(E_{j,t+1})$ is the level of earnings per share for the equity price index $P_{i,t+1}$ $(P_{j,t+1})$. International investors usually shift their funds to purchase securities characterized by relatively better yields' perspectives. In the equity markets, the price-earnings ratio is often used as a barometer of stocks' evaluation, which helps recognize profitable investment opportunities. A stock's price-earnings ratio indicates investors how much they are willing to pay per unit of earnings per share. Its inverse, the earnings yield, gives investors a reliable picture of a company management's ability to make profits out of the amount invested in equities. Consequently, when making their portfolio choices, international investors could take into consideration relative growth in the earnings yield. Funds would be shifted where perspectives on earnings yields are relatively more attractive. Equivalently, given a certain amount of earnings in two different countries/regions, investors move capital where prices are lower. In this case, an increase (decrease) in earnings yields in country *j*, $ey_{j,t+1}$, relative to country *i*, $ey_{i,t+1}$, would be matched with an appreciation (depreciation) of currency *j* relative to *i*.

4. Data

The empirical study is carried out using data from January 1991 to December 2003. The choice of this sample period is motivated by the large increase in cross-border equity flows due to financial liberalization of equity markets across the world. International equity flows on both the asset and liability sides of the United States vis-à-vis all countries/regions investigated in this study skyrocketed over the 1990's (see Figure 1).

All time series are observed at monthly frequency and obtained from Thomson Datastream. When financial variables are used, we employ the last trading day of the month.

Spot exchange rates include the synthetic euro until December 1998 and thereafter the actual euro (EUR), the Japanese Yen (JPY), the pound sterling (GBP), the Swiss franc (CHF), the Canadian dollar (CAD), the French franc (FF) and the Deutsche mark (DM), all against the US dollar (USD).[8]

Returns on equity securities are continuously compounded and computed with Thomson Datastream price indices for the United States, the euro area, Japan, the United Kingdom, Switzerland, Canada, France and Germany. Returns do not include dividends, since dividend yields will be employed as instruments and growth rates of earnings will enter the analysis as a separate regression variable. Datastream computes the equity price index for the euro area by using equity market value weights of each member state. Each equity price index has an associated market value and price/earning ratio. The ratio between the market value and the price/earning ratio allows computing corporate total earnings.

Net equity flows are from the US Treasury. Short-term interest rates are provided by the OECD. Finally, annual changes in inflation rates are computed with Consumer Price Indices (CPI) observed at a monthly frequency and published by the OECD.

A number of instruments have been used to implement the GMM estimation technique. Fama and French (1989), Ferson and Harvey (1991a), Kirby (1997) and Barr and Priestley (2004), among others, suggest that dividend yields, term spreads and default risk spreads possess information content for stock and bond market returns. Dividend yields are provided by Thomson Datastream. The term spread is calculated by subtracting the annualized yield on a three-month Treasury bill from the annualized ten-year Treasury yield obtained from Thomson Datastream. The default risk spread is calculated by subtracting the annualized dividend yield from the annualized ten-year Treasury yield. Term and default spreads for the euro area are proxied by the correspondent German variables. We employ differentials in dividend yields, term spreads, and default risk spreads as

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[8] Within the European Monetary Union the euro replaced national currencies on 1 January 1999, when bilateral exchange rates became irrevocably fixed. Before January 1999, Thomson Datastream computes the synthetic euro starting from December 1979. This series is employed to carry out the analysis on the EUR/USD exchange rate. A sensitivity analysis is performed using the synthetic euro constructed by the BIS as well as by the ECB, and the results do not vary.

instruments of differentials in stock market returns.[9] Since these instruments are integrated processes of order one, we use first differences.

Descriptive statistics for the equity returns as well as explanatory variables are reported in Tables 1 and 2. Not surprisingly, all return distributions exhibit skewness and leptokurtosis, a clear sign of non-normality. Descriptive statistics about the information variables are provided in Tables 3 and 4. The size of the correlation coefficients is quite small, indicating that instruments are sufficiently non-redundant.

Figures 2a-2g show developments in levels in equity price indices and in the exchange rates of EUR, GBP, CHF, JPY, CAD, DM and FF vis-à-vis the US dollar. Visual inspection suggests that when the euro area equity market exhibits a relatively better performance than the US equity market, the euro tends to depreciate vis-à-vis the US dollar. Similar trends apply to the DM and FF currency pairs against the US dollar. Analogous relationships may be identified when comparing the UK-US equity price ratio and the GBP/USD exchange rate, on the one hand, and the Swiss-US equity price ratio and the CHF/USD exchange rate, on the other hand. Conversely, this relationship becomes quite loose when comparing Japan and Canada with the United States.

The visual inspection of the relationship between relative cross-country corporate earnings and exchange rates is less informative (see Figures 3a-3g). However, analogous regularities emerge when plotting ratios between country/region earning yields and exchange rates. It seems that, at least over some periods, the exchange rates of the European currencies vis-à-vis the US dollar move in unison with the respective earning yield ratios (see Figures 4a-4g).

5. *Empirical results*

We first test the URP for EUR, GBP, CHF, JPY, CAD, DM and FF, all against the US dollar, assuming that investors are risk neutral. We employ the GMM estimator with a Heteroskedasticity and Autocorrelation Consistent (HAC) covariance matrix.[10] Results of equations (3) and (4) are reported in Table 5. In line with the URP, the α coefficients, except for the JPY and CAD, are significantly different from zero and negative, while the γ parameters are not significant. The

[9] We also employ other information variables, such as returns lagged up to four periods and a dummy variable which takes on value one each January. For each return differential we select instruments adopting a general-to-specific approach where standard errors are heteroskedasticity and autocorrelation consistent (Newey and West, 1987).

[10] We use the standard Bartlett kernel to weigh the autocovariances when computing the weighting matrix. As for the bandwidth selection, we use the fixed Newey-West method for all currency pairs, except for the Swiss franc for which we use the Andrew parameter approach (Andrew, 1991). This methodology assumes that the sample moments follow an AR(1) process.

slopes for the European currencies are less than one in absolute value, suggesting the existence of risk premia, and of about the same magnitude.[11] Since the number of moment conditions implied by equation (3) is larger than the number of parameters to estimate, we report a test for the over-identifying restrictions (Hansen, 1982). The *p*-value of the J-statistic suggests that the null hypothesis that the sample moments in the orthogonality conditions are as close to zero as would be expected if the corresponding population moments were truly zero cannot be rejected at 1% confidence level.

Next we relax the risk neutrality assumption and we proxy the resulting risk premia with economic variables linked to the business cycle: the differential of corporate earnings' growth rates, net equity flows, the annual inflation rate differentials, and the changes in the short-term interest rate differentials. The econometric specification represented by equations (3) and (5) is tested and results are shown in Table 6.[12] Consistently with our previous results, still there exists a significant negative relationship between exchange rate dynamics and equity return differentials, except for the JPY/USD and CAD/USD currency pairs. The estimated risk premia differentials for corporate earnings' growth rates and net equity flows are positive. As for inflation and interest rate risk premia differentials, the sign is not the same for all currency pairs.

Differentials of growth rates of earnings are one of the driving forces of developments in the European exchange rates. If one country/region grows faster than another, it becomes more attractive to global investors since its assets deliver relatively higher earnings, which, in turn, could result in an appreciation of its currency. We find that currency pair evolution is positively related to corporate earnings growth differentials $(\alpha_2 > 0)$ in five out of seven cases. The coefficient associated with the change in the corporate earnings growth differential is negative, suggesting a concave relationship vis-à-vis the above mentioned currency pairs.

The coefficient associated with net equity flows is positive, but statistically significant only for the EUR/USD and CHF/USD currency pairs.[13] The change in inflation differential plays a role only for the EUR/USD exchange rate and the coefficient shows the expected negative sign. The differential in the change of short-term interest rates is important for the evolution of the GBP/USD

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[11] The URP hypothesis is also tested over the 1980's. The coefficients of all currency pairs are not significantly different from zero and the regressions do not posses explanatory power. These results are not surprising given the restrictions and the large transaction costs on international capital flows during this period.

[12] The British pound depreciated dramatically against the US dollar in September and October 1992, as a result of the European Exchange Rate Mechanism (ERM) crisis (see, for example, Soderlind, 2000). A dummy variable, which is equal to one in September and October 1992, is introduced to capture this intercept shift (see figure 1b).

[13] Brooks *et al.* (2001) obtain similar results analyzing the EUR/USD exchange rate.

and FF/USD exchange rates. The estimated semi-elasticity is positive, which is in line with the prediction of the Dornbush's (1976) model.

As for the Japanese yen, the URP fairs poorly, possibly due to foreign exchange interventions during the 1990s by Japanese authorities (see, for instance, Ito, 2002, and Nagayasu, 2004). The same argument might apply to the Canadian dollar. Before September 1998, the Canadian Central Bank intervened in the foreign exchange market and the Canadian dollar fluctuated against the US dollar within a moving band (Chen and Rogoff, 2003). Therefore, we exclude the Japanese yen and the Canadian dollar from further analyses.

Since some risk premia are statistically not significant at 10% confidence level, we remove them from the exchange rate specifications using a general-to-specific approach. The resulting parsimonious models are reported in Table 7 and estimates are consistent with those shown in Table 6. We also test whether the coefficients on equity return differentials (α_1) and earning growth rate differentials (α_2) are statistically the same, but of opposite sign. If this is the case and the number of shares is relatively stable, the resulting variable would be equal to the differential in the growth rates of earning yields, $\Delta\left(ey_{j,t+1} - ey_{i,t+1}\right)$. The null hypothesis $\alpha_1 + \alpha_2 = 0$ cannot be rejected at 5% significance level for the EUR/USD and FF/USD currency pairs and at 1% for the GBP/USD. The test suggests that investors take into consideration earnings yield differentials in deciding their global investment strategies, thereby affecting the dynamics of the exchange rates. In line with the Lucas's model, a positive domestic real shock (i.e. an increase in domestic earning yields) may determine an appreciation in the domestic currency (see equation (A10)). When earning yields are used as explanatory variables, the point elasticities are positive and statistically significant at 1% confidence level for EUR/USD and FF/USD currency pairs and at 5% for the GBP/USD (see Table 8).

The specifications summarized in Table 7 have good explanatory power, as the adjusted coefficients of determination are equal to 24.3% for the EUR/USD, 34.6% for the GBP/USD, and 5.5% for the CHF/USD exchange rates. This is a satisfactory outcome in the view of most previous empirical models, which usually are able to explain little variations in exchange rates. The predictive accuracy of these specifications will be next compared with the predictive accuracy obtained adopting a naïve random walk model.

6. *Can we beat the random walk?*

Following a tradition initiated with the seminal paper of Meese and Rogoff (1983), the forecasting ability of the URP specifications reported in Table 7 is compared with the forecasting performance of a random walk model with drift, where increments are conditionally normally distributed with zero mean and variance σ^2_{t+1}:

(6) $$s_{ij,t+1} = \mu + s_{ij,t} + \varepsilon_{t+1}, \quad \varepsilon_{t+1} | \Im_t \sim N\left(0, \sigma^2_{t+1}\right).$$

The time-varying variance σ^2_{t+1} is assumed to follow the Generalized Autoregressive Conditionally Heteroskedastic (GARCH) process proposed by Engle (1982) and Bollerslev (1986):

$$\sigma^2_{t+1} = \omega + \lambda_1 \varepsilon^2_t + \lambda_2 \sigma^2_t .$$

Notice that equation (6) represents the most general version of the random walk model, since innovations are supposed to be not identically and not independently distributed, although increments are uncorrelated, i.e. $Cov\left(\varepsilon_t, \varepsilon_{t-k}\right) = 0$, for all $k \neq 0$.[14] This representation has been motivated by the fact that financial time series, including exchange rate changes, are usually characterized by volatility clustering.

The specifications described in Table (7) have been initially estimated up to December 1998. Next forecasts are carried out at horizons of one, two, three, four, six, nine and twelve months. The model is then estimated again adding one month of data and another set of forecasts is carried out. The procedure is reiterated until December 2002. In line with Meese and Rogoff (1983), the forecasts of the explanatory and instrumental variables – necessary to generate the forecasts of the exchange rates – are not computed; instead, actual realized values are utilized.[15] This methodology generates 49 forecast observations of the exchange rates, which can be used to compare predictive accuracy of our suggested model against the random walk.

The Mean Square Error (MSE) is employed to test whether the forecasts obtained with the specifications summarised in Table (7) are more accurate than the forecasts generated with the random walk model (6). The null hypothesis that the two specifications have equal accuracy against the alternative hypothesis that the forecasts generated with one model are more accurate than the forecasts generated with another model is tested with the Modified Diebold-Mariano (*MDM*)

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[14] Two other versions of the random walk hypothesis are commonly used in the literature (see Campbell *et al.*, 1997). In the first one it is assumed that innovations are independently and identically distributed, while in the second one increments are independent but not identically distributed. The model described by equation (6) encompasses these two versions as special cases. Notice that since GARCH processes capture the serial correlation of volatility, they permit to relax the independence assumption typical of the first two versions of the random walk hypothesis.

[15] As pointed out by Meese and Rogoff (1983), the use of realised values for the explanatory and instrumental variables prevents that the poor predictive power of exchange rate models can be attributed to the difficulties in predicting explanatory and instrumental variables themselves.

statistic of Harvey *et al*. (1997). The test is based on loss function (MSEs) differentials. The statistic, which has a Student's *t* distribution, reads as follows:

$$(7) \quad MDM = \left[\frac{n+1-2h}{n} + \frac{h(h-1)}{n^2}\right]^{1/2} \frac{\bar{d}}{\sqrt{\hat{V}(\bar{d})}},$$

$$\hat{V}(\bar{d}) = n^{-1}\left(\hat{\gamma}_0 + 2\sum_{k=1}^{M} m_k \hat{\gamma}_k\right), \; \bar{d} = n^{-1}\sum_{t=1}^{n} d_t,$$

where n is the number of forecasts, h the step ahead forecasts, d_t the difference between the loss functions under the two alternative models, $\hat{\gamma}_0$, $\hat{\gamma}_1$, ….., $\hat{\gamma}_{h-1}$ the estimated autocovariances, m_k the associated weights computed using the Barlett (triangular) window;[16] and M the truncation point. M is chosen such that $\hat{V}(\bar{d}) > 0$ (Diebold and Mariano, 1995). In our case, M is set equal to three.

Column (1) of Table 9 reports the ratios between the Root Mean Square Error (RMSE) obtained using the models described in Table 7 and the RMSE computed with the random walk. Our suggested specifications beat the random walk if the statistics are smaller than unity. Column (2) shows the *MDM* statistics.[17] The models we propose beat the random walk if the statistics turn out to be significantly negative. The URP specification forecasts the EUR/USD exchange rate more precisely than the random walk at two- and three-step ahead. The forecasting performances for the Swiss Franc are even better, but they are unsatisfactory for the British Pound.

Leitch and Tanner (1991) underline that the direction of change criterion not only constitutes an alternative forecasting metric, but it is also relevant for profitability and economic concerns. The sign test can be more appropriate than others based on merely statistic motivations. A direction-of-change statistic takes on the value zero if the forecast series correctly predicts the direction of change, and the value one otherwise. The associated loss function reads as follows:

$$(8) \quad L(s_{ij,t}, \hat{s}_{ij,t}) = \begin{cases} 0 & if \; sign(\Delta s_{ij,t}) = sign(\Delta \hat{s}_{ij,t}) \\ 1 & if \; sign(\Delta s_{ij,t}) \neq sign(\Delta \hat{s}_{ij,t}) \end{cases},$$

where $s_{ij,t}$ denotes the actual exchange rate series and $\hat{s}_{ij,t}$ its forecast. The likelihood of correctly predicting the directional change, $\overline{D}$, can be computed by summing up the number of observations

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[16] We have also used the Tukey window (where $m_k = 0.5(1+\cos\{\pi k/M\})$) as an alternative to the Barlett window (where $m_k = 1 - k/M$). The results are similar.

[17] The autoregressive term in the GBP/USD specification is excluded in order to use the *MDM* statistic as it is designed for non-nested forecasts. To control for the possibility that sample moments follow an AR(1) process, we employ the parametric method suggested by Andrews (1991) for the bandwidth selection. Nevertheless, the two methods, Andrews and Fixed-Newey-West, yield similar results.

whose value is zero and dividing them by the total number of predictions. When $\overline{D}$ is significantly larger than 0.5, the forecast has the ability to predict the direction of change. On the other hand, if the statistic is significantly smaller than 0.5, the forecast will tend to give the wrong direction of change. In large samples, it can be shown that the sign test is normally distributed (see Diebold and Mariano, 1995):

$$\frac{\left(\overline{D}-0.5\right)}{\sqrt{0.25/n}} \sim N(0,1).$$

Directions of changes are accurately predicted for the euro two thirds of the times, but less precisely for the other two currencies (see column (3)). Columns (4) reports the correlation coefficients between the actual and URP-based forecast exchange rate changes, while column (5) shows correlation coefficients associated with the forecasts carried out with the random walk model. Correlations are negative and low when predictions are performed with the random walk specification, while they are positive and particularly large for the EUR/USD exchange rate when the currency dynamics is forecast using the URP models.

Figures 5a-5c compare the evolution of the actual exchange rate for the three European currencies and the two-step ahead forecasts, where predictions are performed with the URP models and the random walk specification. The point forecasts computed with the random walk are represented by a strait line.[18] Visual inspection confirms the results presented in columns (4) and (5) of Table 9.

7. *Summary of results and conclusions*

Over the last two decades a large number of studies have tried to explain and test the dynamics of exchange rates. Traditional theoretical models of exchange rate determination fare quite poorly when confronted with data and usually show limited forecasting ability, since almost never perform better than a naïve random walk specification. Major innovative contributions are due to microfounded models *à la* Obstfeld and Rogoff (1995) and the micro-structure literature. Nevertheless, new open-economy macroeconomics frameworks do not seem to be buttressed by solid empirical evidence. As for the micro-structure literature, although the explanatory power of this typology of models increases in comparison to other approaches, the fundamentals driving order flows are not clear.

[18] The function representing the forecasts obtained with a random walk model is not a perfectly straight line since the intercept is re-estimated at the beginning of any forecast period.

The increasing role played by international financial markets in developed economies constitutes a persuasive argument to explore possible relationships between returns on risky assets and exchange rates dynamics. Recently, a new strand of research has investigated the interconnections between equity and bond returns, on one side, and exchange rate dynamics, on the other side, with promising results (see Brandt *et al.*, 2001; Pavlova and Rigobon, 2003; Hau and Rey, 2004 and 2005). In this spirit, this paper develops and tests an arbitrage condition, the URP, which finds its theoretical underpinning in the consumption economy of Lucas (1982). The key idea underlying this equilibrium hypothesis is that, in order to arbitrage away profit opportunities, expected changes in exchange rates are linked to differentials in expected returns on equities. We first test the URP assuming risk neutrality and next we relax this hypothesis. Estimating the URP under risk neutrality, we find that a relative increase in equity returns in the euro area, the United Kingdom, Switzerland, Germany and France vis-à-vis the United States is associated with an appreciation of the US dollar against the currencies of these economies.

When we assume that investors are risk-adverse, we use additional explanatory variables proxying for the resulting risk premia, which, in turn, are related to the business cycle. We employ differentials in corporate earnings' growth rates, short-term interest rate changes, and annual inflation rates, as well as net equity flows. This version of the URP is validated by the data and exhibits good explanatory power.

We also test the forecasting ability of the URP with time-varying risk premia and find that it beats the naïve random walk model with drift at two- and three-month ahead forecasts and always predicts about two thirds of directional changes for the EUR/USD exchange rate. The forecasting performances for the Swiss Franc are better in terms of MSE, but not in terms of the sign test. The specification for the British pound does not beat the naïve random walk model, despite it predicts correctly more than 60% of its directional changes.

Similar specifications fail in explaining the evolution of the Japanese Yen and the Canadian dollar against the US dollar, possibly due to the systematic intervention policy of these countries in the foreign exchange market.

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Appendix A: The URP condition in Lucas' consumption economy

In this appendix we sketch Lucas' (1982) consumption economy model and next we derive the URP condition.

Assume that the world consists of two countries, *i* and *j*, and that in each country there are infinitely-lived consumers. Agents in the two countries exhibit identical preferences, which are defined over the infinite stream of two consumption goods, *x* and *y*, and are risk averse.[19] Consumers, however, have different stochastic endowments of the two goods. At time *t*, each citizen of country *i* is endowed with ξ_t units of a freely transportable, non storable consumption good *x* and nothing of commodity *y*, while each citizen of country *j* is endowed with η_t units of the second good *y* and nothing of commodity *x*. The realizations ξ_t and η_t completely describe the current real state of the system. Moreover, the stochastic bivariate process (ξ_t, η_t) is assumed to be drawn from a unique stationary Markov distribution $F(\xi_t, \eta_t | \xi_{t-1}, \eta_{t-1})$ which gives the transition probability of ξ_t and η_t conditional on ξ_{t-1} and η_{t-1}.

The representative agent's preferences are expressed by the following expected utility function:

(A1) $$E\left\{\sum_{t=0}^{\infty} \beta^t U(x_{lt}, y_{lt}) \middle| \Im_{t=0}\right\},$$

where $E\{\cdot|\cdot\}$ is the expectation operator conditional on the information set $\Im_{t=0}$, β is the common discount factor, $0 < \beta < 1$, while x_{lt} and y_{lt} represent consumption of the good *x* and *y*, respectively, in country *l* = *i*, *j* at time *t*. The utility function is assumed to be bounded, continuously differentiable, increasing in both arguments, and strictly concave. Markets are supposed to be complete in the sense of Arrow (1964) and Debreu (1959), which means that agents trade in both goods contingent of all possible realization of the stochastic process (ξ_t, η_t).

The use of money or currency is introduced by assuming that agents can purchase the endowment of a country only with the currency of that country. Let M_t be the period *t* per capita quantity of money of country *i*, say the nominal euro, and let N_t be the period *t* per capita quantity of the money of country *j*, say the nominal US dollars. Define $w_{i,t}$ $(w_{j,t})$ as the exogenous stochastic rate of change in money. Prior to any trading at time *t*, suppose that each trader in country

[19] The fact that agents are risk averse will enrich the URP with risk premia.

i receives a lump sum euro transfer of $w_{i,t}M_{t-1}$ and, similarly, each trader in country j a lump sum dollar transfer of $w_{j,t}N_{t-1}$ so that the money supply evolves as follows:

(A2) $M_{t+1} = (1 + w_{i,t+1})M_t$,

(A3) $N_{t+1} = (1 + w_{j,t+1})N_t$.[20]

The equilibrium nominal prices of goods x and y in terms of domestic and foreign currency, as well as ξ_t and η_t are given by:

(A4) $P_{x,t}(M_t) = \dfrac{M_t}{\xi_t}$,

(A5) $P_{y,t}(N_t) = \dfrac{N_t}{\eta_t}$.

Maximizing the expected present value of the representative agent's utility function, subject to budget constraints and cash-in-advance constraints gives a set of first order conditions (see Lucas, 1982, for further details). These include the standard requirement that the marginal rate of substitution between domestic and foreign goods equals their relative prices, and the Euler equations for xth and yth stocks:

(A6) $p_{y,t} = \dfrac{U_{y,t}(x_t, y_t)}{U_{x,t}(x_t, y_t)}$,

(A7) $U_{x,t}(\cdot)q_{x,t} = \beta \int U_{x,t+1}(\cdot)\left[q_{x,t+1} + \dfrac{\xi_{t+1}}{1 + w_{i,t+1}}\right] dFdK$,

(A8) $U_{x,t}(\cdot)q_{y,t} = \beta \int U_{x,t+1}(\cdot)\left[q_{x,t+1} + \dfrac{\eta_{t+1}}{1 + w_{j,t+1}} p_{y,t+1}\right] dFdK$.

$p_{y,t}$ is the relative domestic spot price of y in terms of the numeraire x, $U_{y,t}(x_t, y_t) \equiv \partial U(x_t, y_t)/\partial y_t$, $U_{x,t}(x_t, y_t) \equiv \partial U(x_t, y_t)/\partial x_t$, $q_{x,t}$ is the current price, in x-unit, of a claim to the entire future stream $\{\xi_t\}_{t=t+1}^{\infty}$ of the endowment of good x, and $q_{y,t}$ is the current domestic price, in x-unit, of a claim to the entire future stream $\{\eta_t\}_{t=t+1}^{\infty}$ of the endowment of good y.

[20] The transition function for the process $\{w_t\} = \{w_{i,t}, w_{j,t}\}$ is also a known Markov process $K\left[w_t \middle| w_{t-1}, F(\xi_t, \eta_t | \xi_{t-1}, \eta_{t-1})\right]$ which gives the transition probability of w_t conditional on w_{t-1} and the probability of the future real state given by $F(\cdot|\cdot)$.

Notice that $q_{x,t}$ and $q_{y,t}$ are expressed in domestic currency. Therefore, $p_{y,t}$, $q_{x,t}$ and $q_{y,t}$ are real prices expressed in domestic currency.

The nominal exchange rate enters the model because the Purchasing Power Parity (PPP) holds:

(A9) $$p_{y,t} = \frac{S_{ij,t}(M_t, N_t) P_{y,t}(N_t)}{P_{x,t}(M_t)},$$

where $S_{ij,t}(M_t, N_t)$ is the nominal spot exchange rate of currency *i* with respect to currency *j*, that is the number of units of currency *i* exchanged for one unit of currency *j* (for instance euro per US dollars).

Rearranging (A9) and using (A6) give the nominal exchange rate:

(A10) $$S_{ij,t}(M_t, N_t) = \frac{U_{y,t}(x_t, y_t)}{U_{x,t}(x_t, y_t)} \frac{M_t}{N_t} \frac{\eta_t}{\xi_t}.$$

The fundamental determinants of the nominal exchange rate are relative money supplies and relative endowments. In addition, the exchange rate depends also on consumer preferences.

Lucas' model can be extended and the URP derived. We use the Euler equations to build a relationship between expectations in exchange rate dynamics and expected equity returns in the two countries.

Combining (A7) and (A8) yields:

(A11) $$\frac{1}{q_{x,t}} \int U_{x,t+1}(\cdot) \left[q_{x,t+1} + \frac{\xi_{t+1}}{1 + w_{i,t+1}} \right] dFdK = \frac{1}{q_{y,t}} \int U_{x,t+1}(\cdot) \left[q_{y,t+1} + \frac{\eta_{t+1}}{1 + w_{j,t+1}} p_{y,t+1} \right] dFdK.$$

Using (A2) and (A4) on the left-hand side of (A11), and (A3), (A5) and (A9) on the right-hand side of (A11), the above equality becomes:

(A12) $$\int U_{x,t+1}(\cdot) \left[\frac{Q_{x,t+1}}{Q_{x,t}} + \frac{\xi_t P_{x,t}(M_t)}{Q_{x,t}} \right] \frac{P_{x,t}(M_t)}{P_{x,t+1}(M_{t+1})} dFdK =$$
$$\int U_{x,t+1}(\cdot) \left[\frac{Q_{y,t+1}}{Q_{y,t}} + \frac{\eta_t P_{y,t}(N_t)}{Q_{y,t}} \frac{S_{ij,t+1}}{S_{ij,t}} \right] \frac{P_{x,t}(M_t)}{P_{x,t+1}(M_{t+1})} dFdK,$$

where $Q_{x,t}$ is the current nominal price of a claim to the entire future stream $\{\xi_t\}_{t=t+1}^{\infty}$ of the endowment of good *x* expressed in domestic currency, and $Q_{y,t}$ the current nominal foreign price of a claim to the entire future stream $\{\eta_t\}_{t=t+1}^{\infty}$ of the endowment of good *y* expressed in foreign currency.

Since gross total returns may be defined as $1+R_{x,t+1}=\left[Q_{x,t+1}+\xi_t P_{x,t}\left(M_t\right)\right]/Q_{x,t}$ and $1+R_{y,t+1}=\left[Q_{y,t+1}+\eta_t P_{y,t}\left(N_t\right)\right]/Q_{y,t}$, being $\xi_t P_{x,t}\left(M_t\right)$ and $\eta_t P_{y,t}\left(N_t\right)$ the nominal dividends at time t in the domestic and foreign economy, respectively, while the gross inflation rate is equal to $1+\pi_{t+1}=P_{x,t+1}\left(M_{t+1}\right)/P_{x,t}\left(M_t\right)$, equation (A12) can be expressed as:

(A13) $$\int U_{x,t+1}(\cdot)(1+\pi_{t+1})^{-1}(1+R_{x,t+1})dFdK=\int U_{x,t+1}(\cdot)(1+\pi_{t+1})^{-1}(1+R_{y,t+1})\frac{S_{ij,t+1}}{S_{ij,t}}dFdK\ .$$

Equation (A13) can be re-written making use of the conditional expectation operator:

(A14) $$E\left\{U_{x,t+1}(\cdot)(1+\pi_{t+1})^{-1}(1+R_{x,t+1})|\Im_t\right\}=E\left\{U_{x,t+1}(\cdot)(1+\pi_{t+1})^{-1}(1+R_{y,t+1})\frac{S_{ij,t+1}}{S_{ij,t}}|\Im_t\right\}.$$

Using the definition of covariance $Cov(g,h)=E(gh)-E(g)E(h)$, (A14) becomes:

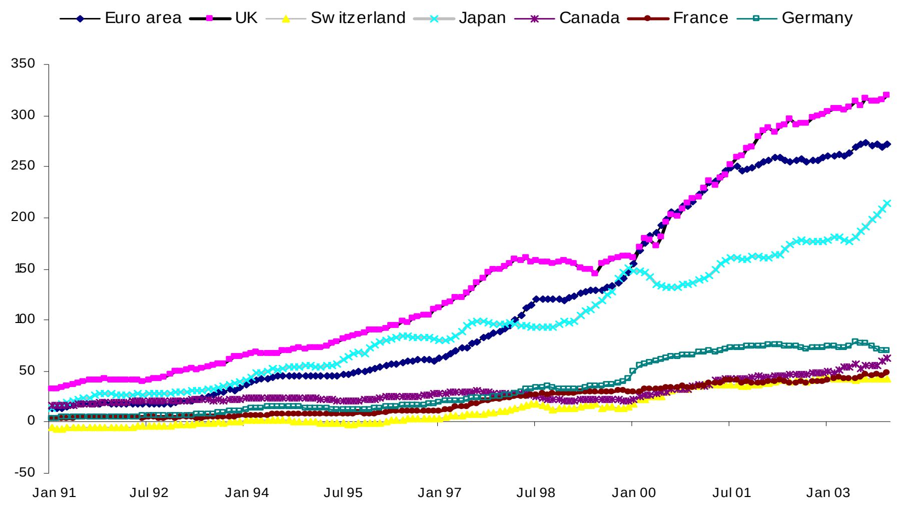
$$E\left\{U_{x,t+1}(\cdot)(1+\pi_{t+1})^{-1}|\Im_t\right\}E\left\{(1+R_{x,t+1})|\Im_t\right\}+Cov\left\{U_{x,t+1}(\cdot)(1+\pi_{t+1})^{-1},(1+R_{x,t+1})|\Im_t\right\}=$$
$$E\left\{U_{x,t+1}(\cdot)(1+\pi_{t+1})^{-1}|\Im_t\right\}\left[E\left\{(1+R_{y,t+1})|\Im_t\right\}E\left\{\frac{S_{ij,t+1}}{S_{ij,t}}|\Im_t\right\}+Cov\left\{(1+R_{y,t+1}),\frac{S_{ij,t+1}}{S_{ij,t}}|\Im_t\right\}\right]+$$
$$Cov\left\{U_{x,t+1}(\cdot)(1+\pi_{t+1})^{-1},(1+R_{y,t+1})\frac{S_{ij,t+1}}{S_{ij,t}}|\Im_t\right\},$$

which can be re-arranged to obtain the URP condition enriched with a risk premium:

(A15) $$E\left\{(1+R_{x,t+1})|\Im_t\right\}=E\left\{(1+R_{y,t+1})|\Im_t\right\}E\left\{\frac{S_{ij,t+1}}{S_{ij,t}}|\Im_t\right\}+riskpremium_{t+1},$$

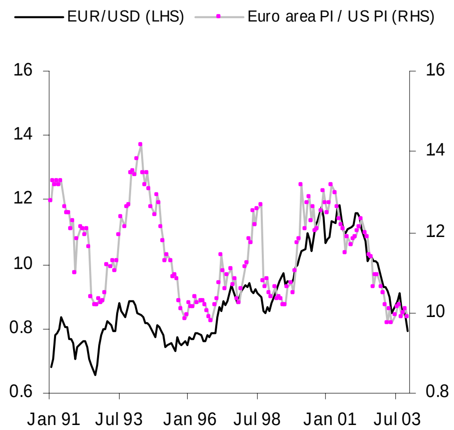
where the risk premium is what is left out after isolating expectations of returns and exchange rates.

Figure 1: Cumulated asset and liability equity flows vis-à-vis the United States
(USD billion)



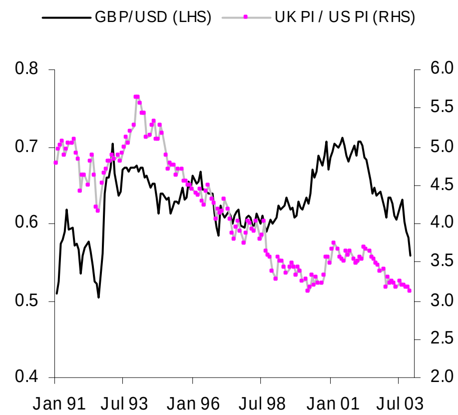
Source: US Treasury.

Figure 2a: EUR/USD and ratio between euro area and US equity price indeces (PI)



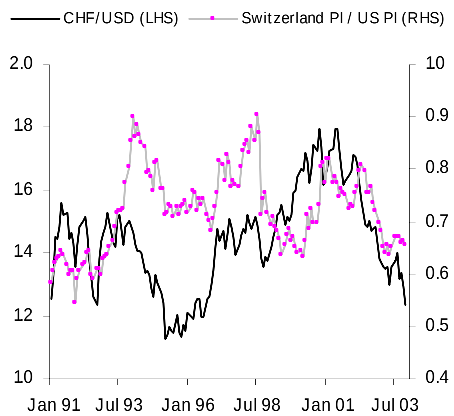
Source: Datastream.

Figure 2b: GBP/USD and ratio between UK and US equity price indeces (PI)



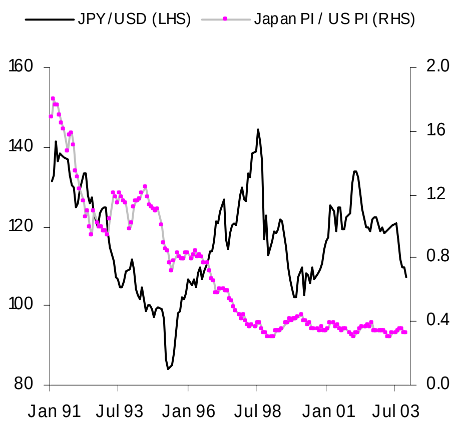
Source: Datastream.

Figure 2c: CHF/USD and ratio between Switzerland and US equity price indeces (PI)



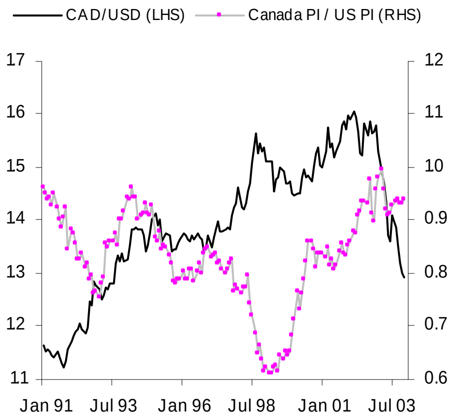
Source: Datastream.

Figure 2d: JPY/USD and ratio between Japan and US equity price indeces (PI)



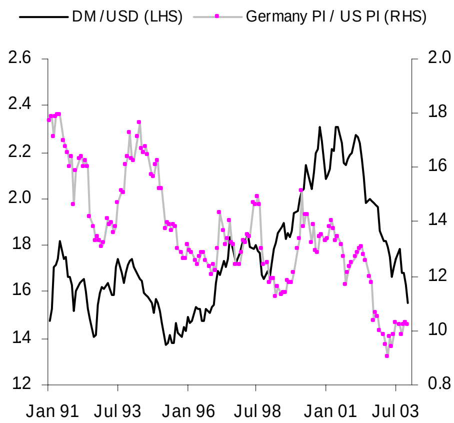
Source: Datastream.

Figure 2e: CAD/USD and ratio between Canada and US equity price indeces (PI)



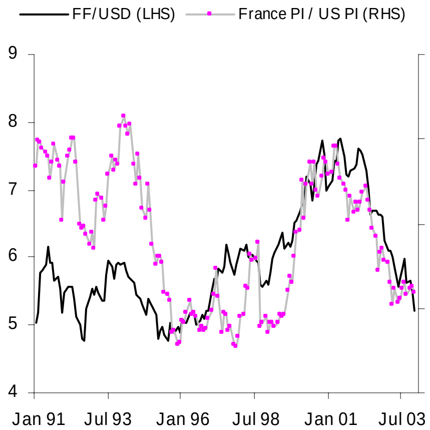
Source: Datastream.

Figure 2f: DM/USD and ratio between Germany and US equity price indeces (PI)



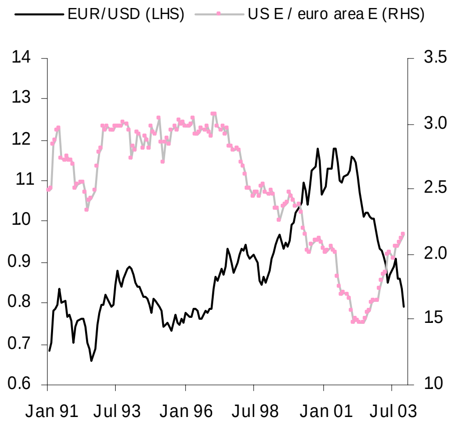
Source: Datastream.

Figure 2g: FF/USD and ratio between France and US equity price indeces (PI)



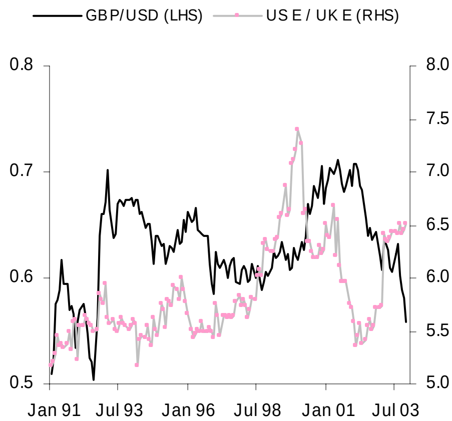
Source: Datastream.

Figure 3a: EUR/USD and ratio between US and euro area corporate earnings (E)



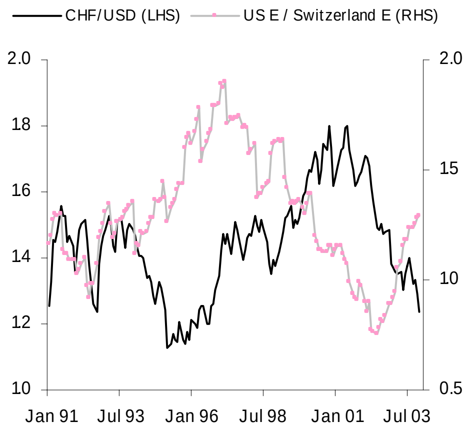
Source: Datastream.

Figure 3b: GBP/USD and ratio between US and UK corporate earnings (E)



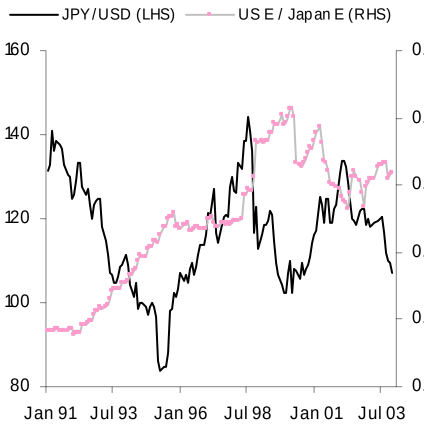
Source: Datastream.

Figure 3c: CHF/USD and ratio between US and Switzerland corporate earnings (E)



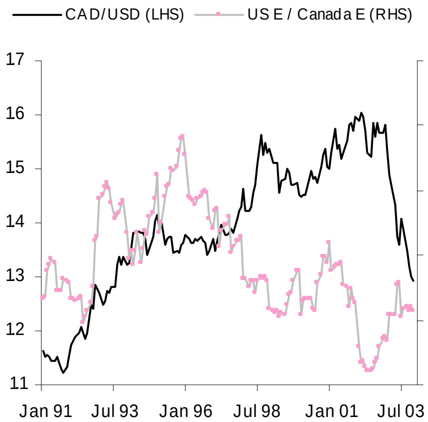
Source: Datastream.

Figure 3d: JPY/USD and ratio between US and Japan corporate earnings (E)



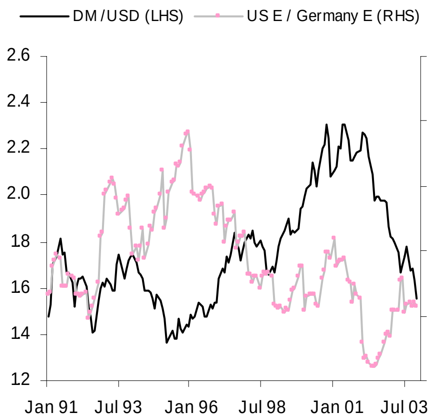
Source: Datastream.

Figure 3e: CAD/USD and ratio between US and Canada corporate earnings (E)



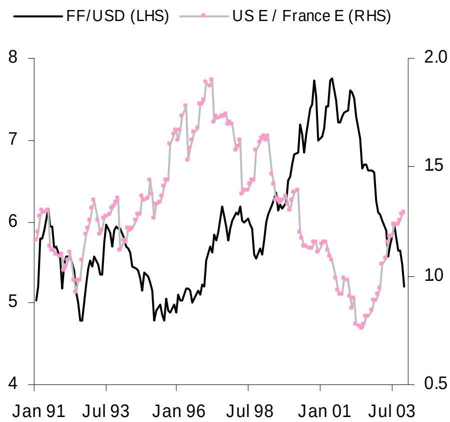
Source: Datastream.

Figure 3f: DM/USD and ratio between US and Germany corporate earnings (E)



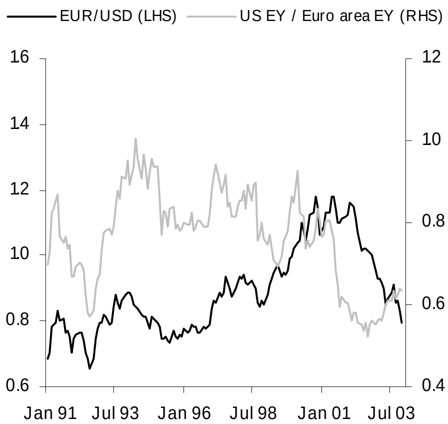
Source: Datastream.

Figure 3g: FF/USD and ratio between US and France corporate earnings (E)



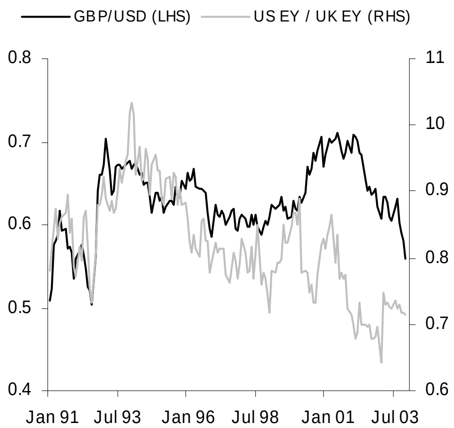
Source: Datastream.

Figure 4a: EUR/USD and ratio between US and euro area earning yield (EY)



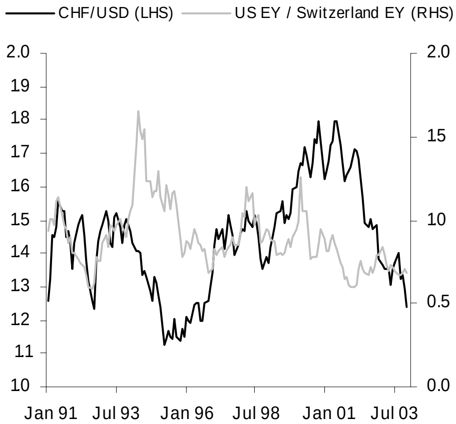
Source: Datastream.

Figure 4b: GBP/USD and ratio between US and UK earning yield (EY)



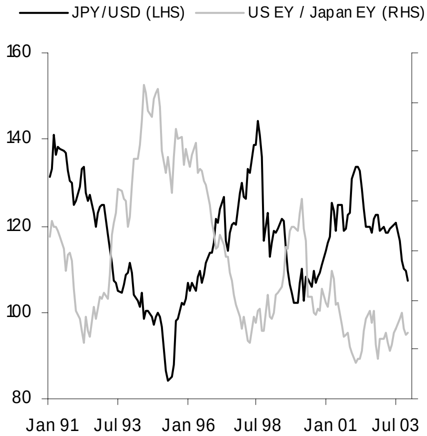
Source: Datastream.

Figure 4c: CHF/USD and ratio between US and Switzerland earning yield (EY)



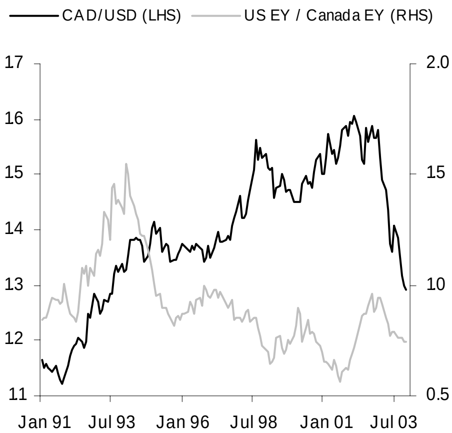
Source: Datastream.

Figure 4d: JPY/USD and ratio between US and Japan earning yield (EY)



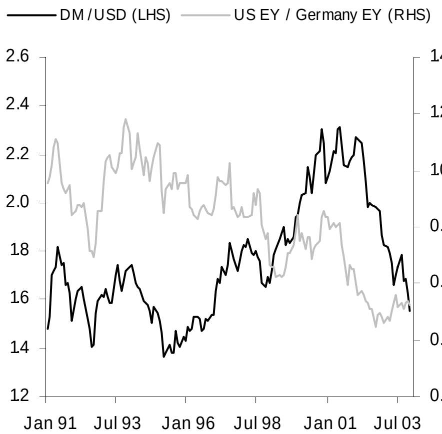
Source: Datastream.

Figure 4e: CAD/USD and ratio between US and Canada earning yield (EY)



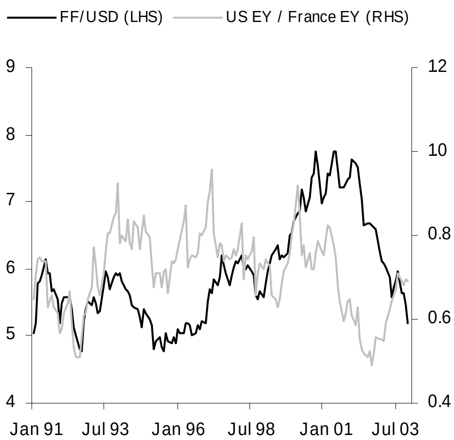
Source: Datastream.

Figure 4f: DM/USD and ratio between US and Germany earning yield (EY)



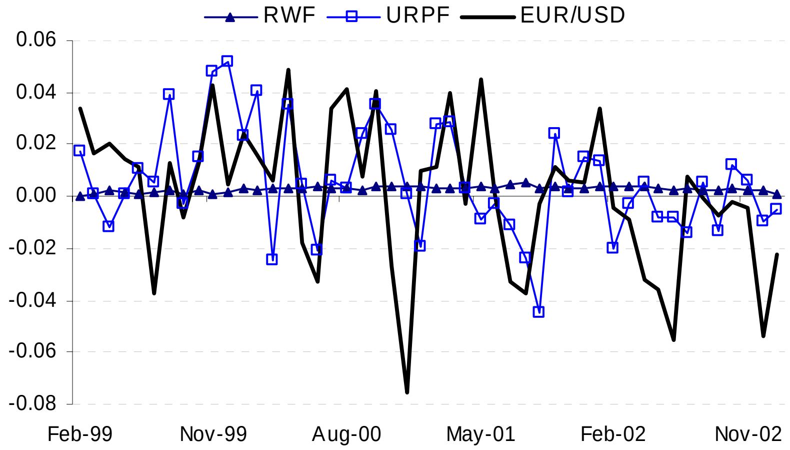
Source: Datastream.

Figure 4g: FF/USD and ratio between US and France earning yield (EY)



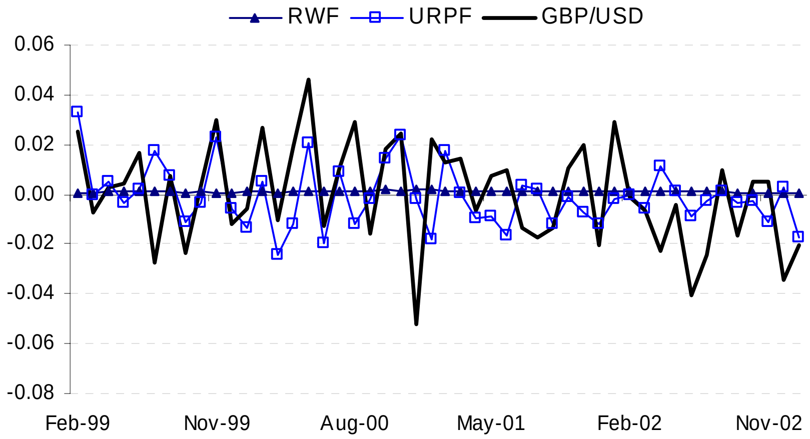
Source: Datastream.

Figure 5a: EUR/USD developments and out of sample forecasts (two-month ahead)



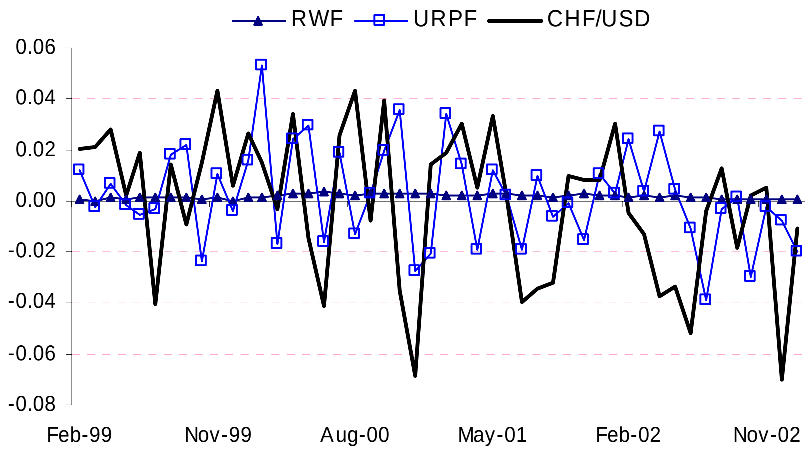
Note: RWF and URPF indicate two-month ahead forecasts carried out with a random walk with drift and the URP specification, respectively.

Figure 5b: GBP/USD developments and out of sample forecasts (two-month ahead)



Note: RWF and URPF indicate two-month ahead forecasts carried out with a random walk with drift and the URP specification, respectively.

Figure 5c: CHF/USD developments and out of sample forecasts (two-month ahead)



Note: RWF and URPF indicate two-month ahead forecasts carried out with a random walk with drift and the URP specification, respectively.

Table 1
Descriptive statistics of log changes in exchange rates

	EUR/USD (%)	GBP/USD (%)	CHF/USD (%)	YEN/USD (%)	CAN/USD (%)	FF/USD (%)	DM/USD (%)
Mean	0.052	0.046	-0.022	-0.152	0.066	0.102	0.117
Std. Deviation	2.980	2.747	3.302	3.310	1.564	3.100	3.153
Skewness	0.222	1.157	0.191	-0.680	0.036	0.757	0.686
Kurtosis	3.688	7.042	3.250	5.665	3.544	4.507	4.534
$L\text{-}B_{12}$	15.455	11.559	22.230	22.152	15.005	7.012	7.9265

Sample period: January 1991 – December 2003; frequency: monthly. The sample period ends on December 1998 for FF/USD and DM/USD currency pairs.
The Ljung-Box ($L\text{-}B_m$) statistic tests the null hypothesis that all autocorrelation coefficients are simultaneously equal to zero up to m lags. It is asymptotically distributed as a χ^2_m. We have chosen m=12 for which the critical values at 95% and 99% confidence levels are 21.026 and 26.2170, respectively.

Table 2
Descriptive statistics of returns on equity indices, growth rate of corporate earnings, net equity flows and annual inflation rates

	Returns on equities (%)	Growth rates of corporate earnings (%)	Net equity flows vis-à-vis the US (USD billion)	Annual inflation rate (%)
United States				
Mean	0.845	0.823	-	2.632
Std. Deviation	4.387	2.067	-	0.785
Skewness	-0.697	-0.573	-	0.652
Kurtosis	3.936	6.290	-	4.428
$L\text{-}B_{12}$	8.784	81.143	-	551.810
Euro area				
Mean	0.659	0.900	1.770	2.673
Std. Deviation	5.095	2.449	3.416	1.125
Skewness	-0.604	-0.426	1.191	0.649
Kurtosis	4.136	8.455	4.601	2.574
$L\text{-}B_{12}$	14.602	27.387	620.380	1420.900
Japan				
Mean	-0.242	-0.046	-0.915	0.488
Std. Deviation	5.418	3.732	2.279	1.248
Skewness	0.085	0.139	-0.709	0.771
Kurtosis	3.054	10.575	4.777	2.745
$L\text{-}B_{12}$	8.384	26.365	105.290	966.490
United Kingdom				
Mean	0.544	0.660	1.009	2.795
Std. Deviation	4.256	2.147	3.693	1.256
Skewness	-0.571	-0.249	0.372	1.769
Kurtosis	3.488	7.307	4.157	8.874
$L\text{-}B_{12}$	4.028	25.003	224.200	478.67
Switzerland				
Mean	0.896	0.949	0.180	1.653
Std. Deviation	4.814	4.551	0.989	1.637
Skewness	-0.992	0.039	0.544	1.340
Kurtosis	5.293	8.040	10.484	3.804
$L\text{-}B_{12}$	14.294	51.674	32.861	1105.400
Canada				
Mean	0.805	0.876	0.107	2.086
Std. Deviation	4.212	5.109	1.132	1.349
Skewness	-1.036	-0.244	0.955	1.287
Kurtosis	6.895	5.281	7.913	5.010
$L\text{-}B_{12}$	7.628	26.579	39.641	477.600
France				
Mean	1.092	0.700	-0.010	1.843
Std. Deviation	5.061	0.048	0.735	0.776
Skewness	-0.346	1.990	1.970	0.059
Kurtosis	2.943	7.860	13.314	2.885
$L\text{-}B_{12}$	9.342	14.155	25.694	475.560
Germany				
Mean	1.006	1.052	0.153	2.744
Std. Deviation	4.608	4.564	0.589	1.524
Skewness	-0.877	0.697	1.038	0.606
Kurtosis	5.135	5.543	4.992	2.234
$L\text{-}B_{12}$	11.483	4.478		698.580

Sample period: January 1991 – December 2003; frequency: monthly. The sample period ends on December 1998 for France and Germany.
$L\text{-}B_{12}$ is the Ljung-Box statistic (see Table 1 for further details).

Table 3
Descriptive statistics of instrumental variables

	Annual dividend yields (%)	Annual 10-year Government bond yields (%)	Annual 3-months interest rate (%)
United States			
Mean	1.965	6.994	4.466
Std. Deviation	0.674	0.874	1.683
Skewness	0.273	0.255	-0.699
Kurtosis	1.699	2.097	2.248
$L\text{-}B_{12}$	1557.200	1120.000	1182.500
Euro area #			
Mean	2.594	6.212	5.747
Std. Deviation	0.609	0.860	2.842
Skewness	-0.001	0.212	0.922
Kurtosis	1.941	1.719	2.564
$L\text{-}B_{12}$	1221.500	1248.500	1448.300
Japan			
Mean	0.817	4.068	1.608
Std. Deviation	0.135	1.196	2.142
Skewness	0.286	0.188	1.675
Kurtosis	2.495	1.810	4.933
$L\text{-}B_{12}$	603.940	1487.900	1166.300
United Kingdom			
Mean	3.571	7.206	6.434
Std. Deviation	0.771	1.537	2.141
Skewness	0.244	0.301	1.224
Kurtosis	2.380	1.763	4.375
$L\text{-}B_{12}$	1285.700	1432.500	967.790
Switzerland			
Mean	1.559	4.417	3.249
Std. Deviation	0.275	0.873	2.430
Skewness	0.055	0.933	1.020
Kurtosis	2.991	2.721	3.066
$L\text{-}B_{12}$	780.450	1513.600	1292.500
Canada			
Mean	2.158	7.615	5.167
Std. Deviation	0.550	1.351	1.780
Skewness	0.330	0.349	0.602
Kurtosis	2.225	1.746	3.284
$L\text{-}B_{12}$	1408.900	1351.400	740.730
France			
Mean	3.109	7.512	6.491
Std. Deviation	0.450	0.996	2.728
Skewness	-0.278	-0.203	0.384
Kurtosis	2.298	1.959	1.764
$L\text{-}B_{12}$	431.960	557.860	781.620
Germany			
Mean	1.932	6.721	5.766
Std. Deviation	0.355	0.690	2.470
Skewness	-0.077	-0.538	0.501
Kurtosis	2.362	2.608	1.626
$L\text{-}B_{12}$	594.00	450.710	922.860

Sample period: January 1991 – Decemebr 2003; frequency: monthly. The sample period ends on December 1998 for France and Germany.

Euro area 10-year government bond yields are proxied by 10-year German government bond yields.

$L\text{-}B_{12}$ is the Ljung-Box statistic (see Table 1 for further details).

Table 4
Correlation matrix of instrumental variables

	Change in dividend yields differential	Change in term spreads differential	Change in default risk spreads differential	Change in dividend yields differential	Change in term spreads differential	Change in default risk spreads differential
	Euro area			**Japan**		
Change in dividend yields differential	1.000			1.000		
Change in term spreads differential	0.140	1.000		-0.019	1.000	
Change in default risk spreads differential	0.229	-0.339	1.000	0.388	-0.417	1.000
	UK			**Switzerland**		
Change in dividend yields differential	1.000			1.000		
Change in term spreads differential	0.000	1.000		-0.044	1.000	
Change in default risk spreads differential	0.259	-0.123	1.000	0.075	-0.283	1.000
	Canada			**France**		
Change in dividend yields differential	1.000			1.000		
Change in term spreads differential	-0.177	1.000		0.117	1.000	
Change in default risk spreads differential	0.335	-0.325	1.000	0.503	-0.189	1.000
	Germany					
Change in dividend yields differential	1.000					
Change in term spreads differential	0.169	1.000				
Change in default risk spreads differential	0.376	-0.339	1.000			

Sample period: January 1991 – December 2003; frequency: monthly. The sample period ends on December 1998 for France and Germany.

Table 5
The uncovered equity return parity condition

$$\Delta s_{ij,t+1} = \gamma + \alpha\left(r_{j,t+1} - r_{i,t+1}\right) + \varepsilon_{t+1}$$

	Euro	Japanese yen	Pound sterling	Swiss franc	Canadian dollar	French franc	Deutsche marc
γ	0.000	-0.000	0.001	-0.001	0.001	0.001	0.000
	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)	(0.003)
α	-0.459***	-0.166	-0.471***	-0.452*	0.008	-0.489***	-0.428**
	(0.147)	(0.197)	(0.127)	(0.254)	(0.181)	(0.134)	(0.175)
Adj. R^2	0.142	0.000	0.092	0.000	0.000	0.067	0.101
J-Stat (P-value)	0.542	0.177	0.487	0.310	0.681	0.633	0.239
Sample period	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 98	Jan 91-Dec 98

Standard errors are shown in parentheses. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.
Each currency is expressed vis-à-vis the US dollar.

Estimation approach: GMM estimator, HAC Covariance Matrix.

Table 6
The uncovered equity return parity condition with risk premia

$$\Delta s_{ij,t+1} = \alpha_0 + \alpha_1\left(r_{j,t+1} - r_{i,t+1}\right) + \alpha_2\Delta\left(e_{j,t+1} - e_{i,t+1}\right) + \alpha_3\Delta^2\left(e_{j,t+1} - e_{i,t+1}\right) + \alpha_4\Delta Q_{ij,t+1} + \alpha_5\Delta\left(\pi_{j,t+1} - \pi_{i,t+1}\right) + \alpha_6\Delta\left(i_{j,t+1} - i_{i,t+1}\right) + \alpha_7\Delta s_t + \zeta_{t+1}.$$

	Euro	Japanese Yen	Pound sterling	Swiss Franc	Canadian dollar	French franc	Deutsche marc
α_0	-0.002	0.003	-0.002	-0.002	0.001	-0.000	0.000
	(0.002)	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)	(0.003)
α_1	-0.304**	-0.235	-0.266**	-0.400*	0.020	-0.300***	-0.456***
	(0.153)	(0.304)	(0.136)	(0.218)	(0.231)	(0.093)	(0.159)
α_2	0.252**	-0.015	0.198*	0.061	-0.014	0.222***	0.080
	(0.099)	(0.077)	(0.101)	(0.077)	(0.037)	(0.070)	(0.070)
α_3	-0.141***	0.004	-0.147***	-0.074	-0.007	-0.130***	0.003
	(0.052)	(0.055)	(0.053)	(0.053)	(0.025)	(0.033)	(0.051)
α_4	0.002***	0.002	0.000	0.008***	0.000	0.003	0.003
	(0.001)	(0.002)	(0.000)	(0.003)	(0.001)	(0.003)	(0.004)
α_5	-2.167**	0.056	0.092	0.222	0.112	-0.688	-0.182
	(0.871)	(0.547)	(0.457)	(0.859)	(0.289)	(0.839)	(1.168)
α_6	-0.003	0.002	0.025***	-0.001	-0.000	0.009**	0.003
	(0.009)	(0.011)	(0.007)	(0.009)	(0.004)	(0.004)	(0.011)
α_7	-0.009	0.101	-0.144***	-0.012	0.023	-0.021	-0.024
	(0.050)	(0.091)	(0.050)	(0.072)	(0.131)	(0.058)	(0.057)
ERM dummy			0.085***				
			(0.011)				
Adj. R^2	0.219	0.000	0.341	0.041	0.000	0.260	0.061
J-Stat (P-value)	0.600	0.185	0.612	0.218	0.727	0.365	0.198
Sample period	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 98	Jan 91-Dec 98

Standard errors are shown in parentheses. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.
Each currency is expressed vis-à-vis the US dollar.

Estimation approach: GMM estimator, HAC Covariance Matrix.

Table 7
Parsimonious models for the uncovered equity return parity condition

$$\Delta s_{ij,t+1} = \alpha_0 + \alpha_1\left(r_{j,t+1} - r_{i,t+1}\right) + \alpha_2\Delta\left(e_{j,t+1} - e_{i,t+1}\right) + \alpha_3\Delta^2\left(e_{j,t+1} - e_{i,t+1}\right) + \alpha_4\Delta Q_{ij,t+1} + \alpha_5\Delta\left(\pi_{j,t+1} - \pi_{i,t+1}\right) + \alpha_6\Delta\left(i_{j,t+1} - i_{i,t+1}\right) + \alpha_7\Delta s_t + \zeta_{t+1}.$$

Coefficients on	Euro	Pound sterling	Swiss franc	French Franc	Deutsche Marc
α_1	-0.355*** (0.134)	-0.286** (0.123)	-0.409* (0.241)	-0.292*** (0.088)	-0.417*** (0.146)
α_2	0.298*** (0.091)	0.191* (0.100)		0.209*** (0.068)	
α_3	-0.150*** (0.050)	-0.147*** (0.055)		-0.127*** (0.030)	
α_4	0.001*** (0.000)		0.007*** (0.002)		
α_5	-2.133*** (0.797)				
α_6		0.024*** (0.007)		0.009** (0.004)	
α_7		-0.134** (0.052)			
ERM dummy		0.084*** (0.011)			
Adj. R^2	0.243	0.346	0.055	0.282	0.114
J-Stat (P-value)	0.481	0.572	0.206	0.460	0.238
χ^2_1 $\alpha_1 + \alpha_2 = 0$	0.097 [Prob. = 0.767]	5.529 [Prob. = 0.019]	–	0.646 [Prob. = 0.422]	–
Sample period	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 98	Jan 91-Dec 98

Standard errors are shown in parentheses. *, **, and *** denote 10%, 5%, and 1% significance level, respectively. Each currency is expressed vis-à-vis the US dollar.

Estimation approach: GMM estimator, HAC Covariance Matrix.

Table 8
Exchange rate dynamics: The role of earnings yields

Coefficients on	**Euro**	**Pound Sterling**	**French franc**
$\Delta(ey_{j,t+1} - ey_{i,t+1})$	0.347***	0.237**	0.239***
	(0.061)	(0.072)	(0.058)
$\Delta^2(e_{j,t+1} - e_{i,t+1})$	-0.152***	-0.141**	-0.138***
	(0.043)	(0.049)	(0.022)
$\Delta Q_{ij,t+1}$	0.001***		
	(0.000)		
$\Delta(\pi_{j,t+1} - \pi_{i,t+1})$	-2.142***		
	(0.692)		
$\Delta(i_{j,t+1} - i_{i,t+1})$		0.027***	0.010**
		(0.006)	(0.004)
Δs_t		-0.154**	
		(0.050)	
ERM dummy		0.082***	
		(0.009)	
Adj. R^2	0.262	0.363	0.286
J-Stat (P-value)	0.530	0.592	0.590
Sample period	Jan 91-Dec 03	Jan 91-Dec 03	Jan 91-Dec 98

Standard errors are shown in parentheses. *, **, and *** denote 10%, 5%, and 1% significance level, respectively. Each currency is expressed vis-à-vis the US dollar.

Estimation approach: GMM estimator, HAC Covariance Matrix.

Table 9
Out-of-sample forecast: The URP model against the random walk

Number of step-ahead forecasts	RMSE (1)	MSE (2)	Direction of change (3)	Correlation between actual exchange rate changes and model-based forecasts (4)	Correlation between actual exchange rate changes and random walk-based forecasts (5)
			Euro		
1-step	0.9804	0.0000	0.6939***	0.4114	-0.2246
2-step	0.8633	-0.0006***	0.6735**	0.4339	-0.1991
3-step	0.9125	-0.0006**	0.6531**	0.4295	-0.1563
4-step	0.9440	-0.0005	0.6327*	0.4101	-0.1476
6-step	0.9779	-0.0003	0.6939***	0.4559	0.0059
9-step	0.9508	-0.0010	0.6939***	0.4899	-0.1799
12-step	0.9702	-0.0011	0.6939***	0.4282	-0.2720
			British pound		
1-step	1.1582	0.0001	0.6122	0.3124	-0.0961
2-step	1.0451	0.0000	0.6327*	0.3538	-0.0779
3-step	1.0915	0.0001	0.6122	0.3181	-0.0003
4-step	1.0419	0.0001	0.5918	0.3121	-0.1056
6-step	1.0227	0.0000	0.6122	0.3202	0.0355
9-step	1.0065	0.0000	0.6122	0.3768	0.0030
12-step	1.0004	0.0000	0.6327*	0.3208	0.0404
			Swiss franc		
1-step	1.0255	0.0001	0.5306	0.2087	-0.1020
2-step	0.9395	-0.0006*	0.5306	0.2347	-0.0566
3-step	0.9546	-0.0007**	0.5306	0.2248	-0.1067
4-step	0.9386	-0.0013***	0.5510	0.2436	0.0380
6-step	0.9335	-0.0016**	0.5510	0.2683	0.1178
9-step	0.9482	-0.0019	0.5918	0.2782	-0.1892
12-step	0.9614	-0.0026*	0.5918	0.2760	-0.1104

Relevant models are estimated from 1991:01 up to 1998:12. Forecasting period: 1999:01-2003:12.
(1) reports the ratios between the RMSE obtained using the models described in Table 7 and the RMSE computed with the random walk of equation (5). Model-based forecasts beat random walk-based forecasts if the statistics are smaller than unity.
(2) shows the modified Diebold-Mariano (MDM) statistic based on differences between MSE. The naïve random walk model is beaten if the statistic is significantly negative. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.
(3) reports the relative likelihood of correctly predicting the directional changes. Model-based directional changes are superior to random walk-based directional changes if the statistic is larger than 50%. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.
(4) reports the correlation coefficients between the actual exchange rate dynamics and forecasts obtained using the models described in Table 7.
(5) reports the correlation coefficients between the actual exchange rate dynamics and forecasts obtained using the random walk models.

Each currency is expressed vis-à-vis the US dollar.

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