The Uncovered Return Parity Condition

Lorenzo Cappiello and Roberto A. De Santis *†

May 2007

Abstract

This paper proposes an equilibrium relationship between expected exchange rate changes and differentials in expected returns on risky assets. We show that when expected returns on a risky asset in a certain economy are higher than the returns that are expected from investing in a risky asset in another economy, then the currency corresponding to the economy whose asset offers higher returns is expected to depreciate. Due to its similarity with Uncovered Interest Parity (UIP), we call this equilibrium condition "Uncovered Return Parity" (URP). However, in the URP condition returns' differentials are *not* known *ex ante*, while in the UIP they are. Empirical evidence shows that economies with strengthening equity and bond markets tend to experience a weakening in their currencies.

Keywords: Uncovered Interest Parity, Uncovered Return Parity, stochastic discount factor, GMM

JEL classification: F30, F31, G12, C32

*Cappiello and De Santis are with DG-Research and DG-Economics at the European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany. Email: lorenzo.cappiello@ecb.int and roberto.de_santis@ecb.int; tel.: +49 69 1344 8765 and +49 69 1344 6611, respectively.

†We are indebted to Andrew Ang, Bruno Biais, Charles Engel, Geert Bekaert, Matteo Ciccarelli, John Cochrane, Luca Dedola, Robert Engle, Philip Lane, Richard Lyons, Simone Manganelli, Nikolaos Panigirtzoglou, Elias Papaioannou, José-Luis Peydró-Alcalde, Sergio Rebelo and ECB internal seminar participants for valuable comments and discussions. Of course, remaining errors are ours alone. The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank or the Eurosystem.

1 Introduction

Global investors benefit from international portfolio diversification since they can reap additional profit potentials while reducing the total risk of their portfolio. When investing globally exchange rates introduce a new source of risk, but at the same time an additional investment opportunity. Therefore, foreign exchange markets add a new dimension to asset pricing equilibria.

In this paper we propose an equilibrium relationship between expected exchange rate changes and differentials in expected returns on risky assets. Risk premia, which investors require to hold risky domestic and foreign assets, the variances of each asset return as well as the variance of exchange rate changes also enter the relationship. We show that when expected returns on a risky asset in a certain economy are higher than the returns that are expected from investing in a risky asset in another economy, then the currency corresponding to the economy whose asset offers higher returns is expected to depreciate vis-à-vis the currency of the other economy.

To illustrate, let us consider, for the sake of simplicity, a world economy with only two countries. A representative domestic agent optimising her intertemporal consumption pattern faces an investment opportunity set constituted of domestic and foreign assets. Suppose that a domestic risky asset is expected to outperform a foreign risky security. The domestic agent willing to diversify her portfolio internationally will invest in the foreign security only if the foreign currency will appreciate vis-à-vis the domestic currency. The appreciation will compensate the potential loss the domestic investor can suffer, due to larger expected returns at home than abroad. By the same token, expected exchange rate dynamics influence portfolio choices. Assume, for instance, that the domestic currency is expected to appreciate against the foreign currency. The domestic investor is willing to buy a foreign asset only if it will deliver higher returns than the equivalent domestic asset, which will offset the loss suffered when proceeds are converted back into the domestic currency. A similar reasoning holds when a foreign risky asset is expected to offer higher returns than a domestic risky security or when the foreign currency is expected to appreciate against the domestic currency.

The equilibrium hypothesis we suggest here is similar to the Uncovered Interest Parity (UIP) condition, where the currency associated with the economy with a higher interest rate is expected to depreciate relative to the currency of the country with a lower interest rate. Due to this similarity, we call our equilibrium condition "Uncovered Return Parity" (URP). There is, however, a key difference between the two equilibrium relationships: in the UIP condition returns' differentials are known *ex ante*, since they are typically computed on short-term risk-free bonds; in the URP, instead, investors form expectations about future return differentials.[1]

The poor empirical performance of UIP is well documented in the literature.[2] This motivates us to explore a new equilibrium condition between exchange rates and risky assets.

Brooks at al. (2001) is perhaps the first paper that documents a negative correlation between equity excess returns in Europe over the US and the euro-dollar exchange rate returns. Nevertheless, the authors judge the finding counter-intuitive since it is at odds with the conventional wisdom that a strengthening in one economy's equity market should bring about an appreciation in its exchange rate.

Hau and Rey (2006) is the most related paper with the present study. Hau and Rey develop a theoretical model where exchange rates, equity market returns and capital flows are jointly determined. They argue that when foreign equity markets outperform domestic equity markets, the relative exposure of domestic investors to exchange rate risk increases. Since markets are assumed to be incomplete, the exchange rate risk cannot be (fully) hedged. To diminish her foreign exchange exposure the home investor can then rebalance her portfolio decreasing her foreign positions. This will generate capital outflows from the foreign to the domestic country. Moreover, a relatively higher foreign market capitalisation leads to relatively higher foreign dividend flows, creating an additional foreign capital outflows. If currency supply is not fully elastic, the foreign capital outflows generated by the risk rebalancing and the dividend repatriation channels will lead to an excess demand for the domestic currency and hence its appreciation.[3] Differently from Hau and Rey's study, we propose a simple equilibrium relationship in the spirit of UIP: the URP condition can be seen as an extension of UIP to portfolios of risky securities.

In a related paper Pavlova and Rigobon (2006) examine the implication of introducing demand and supply shocks as well as goods trade in a standard international asset pricing model *à la* Lucas (1982). The framework includes two countries, each

[1] Recent literature has estimated UIP focusing on government bonds of relatively long maturity, notably three years or more (see, for instance, Chinn and Meredith, 2004 and 2005, Chinn, 2006, and Mehl and Cappiello, 2007). These studies assume that investors' holding period is equivalent to the maturity of the bond under consideration. This implies that the yield delivered by these assets is known *ex ante*, and, apart from credit, liquidity and inflation risks which are relatively small for mature economies, no other risk needs to be taken into account.

[2] See, for instance, Sarno (2005) and references therein.

[3] Similarly to our findings, one corollary of the model developed by Hau and Rey (2006) is what they call the "Uncovered Equity Parity" condition: "higher returns in the home equity market (in local currency) relative to the foreign equity market are associated with a home currency depreciation" (p. 277). In the same vein, Cappiello and De Santis (2005) extend Lucas' (1982) model and propose a relationship (the Uncovered Equity Return Parity condition) between differentials in expected equity returns and expected changes in exchange rates.

specialising in the production of its own good. The stock market is a claim to each country's output, while bonds provide further opportunity for international borrowing and lending. The model generates implications on how equity, bond and foreign exchange markets co-move in response to shocks, which are transmitted internationally across financial markets via the terms of trade. For example, a positive supply shock at home will have a positive effect on the domestic stock market and a negative effect on the home bond market. In line with the comparative advantages theory the domestic terms of trade deteriorate (the domestic exchange rate appreciates), which leads to a rise in the value of foreign output, thereby providing a boost to foreign stock market. Differently from Pavlova and Rigobon, we abstract from current account considerations and the impact of supply and demand shocks on financial markets.

Other studies which relate equity and bond market returns to exchange rate changes are, for example, Adler and Dumas (1983) and, more recently, Campbell, Serfaty-de Medeiros and Viceira (2006). The focus of this research is different from ours. These studies analyse foreign currency holding, which is primarily explained by considerations about the management of portfolio risks. In Adler and Dumas (1983) the minimum-variance portfolio contains foreign currency since no domestic asset that is riskless in real terms is available and there is uncertainty about the inflation rate.[4] Campbell et al. (2006) evaluate the demand for foreign currency that an investor should hold to minimise the risk of a total portfolio of equities and bonds. Differently from Adler and Dumas (1983), however, Campbell et al. (2006) do not rule out the existence of a domestic asset which is riskless in real terms.

We derive the URP condition in the context of a general no-arbitrage model. We take the point of view of a US investor and estimate it considering three asset classes, equities, government bonds and risk-free bills. In terms of currencies we consider the US dollar, which is our reference currency, versus the pound sterling, the Deutsche mark and the Swiss frank. We adopt two estimation strategies. First, we estimate the URP condition and the implied second moments for each pair of return differentials and the corresponding exchange rate with a multi-step procedure. Second, we estimate return differentials for several country pairs and the relative exchange rates simultaneously. The first approach has the advantage that permits to evaluate all the second moments generated by the model (including the evolution of risk premia that investors require to hold risky assets), but it is not efficient. The second estimation strategy is fully efficient. When using the first approach we find that URP tends to hold for equity markets, but not for bond markets, and within the equity markets for the country pairs US-Germany and US-Switzerland.

[4] Empirical investigations relative to this model have been carried out by Dumas and Solnik (1995) and De Santis and Gérard (1998), *inter alia.*

When estimates are carried out with the second approach, empirical evidence shows that economies characterised by a strengthening in their equity and bond markets tend to experience a depreciation in their currencies, a result consistent with the theory's predictions. The sample period also matters: when URP is evaluated from the 1980s until end 2006, it fares poorly. However, if the sample period is restricted from 1990s onwards, URP finds better empirical support in the data. Finally, when the investment opportunity set is restricted to risk-free assets only, which implies that the URP reduces to the UIP condition, we show that currencies with relatively higher short-term interest rates deliver larger returns. This finding is in line with the literature on the forward premium puzzle.[5]

The empirical results on URP are at odds with those found on UIP. When we bring URP to the data, results are consistent with the theory's predictions. UIP estimates, instead, generate puzzling findings. This suggests that, in an equilibrium condition between expected exchange rate changes and differentials in security returns, considering risky rather than risk-free assets matters.

The remainder of the paper is organised as follows. Section 2 derives the URP condition. Section 3 discusses the data. Section 4 describes the empirical methodology. Section 5 presents our findings and section 6 concludes the paper.

2 The Uncovered Return Parity condition

The equilibrium condition proposed in this paper relates the expected changes in exchange rates with differentials in the expected returns on risky securities at home and abroad. Expected exchange rate and risky asset returns should move simultaneously in order to guarantee the equilibrium in international financial markets. To derive URP we adopt a general no-arbitrage model and take the point of view of a domestic investor. In this framework the gross return process of any asset return i, $R_{i,t+1}$, satisfies

$$E\left\{R_{i,t+1}m_{t+1}|\Im_t\right\} = 1, \tag{1}$$

where m_{t+1} denotes the domestic investor's nominal pricing kernel, and $E\left(\cdot|\cdot\right)$ the expectation operator conditional on the information set $\Im_t$.[6] If asset i is a risk-free

[5] See, for instance, Hansen and Hodrik (1980), Fama (1984), Hodrik (1987), Engel (1996), Alvarez, Atkeson and Kehoe (2006), Bacchetta and van Wincoop (2006 and 2007), Boudoukh, Richardson and Whitelaw (2006), Burnside, Eichenbaum, Kleshchelski and Rebelo (2006), and Lustig and Verdelhan (2006).

[6] In the remainder of the paper we use interchangeably the expressions "stochastic discount factor" and "pricing kernel."

bond, then equation (1) reduces to:

$$E\left\{m_{t+1}|\Im_t\right\} = \frac{1}{R_{f,t}}. \tag{1'}$$

In an agent optimality framework, the (nominal) stochastic discount factor is related to investor's preferences and can be shown to be equal to the intertemporal marginal rate of substitution, i.e. $m_{t+1} = \delta U'(C_{t+1})\Pi_t / U'(C_t)\Pi_{t+1}$, where δ is the time discount factor, $U'(C_t)$ the marginal utility of consumption at time t, and Π_t the price level (see, for instance, Lucas, 1978, and Cochrane, 2001).

When a domestic agent invests in a foreign risky asset and then converts the proceeds back into the domestic currency, the fundamental evaluation equation (1) can be written as follows:

$$E\left\{R^*_{i,t+1}\frac{S_{t+1}}{S_t}m_{t+1}\,|\Im_t\right\} = 1, \tag{2}$$

where $R^*_{i,t+1}$ is the gross return on a foreign asset i, which is denominated in a foreign currency, and S_{t+1} the spot exchange rate, defined as the number of units of domestic currency exchanged for one unit of foreign currency (for instance US dollars per pound sterling).

If investments occur in a foreign risk-free bond, equation (2) reduces to the following expression:

$$E\left\{\frac{S_{t+1}}{S_t}m_{t+1}|\Im_t\right\} = \frac{1}{R^*_{f,t}}. \tag{2'}$$

Exploiting the covariances' properties, equations (1) and (2) can be re-arranged as follows:

$$\frac{E\left\{R_{i,t+1}|\Im_t\right\}}{R_{f,t}} + Cov\left\{R_{i,t+1}, m_{t+1}|\Im_t\right\} = 1, \tag{3}$$

$$\frac{E\left\{R^*_{i,t+1}|\Im_t\right\}E\left\{\frac{S_{t+1}}{S_t}|\Im_t\right\}}{R_{f,t}} + \frac{Cov\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}}{R_{f,t}} + Cov\left\{R^*_{i,t+1}\frac{S_{t+1}}{S_t}, m_{t+1}|\Im_t\right\} = 1, \tag{4}$$

where $Cov\left\{R_{i,t+1}, m_{t+1}|\Im_t\right\}$ and $Cov\left\{R^*_{i,t+1}\frac{S_{t+1}}{S_t}, m_{t+1}|\Im_t\right\}$ denote the conditional covariances between the risky assets $R_{i,t+1}$ and $R^*_{i,t+1}\frac{S_{t+1}}{S_t}$ with the stochastic discount factor m_{t+1}, respectively, while $Cov\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}$ is the conditional covariance between $R^*_{i,t+1}$ and the gross return on the exchange rate, i.e. $\frac{S_{t+1}}{S_t}$.[7]

The covariances between risky assets and the stochastic discount factor capture the risk premia. Equation (3), for instance, suggests that when the covariance

[7] Notice that covariances are conditional on the information set $\Im_t$.

$Cov\{R_{i,t+1}, m_{t+1}|\Im_t\}$ is small, the asset i's expected return in excess of the risk-free rate is large.[8] Suppose that asset i exhibits a covariance with the stochastic discount factor which is lower than the covariance between asset j and the (same) stochastic discount factor. This means that asset i has relatively lower returns when the investors' marginal utility of consumption is higher, which occurs when consumption itself is low. Therefore, asset i is relatively riskier than j since it provides a smaller pay-off precisely when wealth is most valuable to investors. As such a relatively higher risk premium will be required to hold that asset (see, for instance, Campbell, Lo and MacKinlay, 1997).

The covariance $Cov\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}$ captures whether a (foreign) asset can hedge against adverse shifts in the exchange rate and vice-versa. If returns on a foreign asset i co-move negatively with the exchange rate, that asset is a good hedge against adverse changes in foreign exchange markets. Vice-versa, if the co-movements are positive, the asset does not provide a good hedge against exchange rate movements. This is the case because a negative correlation between foreign exchange rate returns and equity market returns denominated in a foreign currency reduces the volatility in domestic currency terms, rendering foreign investments more attractive.

Taking the log of the ratio of expressions (3) and (4) and assuming log normality yields the URP condition:[9]

$$E\{\Delta s_{t+1}|\Im_t\} = E\left\{r_{i,t+1} - r^*_{i,t+1}|\Im_t\right\} + second\ moments_{t+1}, \tag{5}$$

where Δ denotes the difference operator, e.g. $\Delta x_{t+1} \equiv x_{t+1} - x_t$, $s_{t+1} \equiv \ln(S_{t+1})$, $r_{i,t+1} \equiv \ln(R_{i,t+1})$ and $r^*_{i,t+1} \equiv \ln\left(R^*_{i,t+1}\right)$. $E\{r_{i,t+1}|\Im_t\}$ and $E\left\{r^*_{i,t+1}|\Im_t\right\}$ are, respectively, the expected compounded returns on domestic and foreign assets. The variable $second\ moments_{t+1}$ includes conditional variances and covariances:

$$\begin{aligned} & second\ moments_{t+1} \equiv \qquad (6) \\ \equiv\ & \ln\left[1 - \frac{Cov\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}}{R_{f,t}} - Cov\left\{R^*_{i,t+1}\frac{S_{t+1}}{S_t}, m_{t+1}|\Im_t\right\}\right] - \\ & - \ln\left[1 - Cov\{R_{i,t+1}, m_{t+1}|\Im_t\}\right] + \\ & + \frac{1}{2}\left[Var\{r_{i,t+1}|\Im_t\} - Var\left\{r^*_{i,t+1}|\Im_t\right\} - Var\{\Delta s_{t+1}|\Im_t\}\right]. \end{aligned}$$

[8] It is easy to see this by re-arranging equation (1) as $E\{R_{i,t+1} - R_{f,t}|\Im_t\} = -R_{f,t}Cov\{R_{i,t+1}, m_{t+1}|\Im_t\}$.

[9] Let us consider, for example, the gross return on a domestic asset i, $R_{i,t+1}$. The Jensen's inequality implies that $\ln E\{R_{i,t+1}|\Im_t\} > E\{\ln(R_{i,t+1})|\Im_t\} = E\{r_{i,t+1}|\Im_t\}$. From the assumption of log normality it follows that $\ln E\{R_{i,t+1}|\Im_t\} = E\{r_{i,t+1}|\Im_t\} + \frac{1}{2}Var\{r_{i,t+1}|\Im_t\}$, (see, for instance, Campbell, Lo and MacKinlay, 1997).

Notice that, when the investment opportunity set is only constituted of risk-free bonds, URP includes as a special case the UIP condition. Assuming log normality for gross risk-free returns, combining equations (1′) and (2′) yields UIP:

$$E\left\{\Delta s_{t+1}|\Im_t\right\} = r_{f,t} - r^*_{f,t} + \ln\left[1 - R^*_{f,t} Cov\left\{\frac{S_{t+1}}{S_t}, m_{t+1}|\Im_t\right\}\right] - \frac{1}{2} Var\left\{\Delta s_{t+1}|\Im_t\right\}, \tag{7}$$

where the covariance $Cov\left\{\frac{S_{t+1}}{S_t}, m_{t+1}|\Im_t\right\}$ captures the exchange rate risk premium.

For given values of the second moments, the URP condition states that discrepancies in expected asset returns at home and abroad are re-equilibrated through contemporaneous adjustments in expected exchange rate changes. Specifically, if expected returns on a certain asset at home are higher than those obtainable from another asset abroad, the domestic currency 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 adjustment mechanism characterising URP is therefore similar to the one driving UIP. The crucial difference between the two equilibrium relationships is that while in the UIP condition return differentials are known *ex ante*, in the URP are not.

It is attractive to consider the case of risk-neutral pricing, since pay-offs can be priced simply as discounted expected values. When investors are risk neutral, the variable $second\ moments_{t+1}$ reduces to:

$$\begin{aligned} second\ moments^Q_{t+1} \quad \equiv \quad & \ln\left[1 - \frac{Cov\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}}{R_{f,t}}\right] + \\ & + \frac{1}{2}\left[Var\left\{r_{i,t+1}|\Im_t\right\} - Var\left\{r^*_{i,t+1}|\Im_t\right\} - Var\left\{\Delta s_{t+1}|\Im_t\right\}\right], \end{aligned} \tag{8}$$

where the superscript "Q" denotes that second moments are computed under the martingale measure (or risk-neutral measure).[10] Arbitrage would lead risk neutral in-

[10]Without loss of generality, equation (8) can be easily derived adopting a power utility function and assuming that consumption growth is log normal. In this case,

$$\begin{aligned} E\left\{R_{i,t+1} - R_{f,t}|\Im_t\right\} &= -Cov\left\{R_{i,t+1}, m_{t+1}|\Im_t\right\}/E\left(m_{t+1}|\Im_t\right) \\ &= \sqrt{Var\left\{m_{t+1}|\Im_t\right\} Var\left\{R_{i,t+1}|\Im_t\right\} Corr\left\{R_{i,t+1}, m_{t+1}|\Im_t\right\}/E\left(m_{t+1}|\Im_t\right)} \\ &\approx \gamma_t \sqrt{Var\left\{\Delta c_{t+1}|\Im_t\right\} Var\left\{R_{i,t+1}|\Im_t\right\} Corr\left\{R_{i,t+1}, m_{t+1}|\Im_t\right\}} \end{aligned}$$

where $Corr\left\{\cdot,\cdot|\Im_t\right\}$ denotes the conditional correlation operator, γ_t the coefficient of risk aversion and Δc_{t+1} the change in consumption (for further details see Cochrane, 2001). If investors are risk neutral, i.e. $\gamma_t = 0$, no risk premium is required to hold risky assets and the conditional covariances between risky assets and the stochastic discount factor are equal to zero.

vestors to equate returns on any asset (including the risk-free bills). Since, empirically this is not the case, we do not estimate URP under risk neutrality.

3 Data

The analysis includes the US, which is our benchmark country, the UK, Germany and Switzerland. The data set we use covers the period January 1981 to October 2006. We employ monthly data which are observed on the last trading day of the month.

The investment opportunity set is composed of two typologies of risky assets, equities and government bonds, as well as risk-free securities. Gross and continuously compounded returns on equities and government bonds are constructed with indices provided by Thomson Datastream. Equity indices include dividends; bond indices refer to a 10-year maturity benchmark coupon-bearing bond. Both equity and bond indices are denominated in US dollars. One-month euro-deposit bid rates are provided by Bank of International Settlements (BIS) and are used to construct returns on money market securities.[11] Spot exchange rates are collected from BIS and include US dollar/pound sterling (USD/GBP), US dollar/Deutsche mark (USD/DEM) and US dollar/Swiss frank (USD/CHF).

Descriptive statistics relative to log returns on equities, bonds, euro deposits as well as exchange rates are reported in table 1, panels A and B. Returns are characterised by excess skewness and leptokurtosis. Non-normality is confirmed by the Jarque-Bera test statistic. Not surprisingly, for each country, equities offer higher returns than bonds, and bonds provide higher returns than one-month deposits, but equities exhibit larger volatility than bonds, which are riskier than money market accounts. Volatility in each equity market is also higher than volatility in each foreign exchange market.

Instrumental variables include lagged returns on assets, dividend yields and first differences in three-month euro deposit rates. Dividend yields are provided by Thomson Datastream, while three-month euro deposit rates by BIS. Descriptive statistics relative to these two variables are reported in Table 1, panel C.

Table 2 shows unconditional correlations between asset returns and instruments. By and large, variables belonging to the same class exhibit a relatively high correlation, while correlation across classes is less pronounced. However, overall correlations are quite low, suggesting that instruments are not redundant.

We use instrumental variables as conditioning information on: (i) moment conditions (see equation (1)), (ii) expected equity and bond return differentials, as well

[11] For instance, the pound sterling money market account is computed multiplying gross returns on the UK one-month euro-deposit by the gross returns on the USD/GBP exchange rate.

as (iii) expected changes in log exchange rates. There is a vast literature on the predictability of asset returns from past information. Entering this debate goes beyond the scope of this paper and we refer to the relevant studies (see, for instance, Chen, Roll and Ross, 1986, Fama and French, 1988 and 1989, Ilmanen, 1995, Campbell, 2000, Ang and Bekaert, 2005, Boudoukh, Richardson and Whitelaw, 2006, Cochrane, 2006, and Bacchetta and van Wincoop, 2007). The debate can be synthesized with Campbell's (2000) words: "Most financial economist appear to have accepted that aggregate returns do contain an important predictable component" (p. 1523). Assets returns exhibit, at times, momentum, which is captured by the inclusion of lagged returns. At short horizons dividend yields and short term interest rates show predictive power for equity. On average, government bond yield curves are upward-sloping and highly convex and changes in short-term interest rates have shown to be useful in predicting bond returns. Interrelations across asset classes as well as international market linkages can also be exploited when forecasting security returns.

4 Empirical methodology

In this section we discuss the empirical methodology which we use to estimate the URP condition. We adopt two estimation strategies. First, we investigate whether equations (5) holds for a specific exchange rate change and a related return differential at the time, for instance for the USD/GBP exchange rate and the US and UK equity market, next for the USD/DEM exchange rate and the US and German equity markets, etc. Second, we estimate different exchange rates and asset pairs contemporaneously.

Each strategy possess advantages and drawbacks. The first strategy relies on a three-step procedure. First, we estimate the domestic investor's stochastic discount factor. Second, we compute the second moments entering equation (5). The pricing kernel series estimated in the first step are used as input in the covariance calculation. Third, we estimate the URP condition, including the second moments obtained in the second step. A multi-stage estimation procedure has the disadvantage that it leads to inefficient estimates: the standard errors of the second and third steps are likely to be understated since the sampling errors in the previous steps are ignored. However, multi-stage estimation approach has the advantage that it generates a more powerful test (see, for instance, Bekaert and Harvey, 1995).

When we estimate URP with different exchange rates and asset pairs at the same time, we make assumptions which simplify the structure of the variable $\textit{second moments}_{t+1}$. However, the advantage of this strategy is that it leads to fully efficient estimates.

4.1 A three-step estimation approach

4.1.1 Stochastic discount factor estimation

We estimate the stochastic discount factor m_{t+1} adopting a Generalised Method of Moments (GMM) methodology in the spirit of Hansen (1982) and Cochrane (1996). Equation (1) – which we now write in vector notation – provides a natural set of moment conditions:

$$E\left\{\mathbf{R}_{t+1}m_{t+1}-1|\Im_t\right\}=\mathbf{0}_n, \tag{9}$$

where $\mathbf{R}_{t+1}$ and $\mathbf{0}_n$ denote $(n\times 1)$ vectors of assets' gross returns and zeros, respectively.

We assume that markets are not complete, which implies that more than one admissible stochastic discount factor exists. However, in line with Hansen and Jagannathan (1991), we choose the pricing kernel which exhibits minimum variance. This pricing kernel, m_{t+1}^{MV}, is shown to be unique and equal to the projection on the space of asset pay-offs. m_{t+1}^{MV} can then be written as a linear combination of asset gross returns:

$$m_{t+1}^{MV}=a+\mathbf{b}'\mathbf{R}_{t+1}. \tag{10}$$

Let $\mathbf{g}_t$ denote the sample moments conditions, which can be derived from equation (9):

$$\begin{aligned}\mathbf{g}_t &\equiv T^{-1}\sum_{t=1}^{T}\left[m_{t+1}^{MV}\mathbf{R}_{t+1}-1\right]\otimes\mathbf{z}_t \qquad (11)\\ &= T^{-1}\sum_{t=1}^{T}\left[\left(a+\mathbf{b}'\mathbf{R}_{t+1}\right)\mathbf{R}_{t+1}-1\right]\otimes\mathbf{z}_t=\mathbf{0}_{ns},\end{aligned}$$

where $\mathbf{z}_t=(z_{1,t},...,z_{s,t})'$ represents a vector of s instruments, $\mathbf{0}_{ns}$ a $(ns\times 1)$ vector of zeros, and $\otimes$ the Kronecker product.[12] Let $\mathbf{W}_T$ represent a weighting matrix. GMM permits estimating the vector of parameters $\boldsymbol{\theta}=(a,\mathbf{b}')'$ by minimising a weighted sum of squares of pricing errors across assets:

$$\widehat{\boldsymbol{\theta}}=\arg\min_{\boldsymbol{\theta}}\mathbf{g}_T'\left(\boldsymbol{\theta}\right)\mathbf{W}_T\mathbf{g}_T\left(\boldsymbol{\theta}\right). \tag{12}$$

[12] The parameters α and $\mathbf{b}$ are assumed to be constant. The assumption is not too restrictive if the number of risky assets is sufficiently large (see, for instance, Cappiello and Panigirzoglou, 2006). Moreover, the use of instrumental variables in the estimation of the stochastic discount factor is equivalent to scaling these coefficients by instruments, which would render them state dependent (see Cochrane, 1996, for further details).

The optimal value for the weighting matrix, $\mathbf{W}_T^*$, is shown to be equal to the inverse of the asymptotic covariance matrix of the sample pricing errors (see Hansen, 1982, and Cochrane, 1996, for further details).

The minimum of the criterion function is typically reported as J_T-statistic:

$$J_T = \mathbf{g}_T' \left(\widehat{\boldsymbol{\theta}}\right) \widehat{\mathbf{W}}_T^* \mathbf{g}_T \left(\widehat{\boldsymbol{\theta}}\right). \tag{13}$$

The J_T-statistic can be used to test for the over-identifying moment conditions.[13]

4.1.2 Second moment estimation

We compute the second moments included in equations (5) and (7) with an Exponentially Weighted Moving Average (EWMA) representation. Given two asset (compounded) returns, $r_{i,t}$ and $r_{j,t}$, the exponential smoothing variance and covariance take on, respectively, the form:

$$\sigma_{i,t}^2 = \lambda \sigma_{i,t-1}^2 + (1-\lambda) r_{i,t-1}^2,^{14} \tag{14}$$

and

$$\sigma_{ij,t} = \lambda \sigma_{ij,t-1} + (1-\lambda) r_{i,t-1} r_{j,t-1}, \tag{15}$$

where λ is the decay parameter. Once λ is arbitrarily chosen and an initial value is assigned to the variance (covariance), it is simple to compute all second moments at each time period.[15]

An alternative statistical model to the EWMA representation is a Generalised Autoregressive Conditionally Heteroskedastic (GARCH) process, which is widely used to parameterise conditional second moments. The advantage of the EWMA approach relative to a multivariate GARCH model is that it is easy to implement and reduces the noise when the second estimation step is implemented. The EWMA model, however, suffers from two drawbacks. First, the decay parameter is not estimated but arbitrarily chosen. We set it equal to 0.94. Second, differently from GARCH representations which are mean reverting, all future second moments are predicted to be the same as current second moments (for further details see, for instance, Andersen et al., 2006).

[13] Under the null hypothesis that the moment conditions are zero, it can be shown that $TJ_T \sim \chi^2_{df}$, where the degrees of freedom, df, are equal to the number of over-identifying restrictions or, equivalently, to the number of moment conditions minus the number of parameters (see, for instance, Cochrane, 1996).

[14] The same formula applies for $r_{j,t}$.

[15] Initial values can be computed using unconditional second moments.

4.1.3 Uncovered Return Parity estimation

Once second moments are computed, it is possible to estimate the URP condition. Equation (5) yields the following testable expression:

$$\begin{aligned}\Delta s_{t+1} &= \alpha + \beta E\left\{r_{i,t+1} - r^*_{i,t+1}|\Im_t\right\} - \\ &-\zeta_1 \frac{\widehat{Cov}\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}}{R_{f,t}} - \zeta_2 \widehat{Cov}\left\{R^*_{i,t+1}\frac{S_{t+1}}{S_t}, m^{MV}_{t+1}|\Im_t\right\} + \\ &+\zeta_3 \widehat{Cov}\left\{R_{i,t+1}, m^{MV}_{t+1}|\Im_t\right\} + \\ &+\frac{1}{2}\left[\zeta_4 \widehat{Var}\left\{r_{i,t+1}|\Im_t\right\} - \zeta_5 \widehat{Var}\left\{r^*_{i,t+1}|\Im_t\right\} - \zeta_6 \widehat{Var}\left\{\Delta s_{t+1}|\Im_t\right\}\right] + \eta_{t+1},\end{aligned} \tag{16}$$

where the "hat" indicates that second moments have been estimated in the previous step.[16]

We assume that the term $E\left\{r_{i,t+1} - r^*_{i,t+1}|\Im_t\right\}$ is a function of differentials between domestic and foreign instrumental variables, $\mathbf{z}_{i,t} - \mathbf{z}^*_{i,t}$. The unknown coefficients of equation (16) can then be estimated with GMM. The hypothesis that expected return differentials depend on instruments amounts to assume that returns are forecastable. The issue of predictability of asset returns has generated a large debate in the literature, which we have briefly discussed in the data section.

Under the hypothesis of market efficiency, α should not be statistically different from zero, while β should be positive and equal to one.

If the investment opportunity set is restricted to risk-free assets, UIP (see equation (7)) will be estimated:

$$\begin{aligned}\Delta s_{t+1} &= \alpha_f + \beta_f\left(r_{f,t} - r^*_{f,t}\right) - \\ &-\zeta_{1f} R^*_{f,t}\widehat{Cov}\left\{\frac{S_{t+1}}{S_t}, m^{MV}_{t+1}|\Im_t\right\} - \zeta_{2f}\frac{1}{2}\widehat{Var}\left\{\Delta s_{t+1}|\Im_t\right\} + \eta_{f,t+1}.\end{aligned} \tag{17}$$

4.2 A one-step estimation approach

URP can be estimated efficiently in one step only. Assuming that $Cov\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}$ and the variances implied by Jensen's inequality are sufficiently small or constant, and exploiting that covariances are linear operators,[17] expression (5) can generate the following system of equations:

[16] Notice that we use a first order Taylor approximation for the variable *second moments*$_{t+1}$.

[17] For instance, $Cov\left\{R_{i,t+1}, m^{MV}_{t+1}|\Im_t\right\} = E\left\{R_{i,t+1}m^{MV}_{t+1}|\Im_t\right\} - R^{-1}_{f,t}E\left\{R_{i,t+1}|\Im_t\right\}$.

$$
\begin{aligned}
& E\left\{\Delta s_{t+1}^{j} - \alpha - \beta\left(r_{i,t+1} - r_{i,t+1}^{j*}\right) + \right. \\
& +\zeta_1^j\left[\left(R_{i,t+1}^{j*}\frac{S_{t+1}^j}{S_t^j}m_{t+1}^{MV}\right) - R_{f,t}^{-1}\left(R_{i,t+1}^{j*}\frac{S_{t+1}^j}{S_t^j}\right)\right] - \\
& \left. -\zeta_2^j\left[\left(R_{i,t+1}m_{t+1}^{MV}\right) - R_{f,t}^{-1}R_{i,t+1}\right]|\Im_t\right\} \\
= \; & 0,
\end{aligned} \tag{18}
$$

where $j = UK, DE, CH$, indicating that the exchange rates we consider are USD/GBP, USD/DEM and USD/CHF, and returns on foreign assets refer to the UK, Germany and Switzerland. Combining equations (9), (10) and (18), consistent and efficient estimates can be obtained with GMM.[18] The system of equations (18) permits to estimate URP on an number of assets and exchange rates simultaneously.

Similarly, UIP can also be estimated in one step. Assuming that the exchange rate variance is sufficiently small, expression (7) can be extended to the following system of equations:

$$
E\left\{\Delta s_{t+1}^{j} - \alpha_f - \beta_f\left(r_{f,t} - r_{f,t}^{j*}\right) + \zeta^j\left[R_{f,t}^{j*}\left(\frac{S_{t+1}^j}{S_t^j}m_{t+1}^{MV}\right) - R_{f,t}^{-1}\frac{S_{t+1}^j}{S_t^j}\right]|\Im_t\right\} = 0. \tag{19}
$$

5 Empirical results

We evaluate the URP condition assuming that the investment opportunity set is composed of equities, long-term government bonds and short term risk-free bills, in addition to foreign exchange markets. Estimates are carried out over two different sample periods. First, we consider the whole sample, from January 1981 until October 2006. Second, we estimate our model since January 1990, when barriers to capital movements were progressively lifted, the degree of financial integration increased and financial flows became prominent (see, for instance, Hau and Rey, 2006).

We first discuss estimates obtained with a three step procedure and next we describe results relative to the one-step approach.

Risk averse agents require a premium when investing in risky assets. The URP condition allows to estimate the premia demanded to hold the domestic assets and the foreign assets converted into domestic currency. When investments are made in

[18] The assumption that $Cov\left\{R_{i,t+1}^{*}, \frac{S_{t+1}}{S_t}|\Im_t\right\}$ and the variances are small or constant can be relaxed and these terms may be included in the estimation. One approach to do so is to express expected returns as a linear projection of instrumental variables (see, for instance, Harvey, 1989). We do not pursue this approach to avoid imposing any parameterisation on expected asset returns.

risk-free bills, we can evaluate foreign exchange risk premia as well. The estimation of these premia requires the evaluation of covariances between asset returns and the domestic investor's minimum variance stochastic discount factor, m_{t+1}^{MV}. Therefore we now discuss the estimation of m_{t+1}^{MV}.

5.1 The domestic investor's pricing kernel

The results relative to the estimation of the system of pricing equations (9) and the stochastic discount factor (10) over the entire sample period are reported in table 3.[19] We consider 11 risky assets and the US risk-free rate, which leads to a system of 12 equations.[20] The domestic investor's minimum variance stochastic discount factor takes on the form (see, for instance, Cochrane, 1996, and Cappiello and Panigirtzoglou, 2005):

$$\begin{aligned} m_{t+1}^{MV} &= a + b_1 R_{eq,t+1}^{US} + b_2 R_{eq,t+1}^{UK} + b_3 R_{eq,t+1}^{DE} + b_4 R_{eq,t+1}^{CH} + b_5 R_{gb,t+1}^{US} + \\ &\quad + b_6 R_{gb,t+1}^{UK} + b_7 R_{gb,t+1}^{DE} + b_8 R_{gb,t+1}^{CH} + b_9 R_{mm,t+1}^{USDGBP} + b_{10} R_{mm,t+1}^{USDDEM} + b_{11} R_{mm,t+1}^{USDCHF}, \end{aligned} \tag{20}$$

where $R_{eq,t+1}^{j}$ and $R_{gb,t+1}^{j}$ represent gross equity and bond returns, respectively, for $j = US, UK, DE, CH$, while $R_{mm,t+1}^{j}$, for $j = USDGBP, USDDEM, USDCHF$, denotes gross returns on money market accounts.

We use a different set of instruments for each equation (we describe the instruments adopted to price each of the 12 assets in appendix A). The risk-free asset is priced with 12 instruments; each equity, bond, and money market asset is priced with 11, 10 and seven instrumental variables, respectively. Therefore, the total number of moment conditions is equal to 117. Since the projection of m_{t+1}^{MV} on the universe of asset returns implies 12 parameters to estimate, our system generates 105 overidentifying restrictions. As the p-value of the J_T-statistic is equal to one,[21] we cannot reject the null hypothesis that the empirical moment conditions are not different from zero. This suggests that, at least in this respect, the model is adequate.

Assuming that there are no arbitrage opportunities implies a strictly positive stochastic discount factor (see, for instance, Cochrane 2001). Some studies estimate the stochastic discount factor imposing a positivity constraint (see, for instance, Balduzzi

[19] Estimates relative to the second part of the sample are not reported but are available from the authors upon request.

[20] The risky assets we take into account are: US, UK, German and Swiss equity returns; US, UK, German and Swiss government bond returns; pound sterling, Deutsche mark and Swiss frank money market accounts.

[21] Notice that the corresponding χ_{105}^2 is equal to 40.17.

and Robotti, 2001). Since our estimated m_{t+1}^{MV} is always positive, we do not need to impose such constraint as it would not be binding.

The b_k, $k = 1, ..., 11$, coefficients of equation (20) possess an appealing intuition (see, for instance, Campbell, 2000, and Cochrane, 2001). Re-arranging equation (1) it is simple to show that the expected excess returns on any asset i satisfy $E\left(R_{i,t+1} - R_{f,t}|\Im_t\right) = -R_{f,t}Cov\left\{R_{i,t+1} - R_{f,t}, m_{t+1}|\Im_t\right\}$. Since the stochastic discount factor we use is a linear combination of asset returns, we can write the negative covariance of any asset excess return with m_{t+1}^{MV} as

$$-Cov\left\{R_{i,t+1} - R_{f,t}, m_{t+1}^{MV}|\Im_t\right\} = \sum_{k=1}^{11} b_k Cov\left\{R_{i,t+1}, R_{k,t+1}, |\Im_t\right\}, \qquad (21)$$

where $R_{k,t+1}$ denotes the kth asset return entering the projection of m_{t+1}^{MV}. Therefore each asset return $R_{k,t+1}$ serves as a risk factor. The covariance $Cov\left\{R_{i,t+1}, R_{k,t+1}, |\Im_t\right\}$ captures the risk exposure of the asset return $R_{i,t+1}$ to $R_{k,t+1}$ and the corresponding coefficient b_k denotes the sensitivity of asset i to this source of risk.

All the coefficients entering the projection of m_{t+1}^{MV} are significantly different from zero, except b_2, b_9 and b_{10}. This indicates that the risk factors UK equity gross returns, UK and German money market accounts -which are the assets corresponding to the parameters b_2, b_9 and b_{10}- are not priced and, as such, do not contribute to the risk premium investors demand to hold asset i. Moreover, the factors whose coefficients exhibit a significant negative sign contribute positively to the risk premium. Instead, those factors with a significant positive sign generate a negative contribution to the risk premium and as such can be considered hedging factors.

5.2 The URP condition

Table 4 reports estimates of the URP condition (see equation (16)).[22] When we consider the whole sample (see table 4, panel A), URP finds little support in the data. In the case investments occur only in equity markets, the β coefficient is either negative or positive but not significant, while the α coefficient is significant for the pound sterling and the Swiss franc. When considering government bond markets, the value of β is always negative and not significant. The terms capturing equity risk premia enter significantly into the regressions.

Over the second part of the sample (see table 4, panel B) results improve: the β coefficient is always positive both for equities and bonds, except for the US-UK bond market. As for the equity markets, β is significantly different from zero for the

[22] The instruments we use to model expectations on equity and bond return differentials are described in appendix B.

USD/DEM and USD/CHF exchange rates. Similarly to the estimates obtained over the whole sample, analysis of bond markets shows that the β coefficient is never significantly different from zero. The α coefficient is not significant across asset classes and currencies, with the exception of the USD/DEM exchange rate and the US/German bond markets. For both equities and bonds the coefficients relative to second moments are almost never significant.

In figures 1a-1c and 2a-2c we plot the terms $Cov\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}/R_{f,t}$ for equities and bonds, respectively. We take the point of view of a US agent investing in an asset denominated in foreign currency. A decrease in asset i returns diminish investor's wealth. When the foreign currency depreciates against the US dollar, the investor will be hurt since the proceeds of asset i will eventually be converted into US dollars. Therefore when the covariances $Cov\{\cdot, \cdot|\Im_t\}$ are negative, this indicates that asset i is a good hedge against an appreciation of the US dollar, or equivalently, that a US dollar depreciation can hedge adverse shifts in security i performance. The data show that the covariances $Cov\{\cdot, \cdot|\Im_t\}$ are most of the time negative for equities, but not for bonds, suggesting that equities can hedge adverse shifts in exchange rates (and vice versa) while bonds cannot.

Figures 3a-3d and 4a-4d report the risk premia investors require to hold equities and bond, respectively. The term $-Cov\left\{R_{i,t+1}, m^{MV}_{t+1}|\Im_t\right\}$ captures the domestic equity and bond risk premia. Similarly, the term $-Cov\left\{R^*_{i,t+1}\frac{S_{t+1}}{S_t}, m^{MV}_{t+1}|\Im_t\right\}$ models the time evolution of the premia relative to foreign equity and bond returns converted into US dollars. Equity premia increase during the major market turbulence episodes, e.g. the stock market crashes in 1987 and 1989 , the recession in 1991 and the Asian-Russian-Latin America crises in 1997-1998, and show an overall tendency to decline over the last part of the sample. Bond premia are relatively high until approximately the first half of the 1990s to diminish thereafter.

The URP derivation provides also useful insights regarding the empirical regularity that equity returns exhibit higher volatility than the relative exchange rate changes (see, for instance, Andersen et al., 2006). The variable $second\ moments_{t+1}$ (see equation (6)) suggests a comparison between the difference in the volatility of *two* equity market returns and the volatility of the corresponding exchange rate changes, rather than a comparison between the volatility of *one* stock market return and the volatility of one associated exchange rate. Figure 5a-5c plots the ratios $\left[abs\left(Var\{r_{i,t+1}|\Im_t\} - Var\left\{r^*_{i,t+1}|\Im_t\right\}\right)\right]/Var\{\Delta s_{t+1}|\Im_t\}$ for the equity market pairs US-UK, US-Germany and US-Switzerland and the corresponding exchange rates, USD/GBP, USD/DEM and USD/CHF, respectively. To illustrate, let us analyse the market pair US-UK (see figure 5a). The ratio is above one when turbulences led to a larger volatility in US than in UK equity market and, at the same time, the difference in volatility was higher than the volatility in the foreign exchange market. This occurred, for instance, at the end of 1990s and at beginning of the new millennium.

The URP condition can be estimated in one step in line with equations (9), (10) and (18). Equations (9) and (10) permit to identify the domestic minimum variance stochastic discount factor. As the degree of financial market integration increases since the 1990s, we only estimate the model for the second part of the sample. First, we consider an investment opportunity set constituted of equities only. Next, we add government bonds. Results for equities are reported in table 5, panel A, while estimates relative to both equities and bonds are shown in table 5, panel B. In both cases, all the coefficients relative to the stochastic discount factor (except b_1) are significantly different from zero. Remarkably, α is not significant, and β is positive and significant.[23] The coefficients ζ_1^j and ζ_2^j, ζ_{1EQ}^j and ζ_{2EQ}^j, and ζ_{1GB}^j and ζ_{2GB}^j, $j = UK, DE, CH$, are also significant, suggesting that risk premia play an important role in the URP condition. The J_T-statistics of the two specifications are equal to 0.25 and 0.20, which imply a $\chi^2_{115} = 49.78$ and a $\chi^2_{124} = 41.00$, respectively, confirming that the models are adequate.

All in all our empirical analysis suggests that markets that are expected to offer relatively higher returns will experience a depreciation in their currencies. This finding is at odds with the forward premium puzzle, according to which currencies that are sold at forward premium tend to depreciate.

5.3 The UIP condition

In table 6 we report the results relative to the UIP estimates from January 1990 until October 2006. In line with previous empirical research on UIP (see, for instance, Hansen and Hodrik 1980, Fama, 1984, Hodrik, 1987, Engel, 1996, Alvarez, Atkeson and Kehoe, 2006, Bacchetta and van Wincoop, 2006 and 2007, Boudoukh, Richardson and Whitelaw, 2006, Burnside, Eichenbaum, Kleshchelski and Rebelo, 2006, and Lustig and Verdelhan, 2006), the β_f coefficient is negative and not significantly different from zero.

Although the foreign exchange risk premia, as captured by the terms $-Cov\left\{\frac{S_{t+1}}{S_t}, m_{t+1}|\Im_t\right\}$, do not enter significantly into the UIP regression, it is insightful to examine their plots

[23] We also estimate the system of equations (9), (10) and (18) with distinct coefficients α and β for equities and bonds. We find that: (i) the α and β relative to equity markets are not significant and positive and significant, respectively; (ii) the α and β relative to bond markets are significant and positive and significant, respectively.

(see figures 6a-6c). To illustrate, the foreign exchange premia for the USD/DEM exchange rate tend to decrease when the US dollar appreciates vis-à-vis the Deutsche mark (i.e. from the beginning of the sample until mid 1980s and over the second half of the 1990s until approximately 2001) and to increase when the US dollar depreciates (i.e. from the second half of the 1980s until around the first half of the 1990s and over the last few years of our sample). This pattern is intuitive: the US investor is hurt if the US dollar is expected to depreciates since this generates capital losses. Therefore the required premium is higher.

We also estimate the UIP condition in one step according to equations (9), (10) and (19). In line with the results obtained with the three-step procedure, the β coefficient continues to be negative and not significant (see table 7).

6 Summary of results and conclusions

The so-called forward premium puzzle is one of the most long-standing anomalies in open economy macroeconomics. A vast theoretical and empirical literature has developed over the years trying to explain the dependence of expected exchange rate changes and interest rate differentials. On average, currencies with relatively higher short-term interest rates are found to deliver larger returns.

This paper proposes a novel equilibrium relationship which includes the UIP condition as a special case. We hypothesize that, for instance, when expected returns on a domestic security are higher than the expected returns on a foreign asset, the domestic currency is expected to depreciate vis-à-vis the foreign currency. The argument can be turned on its head: if the foreign currency is expected to appreciate against the domestic one, foreign assets should be expected to deliver lower returns than the corresponding domestic assets. We call this condition "Uncovered Return Parity," due to its similarity with UIP.

Differently from previous research, we cast our analysis in very general terms. As a result, the model we suggest is very simple and can be estimated over a variety of asset classes. When we bring the URP condition to the data, we show that, over the last 15 years and for equity and bond markets, currencies with relatively higher expected returns tend to depreciate, a finding consistent with the theory's predictions.

Future research may explore why the UIP condition generates puzzling results when confronted with data, while the URP does not.

References

[1] Adler, M. and B. Dumas, 1983, "International Portfolio Choice and Corporation Finance: A Synthesis," *Journal of Finance* 38(3), 925-984.

[2] Andersen, T.G., T. Bollerslev, F.X. Diebold and C. Vega, 2006, "Real-Time Price Discovery in Global Stocks, Bond and Foreign Exchange Markets," Board of Governors of the Federal Reserve System, International Finance Discussion Papers No. 871.

[3] Ang, A. and G. Bekaert, 2005, "Stock Return Predictability: Is it There?," *Review of Financial Studies,* forthcoming.

[4] Bacchetta, P., and E. van Wincoop, 2006, "Incomplete Information Processing: A Solution to the Forward Discount Puzzle," mimeo, Study Center Gerzensee.

[5] Bacchetta, P., and E. van Wincoop, 2007, "Random Walk Expectations and the Forward Discount Puzzle," mimeo, Study Center Gerzensee.

[6] Balduzzi, P., and C. Robotti, 2001, "Minimum-variance pricing kernels, Economic Risk Premia and Tests of Multi-Beta models", Federal Reserve of Atlanta Working Paper No. 2001-24.

[7] Bekaert, G. and C.R. Harvey, 1995, "Time-Varying World Market Integration," *Journal of Finance* 50(2): 403-444.

[8] Boudoukh, J., M. Richardson and R.F. Whitelaw, 2006, "The Information in Long-Maturity Forward Rates: Implications for Exchange Rates and the Forward Premium Anomaly," mimeo, Stern School of Business, NYU.

[9] Boudoukh, J., M. Richardson and R.F. Whitelaw, 2006, "The Myth of Long-Horizon Predictability," *Review of Financial Studies,* forthcoming.

[10] Brooks, R., H. Edison, M. Kumar and T. Sløk, 2001, "Exchange Rates and Capital Flows," IMF Working Paper 01/190.

[11] Burnside, C., M. Eichenbaum, I. Kleshchelski, and S. Rebelo, 2006, "The Returns to Currency Speculation," NBER Working Paper No. 12489.

[12] Campbell, J.Y., 2000, "Asset Pricing at the Millennium," *Journal of Finance* 55(4), 1515-1567.

[13] Campbell, J.Y., A.W. Lo and A.C. MacKinlay, 1997, "The Econometrics of Financial Markets," Princeton University Press, Princeton, N.J.

[14] Campbell, J.Y., K. Serfaty-de Medeiros and L. Viceira, 2006, "Global Currency Hedging," mimeo, Harvard University.

[15] Cappiello, L., and R.A. De Santis, 2005, "Explaining Exchange Rate Dynamics: The Uncovered Equity Return Parity Condition," ECB Working Paper No. 529.

[16] Cappiello, L., and N. Panigirtzoglou, 2005, "Estimates of Foreign Exchange Risk Premia: A Pricing Kernel Approach," Department of Economics, Queen Mary, University of London, Working Paper No. 547.

[17] Chen, N. F., R. Roll, and S. A. Ross, 1986, "Economic Forces and Stock Market," *Journal of Business* 59(3), 383-403.

[18] Cochrane, J., 1996, "A Cross-Sectional Test of an Investment-Based Asset Pricing Model," *Journal of Political Economy* 104(3), 572-621.

[19] Cochrane, J., 2001, "Asset Pricing," Princeton University Press, Princeton, NJ.

[20] Cochrane, J., 2006, "The Dog that Did not Bark: A Defence of Return Predictability," mimeo, Chicago Graduate School of Business.

[21] De Santis, G. and B. Gérard, 1998, "How Big is the Premium for Currency Risk?," *Journal of Financial Economics* 49(3), 375-412.

[22] Dumas, B. and B. Solnik, 1995, "The World Price of Foreign Exchange Risk," *Journal of Finance* 50(2), 445-479.

[23] Engel, C., 1996, "The Forward Discount Anomaly and the Risk Premium: A Survey of Recent Evidence," *Journal of Empirical Finance* 3(2), 123-192.

[24] Fama, E.F., 1984, "Forward and Spot Exchange Rates," *Journal of Monetary Economics* 14(3), 319-338.

[25] Fama, E., and K. French, 1988, "Dividend Yields and Expected Stock Returns," *Journal of Financial Economics* 22(1), 3-25.

[26] Fama, E., and K. French, 1989, "Business Conditions and Expected Returns on Stocks and Bonds," *Journal of Financial Economics* 25(1), 23-49.

[27] Hansen, L.P., 1982, "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica*, 50(4) 1029-1054.

[28] Hansen, L.P. and R.J. Hodrick, 1980, "Forward Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," *Journal of Political Economy* 88(5), 829-853.

[29] Hansen, L.P. and R. Jagannthan, 1991, "Implications of Security Market Data for Models of Dynamic Economies," *Journal of Political Economy* 99(2), 225-262.

[30] Hau, A. and H. Rey, 2006, "Exchange Rate, Equity Prices and Capital Flows," *Review of Financial Studies* 19(1), 273-317.

[31] Harvey, C.R., 1989, "Time-Varying Conditional Covariances in Tests of Asset Pricing Models," *Journal of Financial Economics* 24(2), 289-317.

[32] Hodrick, R.J., 1987, "The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets," Harwood Academic Publishers, Chur, Switzerland.

[33] Ilmanen, A., 1995, "Time-Varying Expected Returns in International Bond Markets," *Journal of Finance* 50(2), 481-506.

[34] Lucas, R.E. Jr., 1978, "Asset Prices in an Exchange Economy," *Econometrica* 46(6), 1429-1445.

[35] Lucas, R.E. Jr., 1982, "Interest Rates and Currency Prices in a Two-Country World," *Journal of Monetary Economics* 10(3), 335-359.

[36] Lustig, H. and A. Verdelhan, 2006, "The Cross-Section of Foreign Currency Risk Premia and Consumption Growth Risk," *American Economic Review,* forthcoming.

[37] Mehl, A., and L. Cappiello, 2007, "Bond Yields, Exchange Rates & the Global Imbalances Debate: Lessons from Uncovered Interest Parity," mimeo, European Central Bank.

[38] Newey, W. and K. West, 1987, "A Simple Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica* 55(3), 703-708.

[39] Newey, W. and K. West, 1994, "Automatic Lag Selection in Covariance Matrix Estimation," *Review of Economic Studies* 61(4), 631-653.

[40] Pavlova, A. and R. Rigobon, 2006, "Asset Prices and Exchange Rates," *Review of Financial Studies,* forthcoming.

[41] Sarno, L., 2005, "Towards a Solution to the Puzzles in Exchange Rate Economics: Where Do We Stand?," *Canadian Journal of Economics*, 38(3), 673-708.

A Instruments used to estimate the pricing kernel

Equations (9) and (10) are used to price the US risk-free asset and 11 risky securities. Equation (20) describes the empirical specification of the minimum variance stochastic discount factor.[24] In this appendix we describe the instruments we adopt to price each asset.

• US risk-free T-bill: a constant, lagged gross equity and bond returns, ($R^{US}_{eq,t}$, $R^{UK}_{eq,t}$, $R^{DE}_{eq,t}$, $R^{CH}_{eq,t}$, $R^{US}_{gb,t}$, $R^{UK}_{gb,t}$, $R^{DE}_{gb,t}$, and $R^{CH}_{gb,t}$), and lagged money market accounts ($R^{USDGBP}_{mm,t}$, $R^{USDDEM}_{mm,t}$, and $R^{USDCHF}_{mm,t}$).

• US, UK, German and Swiss equity securities: a constant, lagged equity returns ($R^{US}_{eq,t}$, $R^{UK}_{eq,t}$, $R^{DE}_{eq,t}$, and $R^{CH}_{eq,t}$), lagged money market accounts ($R^{USDGBP}_{mm,t}$, $R^{USDDEM}_{mm,t}$, and $R^{USDCHF}_{mm,t}$), the respective lagged bond returns, ($R^{US}_{gb,t}$ for US, $R^{UK}_{gb,t}$ for UK, $R^{DE}_{gb,t}$ for Germany, and $R^{CH}_{gb,t}$ for Switzerland), the respective lagged dividend yields (DY^{US}_t for US, DY^{UK}_t for UK, DY^{DE}_t for Germany, and DY^{CH}_t for Switzerland), and the respective lagged first difference in three-month euro deposit rates ($\Delta Y^{US}_{3m,t}$ for US, $\Delta Y^{UK}_{3m,t}$ for UK, $\Delta Y^{DE}_{3m,t}$ for Germany, and $\Delta Y^{CH}_{3m,t}$ for Switzerland).

• US, UK, German and Swiss 10-year government bond securities: a constant, lagged bond retrns ($R^{US}_{gb,t}$, $R^{UK}_{gb,t}$, $R^{DE}_{gb,t}$, and $R^{CH}_{gb,t}$), lagged money market accounts ($R^{USDGBP}_{mm,t}$, $R^{USDDEM}_{mm,t}$, and $R^{USDCHF}_{mm,t}$), the respective lagged equity returns, ($R^{US}_{eq,t}$ for US, $R^{UK}_{eq,t}$ for UK, $R^{DE}_{eq,t}$ for Germany, and $R^{CH}_{eq,t}$ for Switzerland), and the respective lagged first difference in three-month euro deposit rates ($\Delta Y^{US}_{3m,t}$ for US, $\Delta Y^{UK}_{3m,t}$ for UK, $\Delta Y^{DE}_{3m,t}$ for Germany, and $\Delta Y^{CH}_{3m,t}$ for Switzerland).

• Pound sterling, Deutsche mark and Swiss frank money market accounts: a constant, lagged money market accounts ($R^{USDGBP}_{mm,t}$, $R^{USDDEM}_{mm,t}$, and $R^{USDCHF}_{mm,t}$), the respective lagged differencials in the change of three-month euro deposit rates ($\Delta Y^{US}_{3m,t} - \Delta Y^{UK}_{3m,t}$ for UK, $\Delta Y^{US}_{3m,t} - \Delta Y^{DE}_{3m,t}$ for Germany, and $\Delta Y^{US}_{3m,t} - \Delta Y^{CH}_{3m,t}$ for Switzerland), the respective lagged differencials in equity returns ($R^{US}_{eq,t} - R^{UK}_{eq,t}$ for UK, $R^{US}_{eq,t} - R^{DE}_{eq,t}$ for Germany, and $R^{US}_{eq,t} - R^{CH}_{eq,t}$ for Switzerland), the respective lagged differencials in bond returns ($R^{US}_{gb,t} - R^{UK}_{gb,t}$ for UK, $R^{US}_{gb,t} - R^{DE}_{gb,t}$ for Germany, and $R^{US}_{gb,t} - R^{CH}_{gb,t}$ for Switzerland).

B Instruments used to estimate URP

The URP condition (see equation (5)) is estimated assuming a relationship between expected exchange rate changes and expected equity and bond return differentials. Expectations on equity and bond return differentials are modelled with instruments which are similar to those employed in the estimation of the stochastic discount

[24] See also Cappiello and Panigirtzoglou (2005) for a similar specification.

factor. In the case of equities we employ: (i) a constant; (ii) differentials in lagged compounded equity returns, ($r^{US}_{eq,t} - r^{UK}_{eq,t}$ for UK, $r^{US}_{eq,t} - r^{DE}_{eq,t}$ for Germany, and $r^{US}_{eq,t} - r^{CH}_{eq,t}$ for Switzerland);[25] (iii) differentials in lagged compounded bond returns, ($r^{US}_{gb,t} - r^{UK}_{gb,t}$ for UK, $r^{US}_{gb,t} - r^{DE}_{gb,t}$ for Germany, and $r^{US}_{gb,t} - r^{CH}_{gb,t}$ for Switzerland); (iv) differentials in lagged dividend yields, ($DY^{US}_t - DY^{UK}_t$ for UK, $DY^{US}_t - DY^{DE}_t$ for Germany, and $DY^{US}_t - DY^{CH}_t$ for Switzerland); and (v) differencials in lagged changes of three-month euro deposit rates, ($\Delta Y^{US}_{3m,t} - \Delta Y^{UK}_{3m,t}$ for UK, $\Delta Y^{US}_{3m,t} - \Delta Y^{DE}_{3m,t}$ for Germany, $\Delta Y^{US}_{3m,t} - \Delta Y^{CH}_{3m,t}$ for Switzerland).

In the case of bonds we use: (i) a constant; (ii) differentials in lagged compounded bond returns, ($r^{US}_{gb,t} - r^{UK}_{gb,t}$ for UK, $r^{US}_{gb,t} - r^{DE}_{gb,t}$ for Germany, and $r^{US}_{gb,t} - r^{CH}_{gb,t}$ for Switzerland); (iii) differentials in lagged compounded equity returns, ($r^{US}_{eq,t} - r^{UK}_{eq,t}$ for UK, $r^{US}_{eq,t} - r^{DE}_{eq,t}$ for Germany, and $r^{US}_{eq,t} - r^{CH}_{eq,t}$ for Switzerland); (iv) differencials in lagged changes of three-month euro deposit rates, ($\Delta Y^{US}_{3m,t} - \Delta Y^{UK}_{3m,t}$ for UK, $\Delta Y^{US}_{3m,t} - \Delta Y^{DE}_{3m,t}$ for Germany, $\Delta Y^{US}_{3m,t} - \Delta Y^{CH}_{3m,t}$ for Switzerland); (v) and differentials in lagged compounded money market returns, ($r_{f,t} - r^{USDGBP}_{mm,t}$ for UK, $r_{f,t} - r^{USDDEM}_{mm,t}$ for Germany, and $r_{f,t} - r^{USDCHF}_{mm,t}$ for Switzerland).

C Instruments used to estimate URP - One step estimation procedure

When we esimate the URP condition in one step (see equations (9), (10) and (18)), we use the same instruments adopted to estimate the pricing kernel and the single URP equations with a multi-step procedure. In addition we also employ the respective lagged exchange rate changes for each URP equation of the system (see equation (18)).

Estimation of the UIP condition based on one step procedure (see equations (9), (10) and (19)) make use of the same instruments employed for the estimation of the stochastic discount factor. Moreover, wee also use: (i) relevant lagged exchange rate changes for each UIP equation of the system; (ii) differentials in lagged compounded money market returns, ($r_{f,t} - r^{USDGBP}_{mm,t}$ for UK, $r_{f,t} - r^{USDDEM}_{mm,t}$ for Germany, and $r_{f,t} - r^{USDCHF}_{mm,t}$ for Switzerland); (iii) and differentials in lagged changes of three-month euro deposit rates, ($\Delta Y^{US}_{3m,t} - \Delta Y^{UK}_{3m,t}$ for UK, $\Delta Y^{US}_{3m,t} - \Delta Y^{DE}_{3m,t}$ for Germany, $\Delta Y^{US}_{3m,t} - \Delta Y^{CH}_{3m,t}$ for Switzerland).

[25] Notice that the stock indices used to compute compounded returns are denominated in the respective national currency.

Table 1: Descriptive statistics of returns on equities, government bonds, euro-deposits, log changes in exchange rates and dividend yields

This table reports the summary statistics of monthly returns on equity market indices, US_{eq}, UK_{eq}, DE_{eq} and CH_{eq}, returns on 10-year government bond indices, US_{gb}, UK_{gb}, DE_{gb} and CH_{gb}, returns on one-month euro-deposits, US_{Tb}, UK_{Tb}, DE_{Tb} and CH_{Tb}, log changes in USD/GBP, USD/DEM, and USD/CHF exchange rates, dividend yields, DY US_{eq}, DY UK_{eq}, DY DE_{eq} and DY CH_{eq}, and returns on three-month euro-deposits, US_{3MTb}, UK_{3MTb}, DE_{3MTb} and CH_{3MTb}. The countries under consideration are US, UK, Germany (DE) and Switzerland (CH). Mean is in percentage and annualised, min (minimum), max (maximum) and SD (standard deviations) are in percentage. "Skew" and "Kurt" stand for skewness and kurtosis, respectively. The Jarque-Bera (J-B) test for normality combines excess skewness and kurtosis, and is asymptotically distributed as a χ^2_{df} with $df = 2$ degrees of freedom. * and ** denote significance at 1% and 5% confidence level, respectively. The sample period spans from January 1981 to October 2006.

Panel A: equity and government bond returns

	US_{eq}	UK_{eq}	DE_{eq}	CH_{eq}	US_{gb}	UK_{gb}	DE_{gb}	CH_{gb}
Mean	12.48	13.56	10.32	12.01	8.52	10.48	7.31	5.37
Max	12.56	13.35	15.49	11.56	8.03	9.58	4.91	5.93
Min	-23.26	-28.92	-23.44	-26.24	-7.36	-8.59	-6.56	-5.12
SD	4.31	4.67	5.57	4.65	2.33	2.42	1.72	1.53
Skew	-0.89	-1.33	-0.93	-1.38	0.07	-0.12	-0.67	-0.03
Kurt	3.61	5.83	2.71	5.21	0.42	1.89	1.28	1.20
J-B	45.67*	195.29*	45.94*	160.89*	86.12*	16.58*	61.32*	41.79*

Panel B: one-month euro-deposit returns and log exchange rate changes

	US_{Tb}	UK_{Tb}	DE_{Tb}	CH_{Tb}	USD/GBP	USD/DEM	USD/CHF
Mean	6.22	8.18	5.11	3.62	-0.88	0.93	1.33
Max	1.54	1.33	1.24	0.89	13.34	9.32	11.50
Min	0.08	0.28	0.17	0.01	-12.47	-12.17	-10.96
SD	0.29	0.29	0.21	0.22	3.06	3.15	3.39
Skew	1.07	0.48	1.03	0.71	-0.06	-0.02	0.11
Kurt	1.76	-1.05	0.51	-0.44	2.25	0.42	0.21
J-B	79.35*	223.74*	135.38*	179.24	7.39**	85.94*	100.90*

Panel C: dividend yields and three-month euro-deposit returns

	DY US_{eq}	DY UK_{eq}	DY DE_{eq}	DY CH_{eq}	US_{3MTb}	UK_{3MTb}	DE_{3MTb}	CH_{3MTb}
Mean	2.83	3.98	2.19	1.90	6.33	8.23	5.17	3.74
Max	6.56	6.66	4.30	3.63	1.55	1.41	1.20	0.92
Min	0.95	2.26	1.23	0.90	0.08	0.28	0.16	0.01
SD	1.37	0.95	0.60	0.58	0.29	0.29	0.21	0.22
Skew	0.67	0.29	1.12	1.17	1.08	0.48	1.02	0.69
Kurt	-0.43	-0.58	1.52	0.86	1.69	-0.99	0.45	-0.41
J-B	175.60*	170.40*	93.69*	129.60*	82.22*	217.37*	137.92*	174.85*

Table 2: Unconditional correlations of instrumental variables

This table reports unconditional correlations between instrumental variables: equity market returns, US_{eq}, UK_{eq}, DE_{eq} and CH_{eq}, 10-year government bond returns, US_{gb}, UK_{gb}, DE_{gb} and CH_{gb}, one-month euro-deposit returns, US_{Tb}, UK_{Tb}, DE_{Tb} and CH_{Tb}, dividend yields, DY US_{eq}, DY UK_{eq}, DY DE_{eq} and DY CH_{eq}, changes in three-month euro-deposits rates, ΔUS_{3MTb}, ΔUK_{3MTb}, ΔDE_{3MTb} and ΔCH_{3MTb}, and money market returns, UK_{mm}, DE_{mm} and CH_{mm}. The countries under consideration are US, UK, Germany (DE) and Switzerland (CH). The sample period spans from January 1981 to October 2006.

	US_{eq}	UK_{eq}	DE_{eq}	CH_{eq}	US_{gb}	UK_{gb}	DE_{gb}	CH_{gb}
US_{eq}	1.00							
UK_{eq}	0.71	1.00						
DE_{eq}	0.60	0.62	1.00					
CH_{eq}	0.65	0.69	0.74	1.00				
US_{gb}	0.17	0.05	-0.06	-0.03	1.00			
UK_{gb}	0.13	0.26	0.05	0.04	0.43	1.00		
DE_{gb}	0.04	0.05	0.11	0.03	0.60	0.51	1.00	
CH_{gb}	-0.06	0.04	-0.03	0.07	0.30	0.34	0.55	1.00
US_{Tb}	0.01	0.05	0.03	-0.03	0.12	0.12	0.02	-0.03
UK_{Tb}	0.05	0.08	0.03	0.00	0.15	0.20	0.06	0.00
DE_{Tb}	-0.02	0.02	-0.04	-0.05	0.11	0.13	0.10	0.09
CH_{Tb}	-0.02	0.01	-0.05	-0.05	0.11	0.09	0.04	0.04
DY US_{eq}	0.00	0.05	0.01	-0.03	0.13	0.13	0.07	0.03
DY UK_{eq}	0.00	-0.03	-0.06	-0.09	0.15	0.14	0.11	0.09
DY DE_{eq}	-0.05	-0.02	-0.12	-0.14	0.12	0.15	0.09	0.08
DY CH_{eq}	-0.01	0.02	-0.03	-0.10	0.16	0.16	0.11	0.06
ΔUS_{3MTb}	-0.18	-0.10	-0.03	-0.02	-0.54	-0.23	-0.31	-0.10
ΔUK_{3MTb}	-0.04	-0.23	-0.01	-0.01	-0.10	-0.50	-0.18	-0.10
ΔDE_{3MTb}	-0.03	-0.01	0.01	0.02	-0.23	-0.10	-0.43	-0.23
ΔCH_{3MTb}	-0.01	-0.08	0.09	-0.01	-0.20	-0.19	-0.27	-0.33
UK_{mm}	-0.04	-0.18	-0.15	-0.16	0.18	0.12	0.14	-0.01
DE_{mm}	-0.08	-0.21	-0.22	-0.25	0.20	0.00	0.14	0.01
CH_{mm}	-0.13	-0.24	-0.28	-0.29	0.20	0.00	0.13	0.02

	US_{Tb}	UK_{Tb}	DE_{Tb}	CH_{Tb}	DY US_{eq}	DY UK_{eq}	DY DE_{eq}	DY CH_{eq}
US_{Tb}	1.00							
UK_{Tb}	0.76	1.00						
DE_{Tb}	0.61	0.72	1.00					
CH_{Tb}	0.54	0.80	0.91	1.00				
DY US_{eq}	0.82	0.78	0.66	0.60	1.00			
DY UK_{eq}	0.67	0.76	0.76	0.70	0.90	1.00		
DY DE_{eq}	0.58	0.44	0.55	0.37	0.75	0.78	1.00	
DY CH_{eq}	0.74	0.61	0.57	0.45	0.90	0.82	0.86	1.00
ΔUS_{3MTb}	-0.18	-0.17	-0.19	-0.16	-0.12	-0.16	-0.15	-0.18
ΔUK_{3MTb}	0.01	-0.11	-0.09	-0.07	-0.02	-0.03	-0.06	-0.06
ΔDE_{3MTb}	0.06	0.02	-0.11	-0.04	-0.05	-0.06	-0.05	-0.09
ΔCH_{3MTb}	0.08	0.02	-0.06	-0.08	-0.02	-0.05	-0.04	-0.06
UK_{mm}	-0.07	0.07	-0.07	0.01	-0.03	-0.01	-0.10	-0.05
DE_{mm}	-0.06	0.08	0.03	0.09	0.03	0.07	-0.02	0.01
CH_{mm}	-0.04	0.09	0.05	0.13	0.03	0.07	-0.03	0.01

Table 2 - Continued

	ΔUS_{3MTb}	ΔUK_{3MTb}	ΔDE_{3MTb}	ΔCH_{3MTb}	UK_{mm}	DE_{mm}	CH_{mm}
ΔUS_{3MTb}	1.00						
ΔUK_{3MTb}	0.24	1.00					
ΔDE_{3MTb}	0.26	0.16	1.00				
ΔCH_{3MTb}	0.26	0.30	0.55	1.00			
UK_{mm}	-0.17	-0.14	-0.20	-0.11	1.00		
DE_{mm}	-0.18	-0.05	-0.14	-0.12	0.69	1.00	
CH_{mm}	-0.20	-0.06	-0.18	-0.13	0.67	0.93	1.00

Table 3: Domestic investor's stochastic discount factor

This table reports estimates relative to minimum variance domestic investor's stochastic discount factor m_{t+1}^{MV}. This pricing kernel is equal to the projection on the space of asset pay-offs, i.e. $m_{t+1}^{MV} = a + \mathbf{b}'\mathbf{R}_{t+1}$ (see equation (20) for the empirical specification), while the set of moment conditions are given by $E\left\{\mathbf{R}_{t+1}m_{t+1}^{MV} - 1|\Im_t\right\} = \mathbf{0}_n$. Estimates are carried out with GMM. Covariances are weighted using a Bartlett-kernel estimator where the bandwith is selected according to Newey and West (1994). Standard errors are corrected for serial correlation and heteroskedasticity using the Newey and West (1987) methodology. The instruments we use to price each asset return are described in appendix A. The sample period spans from January 1981 to October 2006.

		Standard errors	**p-value**
a	2.14	0.10	0.00
b_1	0.10	0.05	0.02
b_2	-0.02	0.05	0.65
b_3	-0.18	0.03	0.00
b_4	-0.15	0.04	0.00
b_5	-0.47	0.08	0.00
b_6	-0.42	0.09	0.00
b_7	0.52	0.15	0.00
b_8	-0.41	0.12	0.00
b_9	-0.07	0.13	0.60
b_{10}	-0.34	0.17	0.04
b_{11}	0.30	0.18	0.10
J_T-statistic	0.13		

Table 4: Uncovered Return Parity

This table reports estimates relative to the Uncovered Return Parity condition. The equation we estimate is:

$$\Delta s_{t+1} = \alpha + \beta E\left\{r_{i,t+1} - r^*_{i,t+1}|\Im_t\right\} -$$
$$-\zeta_1 \frac{\widehat{Cov}\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}}{R_{f,t}} - \zeta_2 \widehat{Cov}\left\{R^*_{i,t+1}\frac{S_{t+1}}{S_t}, m^{MV}_{t+1}|\Im_t\right\} + \zeta_3 \widehat{Cov}\left\{R_{i,t+1}, m^{MV}_{t+1}|\Im_t\right\} +$$
$$+\frac{1}{2}\left[\zeta_4 \widehat{Var}\left\{r_{i,t+1}|\Im_t\right\} - \zeta_5 \widehat{Var}\left\{r^*_{i,t+1}|\Im_t\right\} - \zeta_6 \widehat{Var}\left\{\Delta s_{t+1}|\Im_t\right\}\right] + \eta_{t+1}.$$

Estimates are carried out with GMM. Covariances are weighted using a Bartlett-kernel estimator where the bandwith is selected according to Newey and West (1994). Standard errors are corrected for serial correlation and heteroskedasticity using the Newey and West (1987) methodology. The instruments we use to model expectations on equity bond return differentials are described in appendix B. * and ** denote significance at 1% and 5% confidence level, respectively.

Panel A - Sample period: January 1981 - October 2006

	Equity markets			***Bond markets***		
	Pound sterling	**Deutsche mark**	**Swiss Franc**	**Pound Sterling**	**Deutsche mark**	**Swiss Franc**
α	1.08**	1.14	1.56**	0.36	0.11	0.37
	(0.53)	(0.94)	(0.73)	(0.57)	(1.26)	(1.08)
β	-0.17	0.26	-0.05	-0.21	-0.33	-1.18
	(0.29)	(0.42)	(0.32)	(0.58)	(0.79)	(1.06)
ζ_1	0.32	-0.05	-0.06	0.12	0.37	0.50
	(0.22)	(0.07)	(0.20)	(0.25)	(0.25)	(0.31)
ζ_2	4.69**	1.48**	2.81**	2.56	3.88*	4.29**
	(1.91)	(0.69)	(0.94)	(2.13)	(1.18)	(1.77)
ζ_3	5.91*	2.50**	3.94*	1.85	1.11	3.48
	(1.74)	(1.26)	(0.90)	(2.93)	(1.77)	(3.49)
ζ_4	0.06	-0.07	0.06	0.05	0.26	0.72
	(0.04)	(0.04)	(0.08)	(0.40)	(0.37)	(0.62)
ζ_5	0.16**	-0.03	0.07	0.30	0.03	0.60
	(0.07)	(0.04)	(0.14)	(0.22)	(0.72)	(0.74)
ζ_6	0.69	0.18	0.36	0.32	0.57	0.50
	(0.36)	(0.19)	(0.21)	(0.31)	(0.29)	(0.32)
J_T-statistic	0.01	0.01	0.01	0.01	0.02	0.00

Table 4 - Continued

Panel B - Sample period: January 1990 - October 2006

	Equity markets			***Bond markets***		
	Pound sterling	**Deutsche mark**	**Swiss Franc**	**Pound Sterling**	**Deutsche mark**	**Swiss Franc**
α	0.61	-0.40	0.60	-0.79	-3.40**	-1.90
	(0.53)	(0.83)	(1.14)	(0.84)	(1.34)	(1.38)
β	0.49	0.46**	0.64**	-0.40	0.69	0.61
	(0.31)	(0.23)	(0.28)	(0.62)	(0.49)	(0.74)
ζ_1	-0.07	-0.04	-0.01	-0.23	0.29	0.29
	(0.13)	(0.09)	(0.17)	(0.16)	(0.25)	(0.29)
ζ_2	0.84	-0.38	-0.35	-0.63	0.33	0.74
	(0.89)	(0.88)	(0.85)	(1.35)	(1.26)	(0.72)
ζ_3	1.95**	0.56	1.39	2.40	3.52	4.07
	(0.71)	(1.12)	(1.35)	(3.01)	(2.18)	(2.07)
ζ_4	0.04	-0.11	0.12	0.45	0.88**	1.12**
	(0.05)	(0.08)	(0.07)	(0.33)	(0.39)	(0.52)
ζ_5	0.00	-0.09**	0.12	-0.19	-0.53	-1.86
	(0.08)	(0.04)	(0.10)	(0.37)	(1.19)	(0.94)
ζ_6	-0.00	-0.22	-0.22	-0.21	-0.32	0.44
	(0.16)	(0.20)	(0.23)	(0.28)	(0.31)	(0.30)
J_T-statistic	0.01	0.02	0.01	0.03	0.06	0.05

Table 5: Uncovered Return Parity - One step estimation procedure

This table reports estimates relative to the Uncovered Return Parity condition. We estimate the following system of equations:

$$E\left\{R_{i,t+1}m_{t+1}^{MV}-1|\Im_t\right\}=0$$

$$E\left\{R_{i,t+1}^{j*}\frac{S_{t+1}^j}{S_t^j}m_{t+1}^{MV}-1\,|\Im_t\right\}=0$$

$$E\left\{\Delta s_{t+1}^j-\alpha-\beta\left(r_{i,t+1}-r_{i,t+1}^{j*}\right)+\zeta_1^j\left[\left(R_{i,t+1}^{j*}\frac{S_{t+1}^j}{S_t^j}m_{t+1}^{MV}\right)-R_{f,t}^{-1}\left(R_{i,t+1}^{j*}\frac{S_{t+1}^j}{S_t^j}\right)\right]-\right.$$
$$\left.-\zeta_2^j\left[\left(R_{i,t+1}m_{t+1}^{MV}\right)-R_{f,t}^{-1}R_{i,t+1}\right]|\Im_t\right\}=0,$$

where $j=UK,DE,CH$. j indicates that the exchange rates we consider are USD/GBP, USD/DEM and USD/CHF, and returns on foreign assets refer to UK, Germany and Switzerland. The pricing kernel is equal to the projection on the space of asset pay-offs, i.e. $m_{t+1}^{MV}=a+\mathbf{b}'\mathbf{R}_{t+1}$ (see equation (20) for the empirical specification), while the set of moment conditions are given by $E\left\{\mathbf{R}_{t+1}m_{t+1}^{MV}-1|\Im_t\right\}=\mathbf{0}_n$. Estimates are carried out with GMM. Covariances are weighted using a Bartlett-kernel estimator where the bandwith is selected according to Newey and West (1994). Standard errors are corrected for serial correlation and heteroskedasticity using the Newey and West (1987) methodology. The instruments we use price each asset and to model expectations on equity and bond return differentials are described in appendix C. The sample period spans from January 1990 until October 2006.

Panel A - Investment opportunity set: equities

		Standard errors	p-value
a	2.74	0.14	0.00
b_1	–0.09	0.05	0.06
b_2	0.37	0.07	0.00
b_3	–0.30	0.04	0.00
b_4	–0.22	0.04	0.00
b_5	–0.41	0.12	0.00
b_6	–0.39	0.10	0.00
b_7	1.10	0.14	0.00
b_8	–1.11	0.13	0.00
b_9	–0.77	0.14	0.00
b_{10}	–2.11	0.20	0.00
b_{11}	2.21	0.22	0.00
α	0.00	0.00	0.35
β	0.35	0.02	0.00
ζ_1^{UK}	–5.47	0.41	0.00
ζ_2^{UK}	–5.97	0.40	0.00
ζ_1^{DE}	–5.52	0.65	0.00
ζ_2^{DE}	–6.35	0.65	0.00
ζ_1^{CH}	–8.97	1.38	0.00
ζ_2^{CH}	–10.47	1.47	0.00
J_T-statistic	0.25		

Table 5 - Continued

Panel B - Investment opportunity set: equities and bonds

		Standard errors	p-value
a	2.50	0.07	0.00
b_1	0.03	0.02	0.10
b_2	0.24	0.03	0.00
b_3	−0.26	0.02	0.00
b_4	−0.32	0.02	0.00
b_5	−0.36	0.05	0.00
b_6	−0.44	0.06	0.00
b_7	0.83	0.07	0.00
b_8	−0.71	0.05	0.00
b_9	−0.26	0.07	0.00
b_{10}	−1.53	0.11	0.00
b_{11}	1.28	0.10	0.00
α	−0.00	0.00	0.16
β	0.40	0.01	0.00
ζ_{1EQ}^{UK}	−4.37	0.24	0.00
ζ_{2EQ}^{UK}	−4.95	0.24	0.00
ζ_{1EQ}^{DE}	−5.41	0.36	0.00
ζ_{2EQ}^{DE}	−6.32	0.37	0.00
ζ_{1EQ}^{CH}	−5.53	0.43	0.00
ζ_{2EQ}^{CH}	−6.95	0.47	0.00
ζ_{1GB}^{UK}	−2.49	0.20	0.00
ζ_{2GB}^{UK}	−3.37	0.20	0.00
ζ_{1GB}^{DE}	−4.17	0.25	0.00
ζ_{2GB}^{DE}	−5.45	0.24	0.00
ζ_{1GB}^{CH}	−17.54	1.03	0.00
ζ_{2GB}^{CH}	−20.81	1.11	0.00
J_T-statistic	0.20		

Table 6: Uncovered Interest Parity

This table reports estimates relative to the Uncovered Interest Parity condition. The equation we estimate is:

$$\Delta s_{t+1} = \alpha_f + \beta_f \left(r_{f,t} - r^*_{f,t} \right) -$$
$$-\zeta_{1f} R^*_{f,t} \widehat{Cov} \left\{ \frac{S_{t+1}}{S_t}, m^{MV}_{t+1} | \Im_t \right\} - \zeta_{2f} \frac{1}{2} \widehat{Var} \left\{ \Delta s_{t+1} | \Im_t \right\} + \eta_{f,t+1}.$$

Estimates are carried out with GMM. Covariances are weighted using a Bartlett-kernel estimator where the bandwith is selected according to Newey and West (1994). Standard errors are corrected for serial correlation and heteroskedasticity using the Newey and West (1987) methodology. The sample period spans from January 1990 to October 2006. * and ** denote significance at 1% and 5% confidence level, respectively.

	Pound sterling	**Deutsche mark**	**Swiss Franc**
α_f	0.50	1.37	2.51
	(0.37)	(2.13)	(1.28)
β_f	-1.27	-3.39	-3.88
	(1.82)	(3.07)	(2.20)
ζ_{1f}	-1.89	-0.60	-0.58
	(1.61)	(0.93)	(1.03)
ζ_{2f}	-0.23	0.22	0.33
	(0.26)	(0.53)	(0.21)
J_T-statistic	0.00	0.00	0.00

Table 7: Uncovered Interest Parity - One step estimation procedure

This table reports estimates relative to the Uncovered Interest Parity condition. We estimate the following system of equations:

$$E\left\{R_{i,t+1}m_{t+1}^{MV}-1|\Im_t\right\}=0$$
$$E\left\{R_{i,t+1}^{j*}\frac{S_{t+1}^j}{S_t^j}m_{t+1}^{MV}-1\,|\Im_t\right\}=0$$
$$E\left\{\Delta s_{t+1}^j-\alpha_f-\beta_f\left(r_{f,t}-r_{f,t}^{j*}\right)+\zeta^j\left[R_{f,t}^{j*}\left(\frac{S_{t+1}^j}{S_t^j}m_{t+1}^{MV}\right)-R_{f,t}^{-1}\frac{S_{t+1}^j}{S_t^j}\right]|\Im_t\right\}=0,$$

where $j = UK, DE, CH$. j indicates that the exchange rates we consider are USD/GBP, USD/DEM and USD/CHF, and returns on foreign assets refer to UK, Germany and Switzerland. The pricing kernel is equal to the projection on the space of asset pay-offs, i.e. $m_{t+1}^{MV} = a + \mathbf{b}'\mathbf{R}_{t+1}$ (see equation (20) for the empirical specification), while the set of moment conditions are given by $E\left\{\mathbf{R}_{t+1}m_{t+1}^{MV}-1|\Im_t\right\} = \mathbf{0}_n$. Estimates are carried out with GMM. Covariances are weighted using a Bartlett-kernel estimator where the band-with is selected according to Newey and West (1994). Standard errors are corrected for serial correlation and heteroskedasticity using the Newey and West (1987) methodology. The instruments we use to price each asset and to model expectations on equity return differentials are described in appendix C. The sample period spans from January 1990 until October 2006.

		Standard errors	p-value
a	2.66	0.12	0.00
b_1	–0.08	0.04	0.06
b_2	0.37	0.07	0.00
b_3	–0.31	0.05	0.00
b_4	–0.30	0.06	0.00
b_5	–0.43	0.12	0.00
b_6	–0.47	0.12	0.00
b_7	0.98	0.13	0.00
b_8	–0.87	0.10	0.00
b_9	–0.42	0.15	0.00
b_{10}	–1.58	0.19	0.00
b_{11}	1.45	0.19	0.00
α_f	–0.00	0.00	0.00
β_f	–0.09	0.09	0.29
ζ^{UK}	0.87	0.06	0.00
ζ^{DE}	1.18	0.04	0.00
ζ^{CH}	0.86	0.05	0.00
J_T-statistic	0.25		

Figure 1: Hedging between equities and exchange rates

Figures 1a-1c plot the term $Cov\left\{R^*_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}/R_{f,t}$ for equities and exchange rates.

Fig. 1a: US-UK

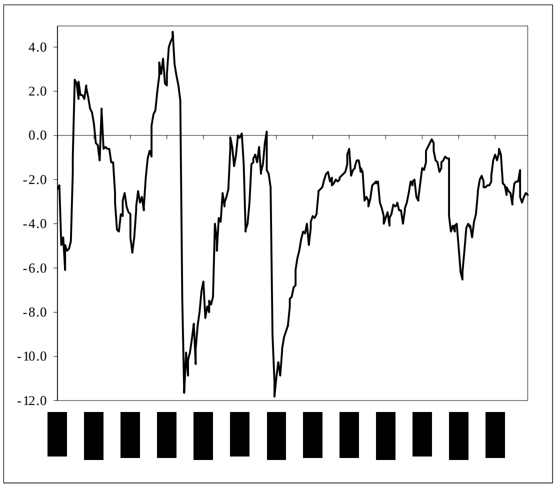

Fig. 1b: US-DE

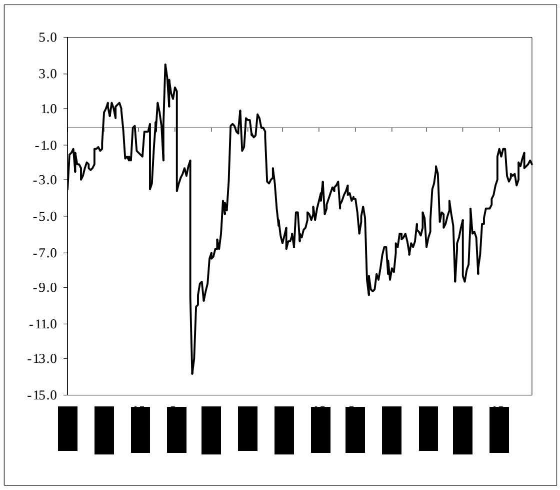

Fig. 1c: US-CH

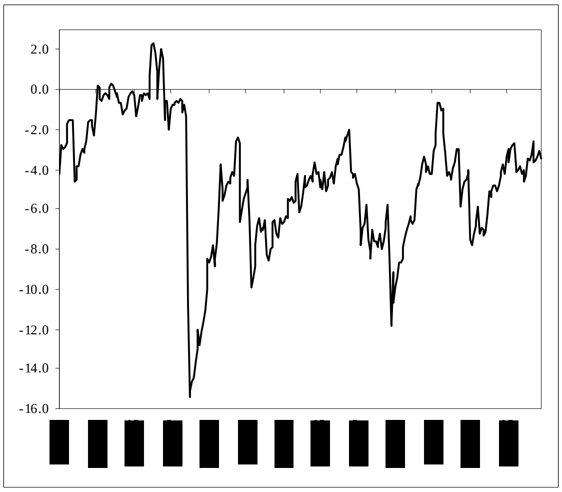

Figure 2: Hedging between bonds and exchange rates

Figures 2a-2c plot the term $Cov\left\{R^{*}_{i,t+1}, \frac{S_{t+1}}{S_t}|\Im_t\right\}/R_{f,t}$ for bonds and exchange rates.

Fig. 2a: US-UK

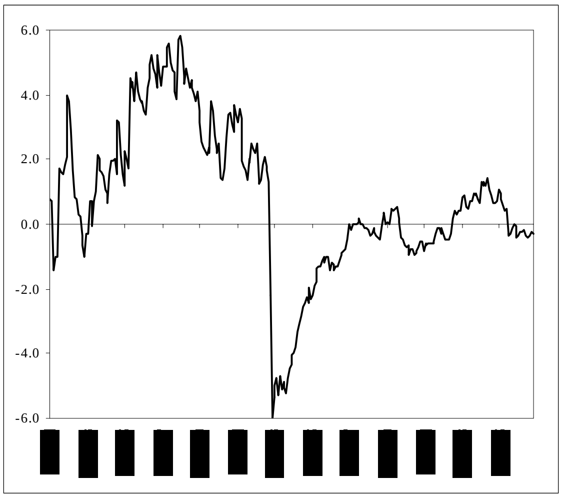

Fig. 2b: US-DE

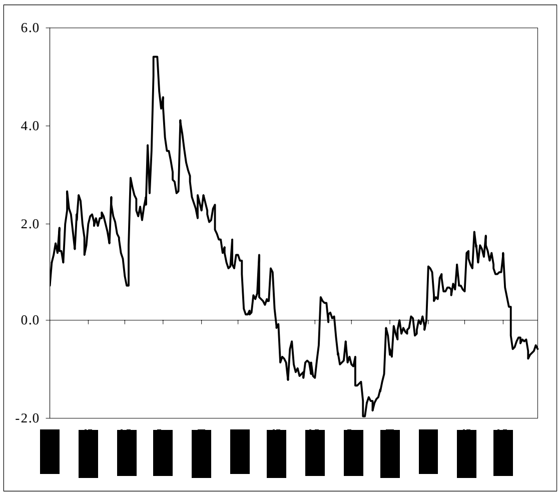

Fig. 2c: US-CH

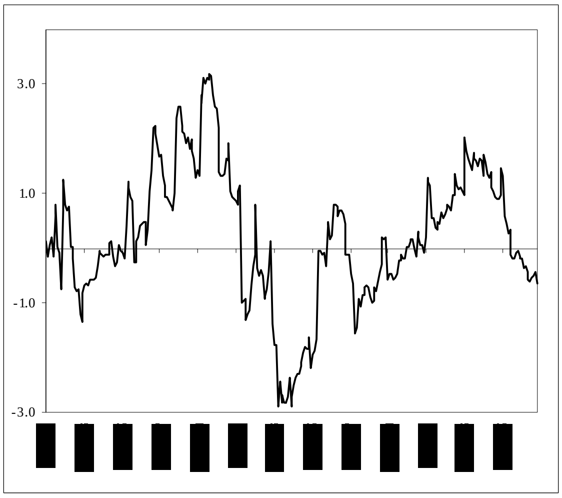

Figure 3: Equity risk premia

Figures 3a-3d plot the terms $-Cov\left\{R_{i,t+1}, m_{t+1}^{MV}|\Im_t\right\}$ and $-Cov\left\{R_{i,t+1}^{*}\frac{S_{t+1}}{S_t}, m_{t+1}^{MV}|\Im_t\right\}$ for US, UK, German and Swiss equity returns.

Fig. 3a: US equity premia

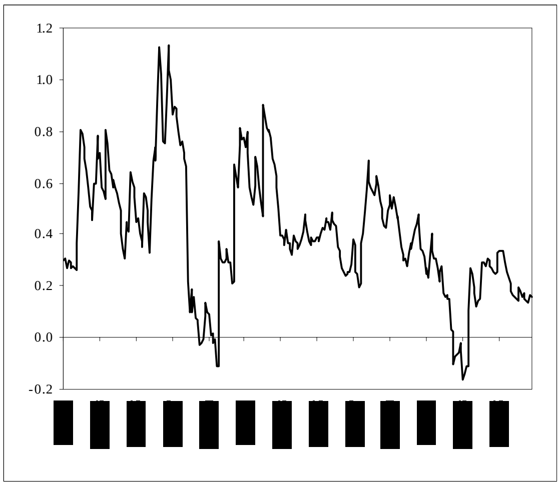

Fig. 3b: UK equity premia

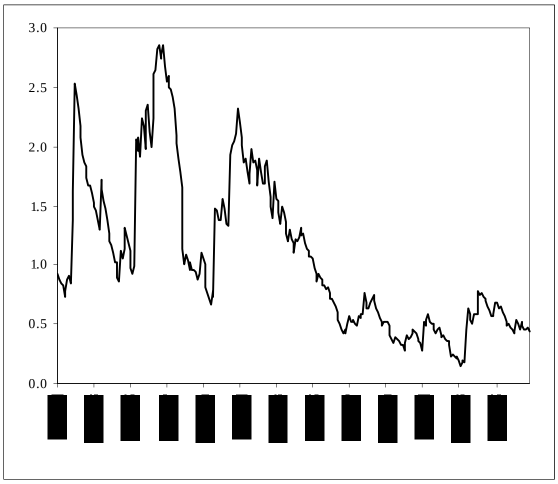

Fig. 3c: DE equity premia

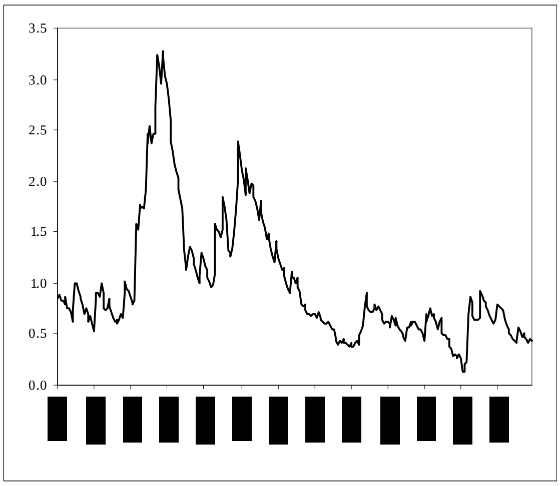

Fig. 3d: CH equity premia

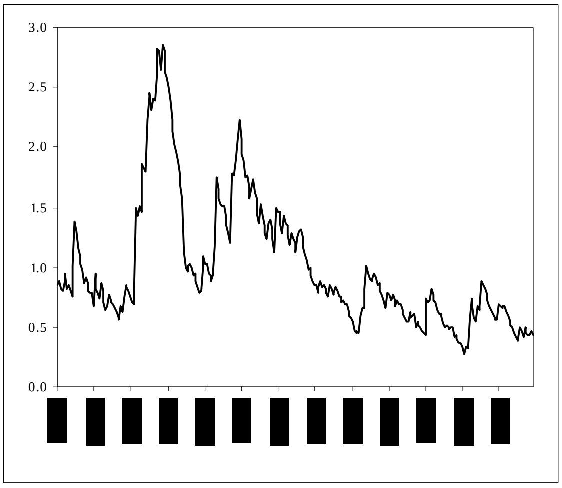

Figure 4: Bond risk premia

Figures 4a-4d plot the terms $-Cov\left\{R_{i,t+1}, m_{t+1}^{MV}|\Im_t\right\}$ and $-Cov\left\{R_{i,t+1}^{*}\frac{S_{t+1}}{S_t}, m_{t+1}^{MV}|\Im_t\right\}$ for US, UK, German and Swiss bond returns.

Fig. 4a: US bond premia

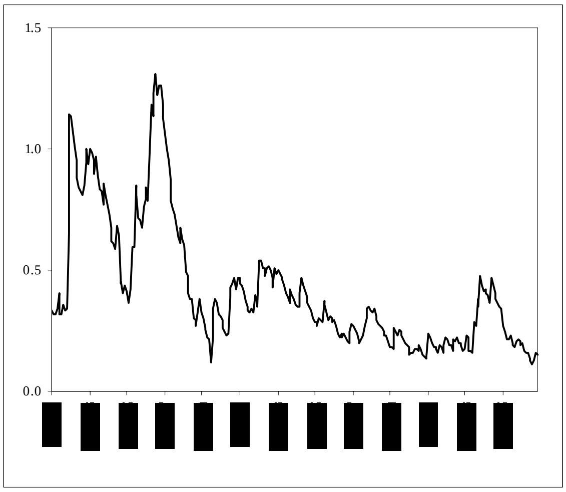

Fig. 4b: UK bond premia

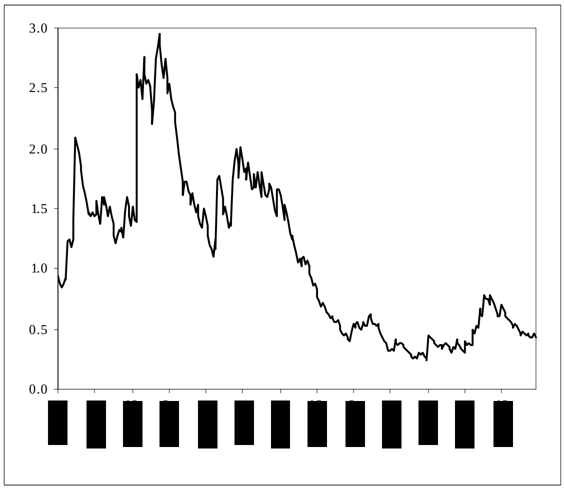

Fig. 4c: DE bond premia

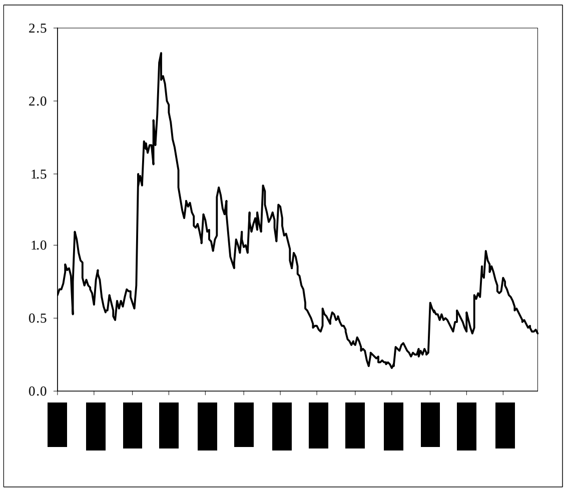

Fig. 4d: CH bond premia

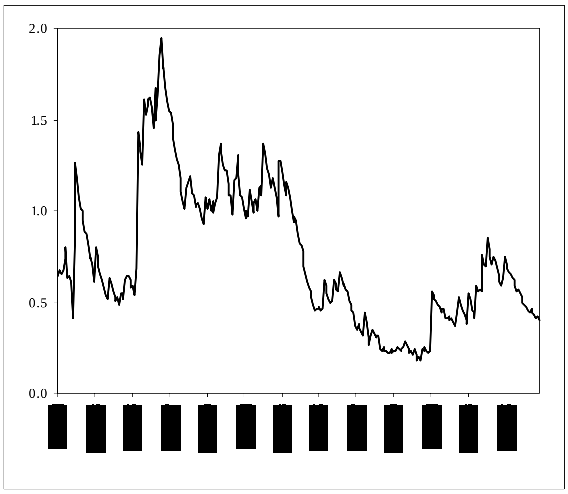

Figure 5: Equity market volatility versus foreign exchange volatility

Figures 5a-5c plot the ratios $\left[abs\left(Var\left\{r_{i,t+1}|\Im_t\right\} - Var\left\{r^*_{i,t+1}|\Im_t\right\}\right)\right]/Var\left\{\Delta s_{t+1}|\Im_t\right\}$ for the equity returns US-UK, US-Germany and US-Switzerland and the corresponding exchange rates, USD/GBP, USD/DEM and USD/CHF, respectively.

Fig. 5a: US-UK

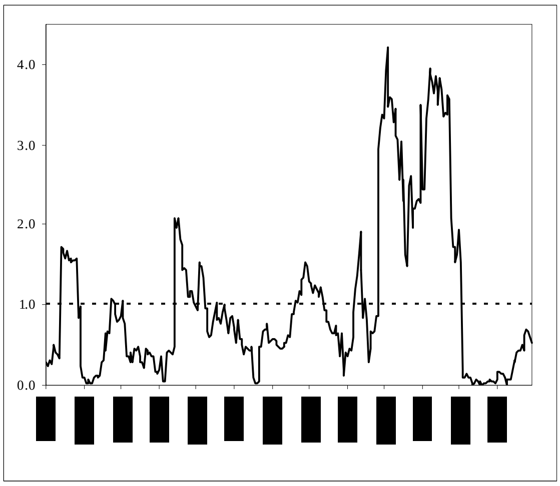

Fig. 5b: US-DE

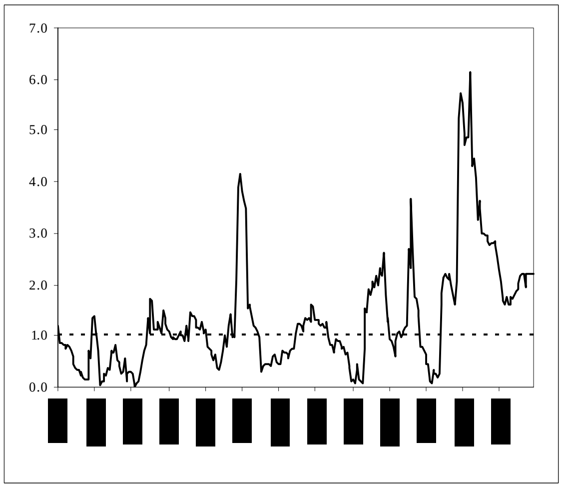

Fig. 5c: US-CH

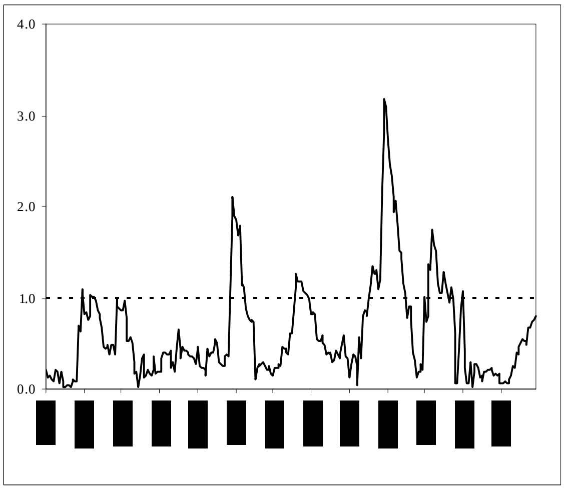

Figure 6: Foreign exchange risk premia

Figures 6a-6c plot the terms $-Cov\left\{\frac{S_{t+1}}{S_t}, m_{t+1}^{MV}|\Im_t\right\}$ for the USD/GBP, USD/DEM and USD/CHF exchange rates.

Fig. 6a: USD/GBP risk premia

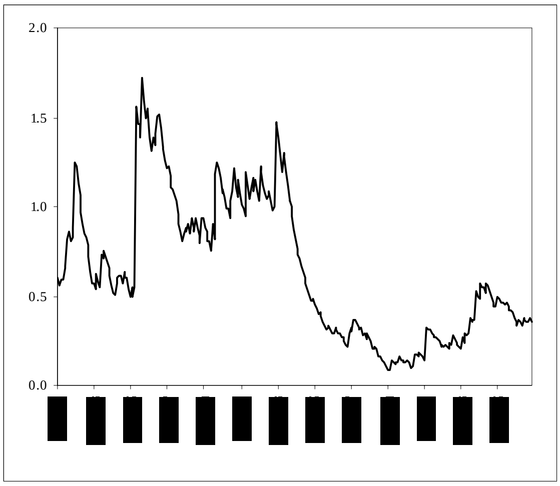

Fig. 6b: USD/DEM risk premia

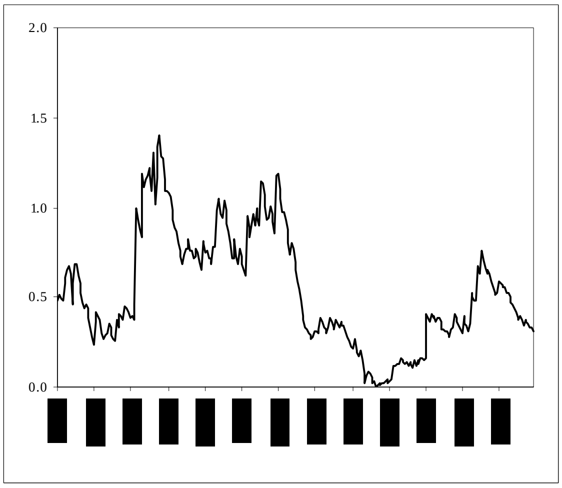

Fig. 6c: USD/CHF risk premia