Common Risk Factors in Currency Markets

Comments welcome.*

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Abstract

We build portfolios of monthly currency forward contracts sorted on forward discounts. The spread between returns on the lowest and highest interest rate currency portfolios is more than 5 percentage points per annum between 1983 and 2007 after taking into account bid-ask spreads. The annualized Sharpe ratio on a carry trade strategy that goes long in the highest and short in the lowest interest rate currency basket is 0.6. We provide new evidence for a systematic risk explanation of these currency excess returns. We show that a single common risk factor accounts for their cross-sectional variation. We find that these excess returns are highly predictable over time and that expected excess returns are strongly counter-cyclical, supporting the view that currency excess returns are compensation for bearing macroeconomic risk. We show that a simple affine framework reproduces both cross-sectional and predictability results.

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A typical currency carry trade at the start of July 2007 was to borrow in yen - a low interest rate currency - and invest in Australian and New Zealand dollars - high interest rate currencies. Over the course of the summer, each large drop in the S&P 500 was accompanied by a large appreciation of the yen of up to 1.7 percent and a large depreciation of the New Zealand and Australian dollar of up to 2.3 percent (Figure 1 plots the percentage change in the dollar exchange rate for the yen against the New Zealand and Australian dollar).[1] Clearly, a US investor who was long these high interest rate currencies and short low interest rate currencies, was heavily exposed to US aggregate stock market risk during the subprime mortgage crisis, and thus should have been compensated by a risk premium ex ante. In this paper, we demonstrate that currency risk premia are a robust feature of the data. Currency carry trades, which are defined broadly as investing in high interest rate currencies and borrowing in low interest rate currencies, expose US investors to more US aggregate risk, especially during "bad times" in the US economy. We identify a single aggregate risk factor that explains most of the differences in average excess returns between high and low interest rate currencies. After accounting for the covariance with this risk factor, there are no significant anomalous or unexplained excess returns in currency markets.

[Figure 1 about here.]

[Figure 2 about here.]

To make these points, we apply the Fama and French (1993) approach to analyzing stock and bond returns to currencies. As in Lustig and Verdelhan (2007), we sort currencies on their forward discount and allocate them to six portfolios. Forward discounts are simply log differences between forward rates and spot rates. As covered interest rate parity holds on average, forward discounts reflect interest rate differential. As a result, the first portfolio contains the lowest interest rate currencies while the last portfolio contains the highest interest rate currencies. Unlike Lustig and Verdelhan (2007), we only use spot and forward exchange rates. Our main sample comprises 37 currencies. Forward contracts are not subject to sovereign default risk and they are easily tradable. We account for bid-ask spreads that investors incur when they trade these spot and forward contracts. By sorting currencies on their risk characteristics, we focus on sources of risk and we average out idiosyncratic variations.

For each portfolio, we compute the monthly foreign currency excess returns realized by buying or selling one-month forward contracts for all currencies in the portfolio, net of transaction costs. Between 1983 and 2007, US investors earn an annualized log excess return of 5 percent by buying one-month forward contracts for currencies in the last portfolio and by selling forward contracts

[1] The 2.3 percent depreciation of the New Zealand dollar on July 26 is 3 times the size of the daily standard deviation in 2007. The 2 percent drop in the Australian dollar is 3.5 times the size of the daily standard deviation in 2007 –the steepest one-day drop since it was allowed to trade freely in 1983.

for currencies in the first portfolio. The annualized Sharpe ratio on such a strategy is 0.6. These findings are robust. We find similar results when we limit the sample to developed currencies, and when we take the perspective of investors in other countries. In this paper, we investigate the cross-sectional and time-series properties of these currency excess returns.

We show that a single risk factor explains about 80 percent of the variation in average excess returns on our 6 currency portfolios. This risk factor is the return on a zero-cost strategy that goes long in the last portfolio and short in the first portfolio. We label this factor HML_{FX}, for high interest rate minus low interest rate currencies. The risk price of this factor implied by the cross-section of currency portfolio returns is roughly equal to its sample mean, consistent with the Arbitrage Pricing Theory of Ross (1976). Low interest rate currencies provide US investors with insurance against HML_{FX} risk, while high interest rate currencies expose investors to more HML_{FX} risk. By ranking currencies into portfolios based on their forward discounts, we find that a currency's forward discount determines its exposure to HML_{FX}, and hence its risk premium. As a check, we also rank currencies based on their HML-exposure, and we find that portfolios with high HML_{FX}-exposure yield higher average returns and have higher forward discounts.

The standard Capital Asset Pricing Model ($CAPM$) does not fully account for the cross-sectional variation in currency returns, yet there is substantial covariation between the U.S. stock market return and HML_{FX} as well as individual portfolio returns. Low discount currencies provide a hedge against US market risk and thus earn negative average returns, while high discount currencies expose investors to more aggregate risk and, consequently, earn positive average returns. However, the market risk premium implied by the cross-section of currency returns is 40 percent, compared to the realized stock market average excess return of 7.5 percent. This means that the unconditional covariances (or betas) between the stock market excess return and the currency excess returns are far too small. Importantly, these betas vary over time. For example, during the spring of 1998 (following the Asian crisis), high interest rate currencies depreciated relative to low interest rate ones by 1.2 percent while the U.S. stock market declined by 1 percent. We find that such beta tends to increase dramatically during episodes of other financial crisis, consistent with the recent sub-prime mortgage crisis' effect on the carry trade shown in figure 1. These patterns of conditional covariation between the U.S. stock market and the currency risk factor suggest a nonlinear relationship between currency returns and the market portfolio.

In the time series, we document predictability in portfolios of currency excess returns that is even stronger than the predictability of individual currency excess returns revealed by uncovered interest rate parity tests. Both financial and macroeconomic variables predict portfolio excess returns. The average forward discount rate on all the portfolios is a better predictor than the forward discounts associated with individual portfolios. Expected excess returns on portfolios with medium to high interest rates, built with the average or the portfolio-specific forward discount, comove strongly with the US business cycle as measured by industrial production or payroll help wanted indices, the term or default premia or the option-implied volatility index (VIX). The single best predictor other than the forward discount is the change in US industrial production. At the 12-month horizon, a one percentage point decrease in industrial production raises foreign currency excess returns by 100 to 200 basis points. US industrial production forecasts currency returns with 20 to 40 percent accuracy at annual horizon. Moreover, expected returns on the highest interest rate portfolios respond strongly to increases in US stock market uncertainty as measured by the option-implied volatility index VIX. Since forecasted excess returns on high interest rate portfolios are strongly counter-cyclical and increase in times of crisis, this evidence is consistent with the view that trading strategies in currency markets earn average returns in compensation for exposure to macroeconomic risk.

We formalize the economic intuition behind our empirical results using a simple stylized model of exchange rates. We posit a simple exogenous process for the stochastic discount factors (marginal utility) of investors in different countries with imperfect international risk-sharing. This reduced-form SDF is broadly consistent with a number of equilibrium asset pricing models that feature time varying price of aggregate risk. We simulate the model and show that it is able to replicate qualitatively the main features of our currency portfolios, including the spread in average returns and Sharpe ratios, as well as the loadings on a common pricing factor.

The literature on currency excess returns that derive from the failure of the uncovered interest parity can broadly be divided into two different segments. The first strand of the literature aims to understand exchange rate predictability within a standard asset pricing framework based on systematic risk. This segment includes recent papers by Backus, Foresi and Telmer (2001), Harvey, Solnik and Zhou (2002), Alvarez, Atkeson and Kehoe (2005), Verdelhan (2005), Campbell, de Medeiros and Viceira (2006), Lustig and Verdelhan (2007), Graveline (2006), Bansal and Shaliastovich (2007), Brennan and Xia (2006), Farhi and Gabaix (2007) and Hau and Rey (2007).[2] The second strand looks for non-risk-based explanations. This segment includes papers by Froot and Thaler (1990), Lyons (2001), Gourinchas and Tornell (2004), Bacchetta and van Wincoop (2006), Frankel and Poonawala (2007), Sarno, Leon and Valente (2006), Plantin and Shin (2007), Burnside, Eichenbaum, Kleshchelski and Rebelo (2006), Burnside, Eichenbaum and Rebelo (2007a) and Burnside, Eichenbaum and Rebelo (2007b).

Our paper is organized as follows. We start by describing the data, how we build currency portfolios and the main characteristics of these portfolios in section 1. Section 2 shows that a single factor, HML_{FX}, explains most of the cross-sectional variation in foreign currency excess returns. Section 3 describes the time variation in excess returns that investors demand on these currency portfolios. Section 4 relates HML_{FX} to stock market returns and currency volatilities.

[2] Earlier work includes Hansen and Hodrick (1980), Fama (1984), Bekaert and Hodrick (1992), Bekaert (1995), Bekaert (1996).

Section 5 presents a simple stylized model that rationalizes our findings. Section 6 concludes.

1 Currency Portfolios and Risk Factors

We focus on investments in forward and spot currency markets. Compared to Treasury Bill markets, forward currency markets only exist for a limited set of currencies and shorter time-periods. However, forward currency markets offer two distinct advantages. First, the carry trade is easy to implement in these markets, and the data on bid-ask spreads for forward currency markets are readily available. This is not the case for most foreign fixed income markets. Second, these forward contracts are not subject to default risk, and counterparty risk is minimal. This section presents moments of monthly foreign currency excess returns from the perspective of a US investor. We consider currency portfolios that include developed and emerging countries for which forward contracts exist. We find that currency markets offer Sharpe ratios comparable to the ones measured on equity markets, even after controlling for bid-ask spreads. In a separate appendix available on our websites, we report several robustness checks considering only developed countries, non-US investors, and longer investment horizons.

1.1 Building Currency Portfolios

We start by setting up some notation. Then, we describe our portfolio building technology, and we conclude by giving a summary of the currency portfolio returns.

Currency Excess Returns We use s to denote the log of the spot exchange rate in units of foreign currency per US dollar, and f for the log of the forward exchange rate, also in units of foreign currency per US dollar. An increase in s means an appreciation of the home currency. The log excess return rx on buying a foreign currency in the forward market and then selling it in the spot market after one month is simply:

$$rx_{t+1} = f_t - s_{t+1}.$$

This excess return can also be stated as the log forward discount minus the change in the spot rate: $rx_{t+1} = f_t - s_t - \Delta s_{t+1}$. In normal conditions, forward rates satisfy the covered interest rate parity condition; the forward discount is equal to the interest rate differential: $f_t - s_t \approx i_t^\star - i_t$, where $i^\star$ and i denote the foreign and domestic nominal risk-free rates over the maturity of the contract. Hence, the log currency excess return approximately equals the interest rate differential less the rate of depreciation:

$$rx_{t+1} \approx i_t^\star - i_t - \Delta s_{t+1}.$$

Transaction Costs Since we have bid-ask quotes for spot and forward contracts, we can compute the investor's actual realized excess return net of transaction costs. The *net* log currency excess returns for an investor who goes long in foreign currency is:

$$rx^{l}_{t+1} = f^{b}_{t} - s^{a}_{t+1}.$$

The investor buys the foreign currency or equivalently sells the dollar forward at the bid price (f^b) in period t, and he sells the foreign currency or equivalently buys dollars at the ask price (s^a_{t+1}) in the spot market in period $t+1$. Similarly, for an investor who is long in the dollar (and thus short the foreign currency), the net log currency excess return is given by:

$$rx^{s}_{t+1} = -f^{a}_{t} + s^{b}_{t+1}.$$

Data We start from daily spot and forward exchange rates in US dollars. We build end-of-month series from November 1983 to August 2007.[3] These data are collected by Barclays and Reuters and available on Datastream. Our main data set contains 37 currencies: Australia, Austria, Belgium, Canada, Hong Kong, Czech Republic, Denmark, Euro area, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Kuwait, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, United Kingdom. Some of these currencies have pegged their exchange rate partly or completely to the US dollar over the course of the sample. We keep them in our sample because forward contracts were easily accessible to investors. We leave out Turkey and United Arab Emirates, even if we have data for these countries, because their forward rates appear disconnected from their spot rates. The currency portfolios excess returns are available on our websites.

As robustness checks, we also report results obtained on a smaller data set that contains only 15 developed countries: Australia, Belgium, Canada, Denmark, Euro area, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland and United Kingdom. In a separate appendix, we also report results obtained on smaller or large datasets that match previous published results. We use mostly one-month currency excess returns built using one-month forward contracts. Yet, forward contracts are easily available at longer maturities of 2, 3, 6 and 12 months. We present additional evidence on currency portfolios of longer horizons both in the text and in our separate appendix.

Currency Portfolios At the end of each period t, we allocate all currencies in the sample to six portfolios on the basis of their forward discounts $f-s$ observed at the end of period t. Portfolios are

[3]When the last day of the month is Saturday or Sunday, we use the next business day.

re-balanced at the end of every month. They are ranked from low to high interests rates; portfolio 1 contains the currencies with the lowest interest rate or smallest forward discounts, and portfolio 6 contains the currencies with the highest interest rates or largest forward discounts. We compute the log currency excess return rx^j_{t+1} for portfolio j by taking the average of the log currency excess returns in each portfolio j. We assume that investors simply *short* the foreign currencies in the *first* portfolio and go *long* in all the other foreign currencies.

The total number of currencies in our portfolios varies over time. We have a total of 9 countries at the beginning of the sample in 1983 and 26 at the end in 2007. We only include currencies for which we have forward and spot rates in the current and subsequent period. The maximum number of currencies attained during the sample is 34; the launch of the euro accounts for the subsequent decrease in the number of currencies. The average number of portfolio switches per month is 5.97 for portfolios sorted on one-month forward rates. We define the average frequency as the time-average of the following ratio: the number of portfolio switches divided by the total number of currencies at each date. The average frequency is 29.30 percent, implying that currencies switch portfolios roughly every three months. When we break it down by portfolio, we get the following frequency of portfolio switches (in percentage points): 19.9 for the 1st, 33.8 for the 2nd, 40.7 for the 3rd, 43.6 for the 4th, 42.1 for the 5th, and 13.4 for the 6th. Overall, there is quite some variation in the composition of these portfolios, but there is more persistence in the composition of the corner portfolios. To illustrate this, figure 3 plots the forward discount and the portfolio to which the currency is allocated. We report the examples of the Japanese yen (¥) in the top panel and the UK pound (*£*) in the bottom panel. The yen starts off in the fourth portfolio early on in the sample, then gradually ends up in the first portfolio as Japanese interest rates fall in the late eighties and it briefly climbs back up to the sixth portfolio in the early nineties. The yen stays in the first portfolio for the remainder of the sample. The pound's experience (bottom panel) is quite different. Overall, it is subject to shorter spells in the medium to high interest rate portfolios.

[Figure 3 about here.]

1.2 Returns to Currency Speculation for a US investor

Table 1 provides an overview of the properties of the six currency portfolios from the perspective of a US investor. For each portfolio j, we report average changes in the spot rate Δs^j, the forward discounts $f^j - s^j$, the log currency excess returns $rx^j = -\Delta s^j + f^j - s^j$, and the log currency excess returns net of bid-ask spreads rx^j_{net}. Finally, we also report log currency excess returns on carry trades or high-minus-low investment strategies that go long in portfolio $j = 2, 3 \ldots, 6$, and short in the first portfolio: $rx^j_{net} - rx^1_{net}$. All exchange rates and returns are reported in US dollars and the moments of returns are annualized: we multiply the mean of the monthly data by 12 and the standard deviation by $\sqrt{12}$. The Sharpe ratio is the ratio of the annualized mean to the annualized standard deviation.

The first panel reports the average rate of depreciation for all currencies in portfolio j. According to the standard uncovered interest rate parity (UIP) condition, the average rate of depreciation $E_T(\Delta s^j)$ of currencies in portfolio j should equal the average forward discount on these currencies $E_T(f^j - s^j)$, reported in the second panel. Instead, currencies in the first portfolio trade at an average forward discount of -390 basis points, but they appreciate on average only by 61 basis points over this sample. This adds up to a log currency excess return of minus 330 basis points on average, which is reported in the third panel. Currencies in the last portfolio trade at an average discount of 788 basis points but they depreciate only by 211 basis points on average. This adds up to a log currency excess return of 577 basis points on average. These results are not surprising. A large body of empirical work starting with Hansen and Hodrick (1980) and Fama (1984) reports violations of the UIP condition.[4]

The fourth panel reports average log currency excess returns net of transaction costs. Since we rebalance portfolios monthly, and transaction costs are incurred each month, these estimates of net returns to currency speculation (rx_{net}) are conservative. After taking into account bid-ask spreads, the average return on the first portfolio drops to minus 206 basis points. Note that the first column reports *minus* the actual log excess return for the first portfolio, because the investor is short in these currencies. The corresponding Sharpe ratio on this first portfolio is minus 25 percent. The return on the sixth portfolio drops to 296 basis points. The corresponding Sharpe ratio on the last portfolio is 0.32.

The fifth panel reports returns on zero-cost strategies that go long in the high interest rate portfolios and short in the low interest rate portfolio. The spread between the net returns on the first and the last portfolio is 502 basis points. This high-minus-low strategy delivers a Sharpe ratio of 0.56. Equity returns provide a natural benchmark. Over the same sample, the (annualized) monthly log excess return on equity, computed using the value-weighted CRSP index on NYSE, NASDQ and AMEX and the Fama risk-free rate, is 6.85 percent and the equity Sharpe ratio is 0.49. Note that this equity return does *not* reflect any transaction costs.

[Table 1 about here.]

[4] Hodrick (1987) and Lewis (1995) provide extensive surveys and updated regression results. UIP appears to be a reasonable description of the data only in four cases. First, Bansal and Dahlquist (2000) show that UIP is not rejected at high inflation levels, and likewise Huisman, Koedijk, Kool and Nissen (1998) find that UIP holds for very large forward premia. Second, Chaboud and Wright (2005) show that UIP is valid at very short horizons but is rejected for horizons above a few hours. Third, Meredith and Chinn (2005) find that UIP cannot be rejected at horizons above 5 years. Finally, Lothian and Wu (2005) find positive UIP slope coefficients for France/UK and US/UK exchange rates on annual data over 1800-1999, because of the 1914-1949 sub-sample. Engel (1996) and Chinn (2006) provide recent surveys of the UIP tests. Such UIP regressions suffer from small sample bias and persistence in the right hand side variables, but Liu and Maynard (2005) and Maynard (2006) show that these biases can only explain a small part of the results.

We have documented that a US investor with access to forward currency markets can realize large excess returns with annualized Sharpe ratios that are comparable to those in the US stock market. Table 1 reports results obtained on a smaller sample of developed countries. The Sharpe ratio on a long-short strategy is 0.43. We conduct three other robustness checks. We show that large currency excess returns obtain after accounting for bid-ask spreads even when (i) we restrict our sample to even fewer developed countries, (ii) we take the perspective of different foreign investors, and (iii) we consider longer investment horizons. To save space, we report these results in a separate appendix, available on our websites. There is no evidence that time-varying bid-ask spreads can account for the failure of UIP in these data or that currency excess returns are small in developed countries, as suggested by Burnside et al. (2006). We turn now to cross-sectional asset pricing tests on these currency portfolios.

2 Common Factors in Currency Returns

We show that the sizeable currency excess returns described in the previous section are matched by covariances with risk factors. The riskiness of different currencies can be fully understood in terms of two currency factors that are essentially the first two principal components of the portfolio returns. All portfolios load equivalently on the first factor, which is the average currency excess return. We label it the *dollar risk factor*. The second principal component, which is the difference in returns between the low and high interest rate currencies, explains a large share of the cross-section. We refer to this component as the *carry risk factor*. The risk premium on any currency is determined by the dollar risk premium and the carry risk premium. The carry risk premium depends on which portfolio a currency belongs to, i.e. whether the currency has high or low interest rates, but the dollar risk premium does not. To show that a currency's interest rate relative to that of other currencies truly measures its exposure to carry risk, we also rank all the currencies into portfolios based on their carry-betas, and we recover a similar pattern in the forward discounts and in the excess returns. These results also hold for sub-samples of developed countries, foreign investors and longer investment horizons as reported in a separate appendix. We detail below our methodology and our results.

2.1 Methodology

A principal component analysis on our currency portfolios reveals that two factors explain more than 80 percent of the variation in returns on these six portfolios.[5] The first principal component is indistinguishable from the average portfolio return. The second principal component is essentially the difference between the return on the sixth portfolio and the return on the first portfolio. As a

[5]Table 23 in the separate appendix reports the principal component coefficients.

consequence, we consider two risk factors: the average currency excess return, denoted RX_{FX}, and the difference between the return on the last portfolio and the one on the first portfolio, denoted HML_{FX}. The correlation of the first principal component with RX_{FX} is .99. The correlation of the second principal component with HML_{FX} is .94. Both factors are computed from net returns, after taking into account bid-ask spreads.

These currency risk factors have a natural interpretation. HML_{FX} is the return in dollars on a zero-cost strategy that goes long in the highest interest rate currencies and short in the lowest interest rate currencies. This is the portfolio return of a US investor engaged in the usual currency carry trade. Hence, this is a natural candidate currency risk factor, and, as we are about to show, it explains much of the cross-sectional variation in average excess returns. RX_{FX} is the average portfolio return of a US investor who buys all foreign currencies available in the forward market. This second factor is essentially the currency "market" return in dollars available to an US investor.

Cross-sectional Asset Pricing We use Rx^j_{t+1} to denote the average excess return on portfolio j in period $t+1$.[6] In the absence of arbitrage opportunities, this excess return has a zero price and satisfies the following Euler equation:

$$E_t[M_{t+1}Rx^j_{t+1}] = 0.$$

We assume that the stochastic discount M is linear in the pricing factors f:

$$M_{t+1} = 1 - b(f_{t+1} - \mu),$$

where b is the vector of factor loadings and μ denotes the factor means. This linear factor model implies a beta pricing model: the expected excess return is equal to the factor price λ times the beta of each portfolio β^j:

$$E[Rx^j] = \lambda' \beta^j,$$

where $\lambda = \Sigma_{ff} b$, $\Sigma_{ff} = E(f_t - \mu_f)(f_t - \mu_f)'$ is the variance-covariance matrix of the factor, and β^j denotes the regression coefficients of the return Rx^j on the factors.[7] To estimate the factor prices λ and the portfolio betas β, we use two different procedures: a Generalized Method of Moments estimation (GMM) applied to linear factor models, following Hansen (1982), and a 2-stage OLS estimation following Fama and MacBeth (1973) (henceforth FMB). We now briefly describe these

[6] All asset pricing tests are run on excess returns and not log excess returns.

[7] The Euler equation $E[MRx^j] = E[Rx^j - b(f-\mu)Rx^j] = 0$ implies that:

$$E[Rx^j] = \Sigma_{ff} b \frac{E[(f-\mu)Rx^j]}{\Sigma_{ff}}.$$

two techniques, starting with GMM.

GMM The moment conditions are the sample analog of the population pricing errors:

$$g_T(b) = E_T(M_t Rx_t) = E_T(Rx_t) - E_T(Rx_t f_t')b,$$

where $Rx_t = [Rx_t^1 \; Rx_t^2 \; .. \; Rx_t^N]'$ bunches all N currency portfolios. In the first stage of the GMM estimation, we use the identity matrix as the weighting matrix, while in the second stage we use the inverse of the spectral density S matrix of the pricing errors in the first stage: $S = \sum_{-\infty}^{\infty} E[(M_t Rx_t)(M_{t-j} Rx_{t-j})']$.[8] We use demeaned factors in both stages. Since we focus on linear factor models, the first stage is equivalent to an OLS-cross-sectional regression of average returns on the second moment of returns and factors. The second stage is a GLS cross-sectional regression of average excess returns on the second moment of returns and factors.

FMB In the first stage of the FMB procedure, for each portfolio j, we run a time-series regression of the currency returns Rx_{t+1}^j on a constant and the factors f_t, in order to estimate β^j. The only difference with the first stage of the GMM procedure stems from the presence of a constant in the regressions. In the second stage, we run a cross-sectional regression of the average excess returns $E_T[Rx_t^j]$ on the betas that were estimated in the first stage, to estimate the factor prices λ. The first stage GMM estimates and the FMB point estimates are identical, because we do *not* include a constant in the second step of the FMB procedure. Finally, we can back out the factor loadings b from the factor prices and covariance matrix of the factors.

2.2 Results

Table 2 reports the asset pricing results obtained using GMM and FMB on six currency portfolios sorted on forward discounts. The left hand side of the table corresponds to our large sample of developed and emerging countries, while the right hand side focuses on developed countries. We describe first results obtained on our large sample.

[Table 2 about here.]

Market Prices of Risk The top panel of the table reports estimates of the market prices of risk λ and the SDF factor loadings b, the adjusted R^2, the square-root of mean-squared errors $RMSE$ and the p-values of χ^2 tests (in percentage points). The market price of HML_{FX} risk is 570 basis points *per annum*. This means that an asset with a beta of one earns a risk premium

[8] We use a Newey and West (1987) approximation of the spectral density matrix. The optimal number of lags is determined using Andrews (1991)'s criterion with a maximum of 6 lags.

of 5.70 percent per annum. Since the factors are returns, no arbitrage implies that the risk prices of these factors should equal their average excess returns. This condition stems from the fact that the Euler equation applies to the risk factor itself, which clearly has a regression coefficient β of one on itself. In our estimation, this no arbitrage condition is satisfied. The average excess return on the high-minus-low strategy (last row in Table 2) is 556 basis points.[9] So the estimated risk price is only 14 basis points removed from the point estimate implied by the theory. The GMM standard error of the risk price is 238 basis points. The FMB standard error is 187 basis points. In both cases, the risk price is more than 2.5 standard errors from zero.

The second risk factor RX_{FX}, the average currency excess return, has an estimated risk price of 102 basis points, compared to a sample mean for the factor of 103 basis points. This is not surprising, because all the portfolios have a beta of close to one with respect to this second factor. As a result, the second factor explains none of the cross-sectional variation in portfolio returns, and the standard errors on the risk price estimates are large: for example, the GMM standard error is 170 basis points. Overall, asset pricing errors are small. The RMSE is around 96 basis points and the adjusted R^2 is 70 percent. The null that the pricing errors are zero cannot be rejected, regardless of the estimation procedure.

Figure 4 plots predicted against realized excess returns for all six currency portfolios. Clearly, the model's predicted excess returns are consistent with the average excess returns. Note that the predicted excess return is here simply the OLS estimate of the betas times the sample mean of the factors, not the estimated prices of risk, which would imply an even better fit.

These results are robust. They hold true in a smaller sample of developed countries, as shown in the right-hand side of Table 2. In a separate appendix, we report precise estimates of the corresponding foreign prices of risk estimated on portfolios built from the perspective of foreign investors.

Alphas in the Carry Trade? The bottom panel of Table 2 reports the constants (denoted α^j) and the slope coefficients (denoted β^j) obtained by running time-series regressions of each portfolio's currency excess returns Rx^j on a constant and risk factors. The returns and α's are in percentage points per annum. The first column reports estimates for α's. The fourth portfolio has a large α of 156 basis points per annum, but is not statistically significant at the 5 percent level. The other α estimates are smaller than 50 basis points. These are not significantly different from zero. The null that all the α's are zero cannot be rejected. The p-value of the χ^2 statistic (reported on the last row) is 34 percent.

The second column of the same panel reports the estimated β's for the HML_{FX} factor. These β's increase monotonically from -.40 for the first portfolio to .60 for the last currency portfolio,

[9] Note that this value differs slightly from the previously reported mean excess return because we use excess returns in *levels* in the asset pricing exercise, but table 1 reports *log* excess returns.

and they are estimated very precisely. The first three portfolios have betas that are negative and significantly different from zero. The last two have betas that are positive and significantly different from zero. The third column shows that betas for the second factor are essentially all equal to one. Obviously, this second factor does not explain any of the variation in average excess returns across portfolios, but it helps to explain the average level of excess returns. This is consistent with factor pricing: the intertemporal APT of Connor and Korajczyk (1989) predicts that one of the factors has betas equal to one for all assets. Again, these results are robust and comparable to the ones obtained on a sample of developed countries (reported on the right hand side of the table).

[Figure 4 about here.]

2.3 Sorting on HML_{FX} exposure

To show that the ranking of forward discounts really does measure a currency's exposure to the risk factor, we build portfolios based on each currency's exposure to aggregate currency risk as measured by HML_{FX}. For each date t, we first regress each currency i log excess return rx^i on a constant and HML_{FX} using a 36-month rolling window that ends in period $t-1$. This gives us currency i's exposure to HML_{FX}, and we denote it $\beta_t^{i,HML_{FX}}$. Note that it only uses information available at date t. We then sort currencies into six groups at time t based on these slope coefficients $\beta_t^{HML_{FX}}$. Portfolio 1 contains currencies with the lowest β's. Portfolio 6 contains currencies with the highest β's. Table 3 reports summary statistics on these portfolios. We do not take into account bid-ask spreads here, because it is not obvious a priori when the investor wants to go long or short. The first panel reports average changes in exchange rates. The second panel shows that average forward discounts increase monotonically in our portfolios. Thus, sorts based on forward discounts and sorts based on betas are clearly related, which implies that the forward discounts convey information about riskiness of individual currencies. The third panel reports the average log excess returns. They are monotonically increasing from the first to the last portfolio. Clearly, currencies that covary more with our risk factor - and are thus riskier - provide higher excess returns. This finding is quite robust. When we estimate betas using a 12-month rolling window, we also obtain a 300 basis point spread between the first and the last portfolio.

[Table 3 about here.]

2.4 Foreign Equity

We conclude our discussion of cross-sectional asset pricing by showing that our risk factors can shed some light on risk premia above and beyond currency excess returns. US risk factors do not account for the cross-sectional variation in dollar returns on foreign equity portfolios, but our currency risk factors explain part of this phenomenon. To illustrate this, we construct six foreign equity portfolios using the same sorting procedure based on forward discounts. We use MSCI market indices for all countries in our sample. The US dollar excess returns on these portfolios increase from 9.7 percent to 13.9 percent on the fifth portfolio. The last portfolio has a much lower excess return of 7.6 percent, because of very low returns in the stock market in some of these countries over this sample period.

3 Return Predictability in Currency Markets

The vast literature on the UIP condition considers country-by-country regressions of changes in exchange rates on forward discounts. Because the UIP condition fails in the data, forward discounts predict currency excess returns. In this section, we investigate return predictability using our currency portfolios. We first consider each portfolio separately. We show that the average forward discount across portfolios does a better job of describing the time variation in expected currency excess returns than the individual portfolio forward discounts. We build expected excess returns using either portfolio-specific or average forward discounts. We find that these expected excess returns are closely tied to the US business cycle: expected currency returns increase in downturns and decrease in expansions, as is the case in stock markets and bond markets. We then turn to portfolio spreads, going long in high interest rate currencies and short in the lowest interest rate currencies. We show that these spreads are predictable, and the corresponding expected excess returns are linked to higher frequency variation in global credit spreads and global market volatility.

3.1 Predictability in Portfolio Excess Returns

Individual Forward Discounts For each portfolio j, we run a time series regression of each portfolio's average log currency excess returns on each portfolio's average log forward discounts:

$$rx^j_{t+1} = \gamma^j_0 + \gamma^j_f(f^j_t - s^j_t) + \eta^j_t.$$

If UIP was an accurate description of the data, there would be no predictability in currency excess returns, and the slope coefficient γ_f would be zero. Table 4 reports regression results in two panels for all the currency portfolios. The left panel reports results obtained on returns without accounting for bid-ask spreads (rx^j_{t+1}), while the right panel reports results on net returns ($rx^j_{net,t+1}$). We start by discussing the results in the left panel for gross returns.

The portfolio forward discount accounts for between 1.8 percent and 6.4 percent of the monthly variation in excess returns on these currency portfolios. There is strong evidence against UIP in these portfolio returns, more so than in individual currency returns. Looking across portfolios, from low to high interest rates, the slope coefficient γ_f^j (column 3) varies a lot: it increases from 108 basis points for currencies in the first portfolio to 357 basis points for currencies in the fourth portfolio. The slope coefficient decreases to 72 basis points for the sixth portfolio. The deviations from UIP are highest for currencies with medium to high forward discounts. However, the forward rates are strongly autocorrelated. This complicates statistical inference about these slope coefficients. To deal with this issue, we use two asymptotically valid corrections. The Newey-West standard errors (NW) were computed with the optimal number of lags following Andrews (1991). The Hansen-Hodrick standard errors (HH) are computed with one lag. Both of these methods correct for arbitrary error correlation and conditional heteroscedasticity. Bekaert, Hodrick and Marshall (1997) note that the small sample performance of these test statistics is also a source of concern. To address this problem, we also report small sample standard errors. These were generated by bootstrapping 10.000 samples of returns and forward discounts from a bivariate VAR with one lag. The null of no predictability is rejected at the 1 percent significance level for all of these portfolios except for the third.

Since the log excess returns are the difference between changes in spot rates at $t+1$ and forward discounts at t, these are predictability regressions for spot changes in exchange rates.[10] At the one-month horizon, the R^2 on these predictability regressions varies between 1.8 and 6.36 percent. In other words, when considering currency portfolios, up to 6 percent of the variation in spot rates is predictable at a one-month horizon.

Average Forward Discount There is even more predictability in these excess returns than the standard UIP regressions reveal, because the forward discounts on the other currency portfolios also help to forecast returns. We found that a single return forecasting variable describes time variation in the dollar risk premium even better than the forward discount rates on the individual currency portfolios. This variable is the average of all the forward discounts across portfolios. We use ι to denote the 6×1 vector with all elements equal to 1/6. For each portfolio j, we run the following regression of log excess returns on the average forward rates:

$$rx^j_{net,t+1} = \gamma_0^j + \gamma_{\mathbf{f}}^j \iota'(\mathbf{f}_t - \mathbf{s}_t) + \eta_t^j,$$

where $\mathbf{f}_t - \mathbf{s}_t$ bunches together all forward discounts. A summary of the results is reported in columns 3 and 4 of Table 4. This single factor explains between 3.0 and 8.3 percent of the variation in returns at the one-month horizon. The average forward discount outperforms the

[10]From γ_f^j, the slope coefficient in the return predictability regression, we can back out the implied slope coefficients δ_f in the standard UIP regression:

$$-\Delta s^j_{t+1} = \delta_0^j + \delta_f^j (f_t^j - s_t^j) + \eta_t^j,$$

where $\delta_f = 1 - \gamma_f$. For example, the implied UIP coefficient on the fourth portfolio is -2.6: each 100 basis point increase in the forward discount reduces the expected appreciation of the foreign currency by 260 basis points.

portfolio-specific forward discounts, except in portfolios 3 and 4. In this case, slope coefficients vary less across the different portfolios.

Bid-ask spreads Next, we turn to the predictability of the net returns in Table 4. Comparing the coefficient estimates in column 1 and 3 reveals that time variation in bid-ask spreads absorbs only a small fraction of the time variation in expected returns. For example, a 100 basis point increase in the average forward discount on the fourth portfolio raises the net expected excess return by 336 basis points, compared to 357 basis points for the gross expected excess return. Clearly, time variation in the bid-ask spread does not eliminate the predictability of realized excess returns in currency markets.

[Table 4 about here.]

Longer Horizons At longer horizons, the fraction of changes in log spot rates explained by the forward discount is even greater than at short horizons. We use k-month maturity forward contracts to compute k-period horizon returns (where $k = 1,\ 2,\ 3,\ 6,\ 12.$). The log excess return on the k-month contract is:

$$rx^k_{t+k} = -\Delta s_{t \to t+k} + f^k_t - s_t.$$

Then we sort the currencies into portfolios based on forward rates with the corresponding maturity. Table 5 provides a summary of the results: it lists the R^2 we obtained for each portfolio (rows) and for each forecasting horizon (columns). We only consider the corner portfolios.

At longer horizons, the returns on the first portfolio are most predictable; the returns on the last portfolio are least predictable. On the first portfolio, more than a quarter of the variation in excess returns is accounted for by the forward rate at the 12-month horizon. On the last portfolio, 11 percent is accounted for by the forward rate. One concern is that these measures of fit may be biased because we use overlapping returns and because the predictors are highly autocorrelated. In the bottom panel of Table 5 we also provide the same R^2 measures that we obtained for each forecasting horizon with non-overlapping data. To produce these measures, we simply used the first month of every period (quarter, year) to run the same regressions. Though there are some differences, these R^2's are not systematically lower. Even at longer horizons, the average forward discount seems to do a better job in describing the variation in expected excess returns. This single factor explains between 19 and 36 percent of the variation at the one-year horizon. This single factor mostly does as well and sometimes better than the forward discount of the specific portfolio in forecasting excess returns over the entire period.

Some developing countries like Saudi Arabia and Hong Kong have pegged their exchange rate to the dollar. This naturally inflates the predictability of currency returns. In the bottom panel of Table 5, we report the predictability results that we obtained on our smaller sample of developed countries. The R^2 are lower than those we reported in the top panel of Table 5, but that is mainly because there is more idiosyncratic variation in these returns, as the portfolios are composed of fewer currencies.

[Table 5 about here.]

In a separate appendix, we take a closer look at these forecasting regressions and study the significance of each predictor at longer horizons. We use Newey-West, Hansen-Hodrick, non-overlapping data and bootstrapping techniques to compute standard errors. With the largest standard errors, the average forward discount remains a significant predictor, but the portfolio-specific forward discount does not. As a result, we conclude that the average forward discount contains additional information that is useful for forecasting excess returns on all currency portfolios, while little information is lost by aggregating all these forward discounts into a single predictor. The fact that the average forward discount is a *better predictor* of future excess returns on foreign currency than individual forward discount rates is consistent with the risk premium view: by using the average forward discount, we throw away all information related to inflation in a particular currency and we do better in predicting future changes in exchange rates! In fact, if we take the residuals of the average forward discount forecasting regression and we project these on the individual portfolio forward discounts, there is no predictability left.[11] This finding is similar to results of Stambaugh (1988) and Cochrane and Piazzesi (2005) for the term structure of interest rates. These studies show that linear combinations of forward rates outperform the forward rate of a particular maturity in forcasting bond returns. In particular, Cochrane and Piazzesi (2005) report R^2's of up to 40 percent on one-year holding period returns for zero coupon bonds using a single forecasting factor. Currency returns are *more predictable* than stock returns, and almost as predictable as bond returns.

Counter-Cyclical Dollar Risk Premium Clearly, our predictability results imply that expected excess returns on currency portfolios vary over time. We now show that this time variation has a large US business cycle component: the expected excess returns go up in US recessions and they go down in US expansions. The same counter-cyclical behavior has been documented for bond and stock excess returns.

We use $\widehat{E}_t rx^j_{t+1}$ to denote the forecast of the one-month-ahead excess return based on the forward discount:

$$\widehat{E}_t rx^j_{t+1} = \gamma^j_0 + \gamma^j_f (f^j_t - s^j_t).$$

At high frequencies, forecasted returns on high interest rate currency portfolios – especially for the sixth portfolio – increase very strongly in response to events like the Asian crisis in 1997

[11] In Table 25 in the separate appendix, we report the R^2's of these regressions. There is no information in the individual forward discounts left that helps to forecast currency returns.

and the LTCM crisis in 1998, but at lower frequencies, a big fraction of the variation in forecasted excess returns is driven by the US business cycle, especially for the third, fourth and fifth portfolios. To assess the cyclicality of these forecasted excess returns, we use three standard business cycle indicators and three financial variables: (i) the 12-month percentage change in US industrial production index, (ii) the 12-month percentage change in total US non-farm payroll index, (iii) the 12-month percentage change in the Help Wanted index, (iv) the default spread – the difference between the 20-Year Government Bond Yield and the $S\&P$ 15-year BBB Utility Bond Yield – (v) the slope of the yield curve – the difference between the 5-year and the 1-year zero coupon yield, and (vi) the $S\&P$ 500 VIX volatility index.[12] Macroeconomic variables are often revised. To check that our results are robust to real-time data, we use vintage series of the payroll and industrial production indices from the Federal Reserve Bank of Saint Louis. The results are very similar to the ones reported in this paper.

[Table 6 about here.]

Table 6 reports the contemporaneous correlation of the month-ahead forecasted excess returns with these macroeconomic and financial variables. As expected, forecasted excess returns for high interest rate portfolios are strongly counter-cyclical.

On the one hand, the monthly contemporaneous correlation between predicted excess returns and percentage changes in industrial production (first column), the non-farm payroll (second column) and the help wanted index (third column) are negative for all portfolios except the first one. For payroll changes, the correlations range from -.71 for the second portfolio to -.10. for the sixth. Figure 5 plots the forecasted excess return on portfolio 2 against the 12-month change in US industrial production. Vertical lines identify NBER recession dates. In our sample, NBER recessions cover the months of July 1990 to March 1991 and March 2001 to November 2001. Forecasted excess returns on the other portfolios have similar low frequency dynamics, but in the case of portfolios 5 and 6, they also respond to other events, like the Russian default and LTCM crisis, the Asian currency crisis and the Argentine default.

[Figure 5 about here.]

On the other hand, monthly correlations of the high interest rate currency portfolio with the default spread (fourth column) and the term spread (fifth column) are, as expected, positive. Finally, the last column reports correlations with the implied volatility index. These correlations

[12] Industrial production data are from the IMF International Financial Statistics. The payroll index is from the BEA. The Help Wanted Index is from the Conference Board. Zero coupon yields are computed from the Fama-Bliss series available from CRSP. These can be downloaded from `http://wrds.wharton.upenn.edu`. Payroll data can be downloaded from `http://www.bea.gov`. The VIX index, the corporate bond yield and the 20-year government bond yield are from `http://www.globalfinancialdata.com`.

reveal a clear difference between the low interest rate currencies with negative correlations, and the high interest rate currencies, with positive correlations. In times of heightened market uncertainty in US financial markets, there is a flight to quality: US investors demand a much higher risk premium for investing in high interest rate currencies, and they accept lower (or more negative) risk premia on low interest rate currencies.

Longer Horizons We find the same business cycle variation in expected returns over longer holding periods. The predictability is partly due to the countercyclical nature of the forward discount, but not entirely. Table 7 reports forecasting results for currency portfolios obtained using the 12-month change in industrial production and either the portfolio-specific forward discount or the average forward discount. Controlling for the forward discount reduces the IP slope coefficient by 50 basis points on portfolios 1-4, 20-30 basis points for portfolios 5-6, but the forward discount does not drive out the macroeconomic variable. The currency risk premium increase in response to a one percentage point drop in the growth rate of industrial production varies between 80 (portfolio 1) and 170 basis points (portfolio 5). The IP slope coefficients are still significantly different from zero for the high interest rate portfolios.

Table 7 also checks whether IP growth predicts future currency returns in our smaller sample of developed countries. The slope coefficients in the projection of 12-month future returns on industrial production growth are larger than those we found on the entire sample of currencies; the coefficient varies between 127 and 174 basis points, when we control for the individual portfolio discount, and between 109 and 212 basis points when we control for the average forward discount. There is evidence that industrial production growth drives out the forward discount as a predictor.

The strong response of currency excess returns to industrial production resembles results reported by Cooper and Priestley (2007) on stock market excess returns. Cooper and Priestley (2007) show that the output gap, defined using the deviation of industrial production from a trend, is a very robust predictor of excess returns on the stock market in all G-7 countries. This variable is highly correlated with the growth rate of industrial production in our sample.

[Table 7 about here.]

3.2 Predictability of Carry Trade Returns

This section focuses on the predictability of carry trade returns: the returns on a high-minus-low strategy that goes long in high interest rate currencies and short in low interest rate currencies. We run the following predictability regression of the one-month high-minus-low return $rx^j - rx^1$ on the spread in the one-month forward discount between the j-th and the first portfolio:

$$rx^j_{t+1} = \gamma_{sp,0} + \gamma_{sp,f}\left[(f^j_t - s^j_t) - (f^1_t - s^1_t)\right] + \eta^j_t.$$

There is some evidence that the high-minus-low returns are forecastable by the forward spreads, but the evidence is less strong than on individual portfolios. Table 8 reports predictability results for all spreads. Since the spread in forward discounts is much less persistent than the forward discount and there is no overlap in returns, there is less cause for concern about persistent regressor bias. Nonetheless, we also report NW, HH, and VAR-bootstrapped standard errors.

Table 27 in the separate appendix lists the correlations of expected excess returns with macroeconomic and financial variables. The carry trade risk premium is weakly countercyclical, especially for portfolios 2-5, but less so than the dollar risk premium. Not surprisingly, the carry trade risk premium is most significantly correlated with the credit spread and the volatility index (VIX). In fact, these two variables have some forecasting power for HML_{FX} returns, at least at the one-month horizon as shown in Table 28 in the separate appendix. These right-hand-side variables are less serially correlated than industrial production growth. The small sample test statistics do not allow for rejection of the null in most cases.

[Table 8 about here.]

3.3 Connecting Predictability to the Cross-section of Returns

We have shown that both currency excess returns and currency risk factors are predictable. We consider now the conditional Euler equation of a US investor. As explained by Hansen and Richard (1987), a simple conditional factor model can be turned into an unconditional factor model using all the variables z_t in the information set of the investor. The conditional Euler equation for portfolio j, $E_t\left[M_{t+1}R^j_{t+1}\right] = 1$, is then equivalent to the following unconditional condition:

$$E\left[M_{t+1}z_tR^j_{t+1}\right] = 1.$$

We can interpret this condition as an Euler equation applied to a managed portfolio $z_tR^j_{t+1}$. This managed portfolio corresponds to an investment strategy that goes long portfolio j when z_t is positive and short otherwise. We can also interpret it as an Euler equation on portfolio j when the risk factor is $M_{t+1}z_t$. In our estimation, we assume that one scaling variable z_t summarizes all the information set of the investor. We use the average forward discount as the scaling variable, because we know this variable predicts returns in currency markets. We scale both returns and risk factors as described in Cochrane (1996). As a result, we obtain twelve test assets: the original six portfolios and the same portfolios multiplied by the scaling variable. For the risk factors, we use the average currency return RX and HML_{FX}, and we add $HML_{FX,t+1}z_t$, where the conditioning variable z is the CBOE volatility index, VIX. Table 9 reports the results. We find that the implied market prices of risk associated with the carry trade factor vary significantly through time. They tend to increase in bad times, when the implied stock market volatility is high.

[Table 9 about here.]

We have documented in this section that returns in currency markets are highly predictable. The average forward discount rate accurately predicts up to 35 percent of the variation in annual excess returns. The time variation in expected returns has a clear business cycle pattern: US macroeconomic variables are powerful predictors of these returns, especially at longer holding periods, and expected currency returns are strongly counter-cyclical. We now turn to the properties of HML_{FX} in times of crisis.

4 HML_{FX}, CAPM and Flights-to-Quality

We have shown that a currency's expected excess return depends on its exposure to HML_{FX}: currency investments are HML_{FX} bets. A natural question is then: Why are currency investors rewarded for taking on these HML_{FX} bets? We do not claim to fully answer this question, but we offer here a tentative explanation: HML_{FX} proxies for time-varying stock market exposure, particularly acute in times of crisis and flight-to-quality. In this section, we report that the simple Capital Asset Pricing Model (CAPM) implies currency portfolio excess returns of the same sign as in the data, but of much smaller magnitudes. Market betas vary a lot through time, and are particularly high during episodes of global financial crises. This feature implies that our carry risk factor HML_{FX} is much more correlated with the stock market in times of crisis than in tranquil times. As a result, HML_{FX} captures a time-varying stock market exposure risk.

4.1 CAPM

We now run the same asset pricing experiment on the cross-section of currency excess returns using the US stock market excess return as the pricing factor, instead of the slope risk factor HML_{FX}. To measure the return on the market, we use the CRSP value-weighted return on the NYSE, AMEX and NASDAQ markets in excess of the one-month average Fama risk-free rate. The US stock market excess return and the level factor RX can explain 78 percent of the variation in returns. However, the estimated price of US market risk is 43 percent, while the actual annualized excess return on the market is only 7 percent over this sample. The risk price is 6 times too large. The CAPM betas are reported in Table 10. They vary from -.05 for the first portfolio to .07 for the last one. Low interest rate currencies provide a hedge, while high interest rate currencies expose US investors to more stock market risk. These betas increase almost monotonically from low to high interest rates, but they are too small to explain these excess returns. Therefore, the cross-sectional regression of currency returns on market betas implies market price of risk that far too high.

[Table 10 about here.]

4.2 Carry Risk and CAPM in Times of Crisis

The failure of the benchmark model may be due to time-variation in market betas and/or the market price of risk.[13] We now investigate both.

We first run the same asset pricing experiment using a conditioning variable as we did in the previous section. Table 9 reports results obtained on 12 test assets (the original 6 currency portfolios and the same ones multiplied by the lagged VIX index). Risk factors are the average return on the currency market RX, the value-weighted stock market excess return R^M and $R^M z$, which is R^M multiplied by the lagged value of the VIX index (scaled by its standard deviation). We find that the market price of risk increases significantly in bad times (when the stock market volatility index VIX is high). Taking into account such time-variation improves notably the fit of the CAPM, with an adjusted R^2 increasing from 67 to 92 percent on this set of 12 portfolios.

We now explore time-variation in market betas. There is some evidence that, in times of financial crisis, the CAPM market beta of the high-minus-low strategy in currency markets increases dramatically. We start by examining the recent sub-prime mortgage crisis, and we then consider other crisis episodes.

Table 11 reports the market betas of all the currency portfolios that we obtain on a 12-month (column 1), 6-month (column 3) and 3-month (column 5) window before 08/31/2007. To estimate the market betas, we use daily observations on monthly currency and stock market returns.[14] The NW standard error correction is computed with 20 lags. We estimate a market beta of HML_{FX} of up to 60 basis points. The estimated market betas increase monotonically as we move from low to high interest rate currency portfolios, as we would expect. Over this period, the estimated pricing errors α dropped to between 25 basis points and minus 20 basis points (compared to an unconditional pricing error $\alpha_{HML_{FX}}$ of more than 500 basis points). We report the α's in the bottom panel of Table 11.

[Table 11 about here.]

This is not an isolated event, as these results extend to other crises. In Table 12, we document similar increases in the US market beta of HML_{FX} during the LTCM-crisis (column 1), the Tequila crisis (column 4) and the Brazilian/Argentine crisis (column 7). Again, the market betas increase monotonically in the forward discount rates. For example, $\beta^m_{\tau,HML_{FX}}$ increases to 1.14 in

[13] As shown by Lewellen and Nagel (2006), if the covariance between the market price of risk and the market betas is positive for the high interest rate portfolios, this can account for the large and positive CAPM pricing error α on the high-minus-low strategy.

[14] For example, we compute market $\beta^m_{\tau,HML_{FX}}$'s of HML_{FX} over rolling 6-month windows with the following regressions on daily data:

$$HML_{FX,t} = \alpha_\tau + \beta^m_{\tau,HML_{FX}} R^m_t + \eta_t,$$

where $t \in [\tau, \tau - 128]$.

the run-up to the Russian default in 1998, implying that high interest rate currencies depreciate on average by 1.14 percent relative to low interest rate currencies when the stock market goes down by one percent. Low interest rate currencies provide a hedge against market risk while high interest rate currencies expose US investors to more market risk in times of crisis.[15] Whenever the US stock market falls, there is a *flight to quality* which puts downward pressure on high interest rate currencies and upward pressure on low interest rate currencies. Conversely, when the stock market recovers, high interest rate currencies appreciate. The fact that these high correlations between currency portfolio returns and US stock market returns are only present during specific episodes of high stock market volatility suggests that the payoffs to currency strategies are highly non-linear with respect to stock market returns. It is therefore not surprising that the CAPM fails to account for the average returns on these portfolios, since it is not an appropriate benchmark for assets with highly non-linear payoffs.

[Table 12 about here.]

5 Cross-sectional and Predictability Results on Simulated Data

In this section, we show that a simple stylized model rationalizes and links our cross-sectional asset pricing and predictability results. We first analyze the main features of the leading risk-based explanations of the forward premium puzzle, and building on these results, derive our toy model. We then reproduce on simulated data our cross-sectional asset pricing and predictability results

5.1 Model

Three types of models reproduce the forward premium puzzle: Verdelhan (2005) uses habit preferences a la Campbell and Cochrane (1999), Bansal and Shaliastovich (2007) build on the long run risk literature pioneered by Bansal and Yaron (2004), and Farhi and Gabaix (2007) augment the standard consumption-based model with disaster risk following Barro (2006). These three models have two similarities. First, a persistent variable drives the log stochastic discount factor (SDF): it is the log surplus-consumption ratio in the habit literature (defined as the percentage gap between habit and consumption), the time-varying mean of consumption growth in the long run risk

[15]In a separate appendix, we report time-varying market correlations over our entire sample. Market correlations exhibit enormous variation. In times of crisis and during US recessions, the difference in market correlation between high and low currencies increases significantly. During the Mexican, Asian, Russian and Argentine crisis, the correlation difference jumps up by 50 to 120 basis points.

case and the country resilience (that links each country's productivity to the world's one) in the disaster-based explanation. Second, the log SDF is heteroskedastic. Backus et al. (2001) show that this is a necessary condition for models with log-normals shocks to reproduce the forward premium puzzle. In the habit literature, consumption growth shocks are *iid* but the law of motion of the surplus-consumption is non-linear such that the log SDF is heteroskedastic. In the long-run risk literature, consumption growth shocks are assumed to be heteroskedastic. In the disaster-based case, the heteroskedasticity is embedded in the law of motion of the country's resilience.

In this section, we study a two-factor model that is not explicitly derived from these structural models. Our objective is to show how a standard factor model can replicate the cross-sectional asset pricing and time-series predictability results that we document in the data. Our model shares some features with the continuous-time models proposed by Frachot (1996), Backus et al. (2001) and Brennan and Xia (2006).

Two Factors We consider N countries. In each country i, the log SDF m^i is given by the following two-factor model:

$$-m^i_{t+1} = \lambda^i z^i_t + \sqrt{\gamma^i z^i_t} u^i_{t+1} + \tau^i z^w_t + \sqrt{\delta^i z^w_t} u^w_{t+1}.$$

There is a common global factor z^w_t and a country-specific factor z^i_t. The innovations u^i_{t+1} and u^w_{t+1} are $i.i.d$ gaussian, with zero mean and unit variance; u^w_{t+1} is a world shock, common across countries, while u^i_{t+1} is country-specific. The country-specific volatility component is governed by an AR(1) process:

$$z^i_{t+1} = (1-\phi^i)\theta^i + \phi^i z^i_t + \sigma^i \sqrt{z^i_t} v^i_{t+1},$$

where the innovations v^i_{t+1} are uncorrelated across countries, $i.i.d$ gaussian, with zero mean and unit variance. The world volatility component is also governed by an AR(1) process:

$$z^w_{t+1} = (1-\phi^w)\theta^w + \phi^w z^w_t + \sigma^w \sqrt{z^w_t} v^w_{t+1},$$

where the innovations v^w_{t+1} are also $i.i.d$ gaussian, with zero mean and unit variance. This structure implies that the conditional mean and variance of the log SDF in country i are:

$$\begin{aligned} E_t(m^i_{t+1}) &= -\lambda^i z^i_t - \tau^i z^w_t, \\ Var_t(m^i_{t+1}) &= \gamma^i z^i_t + \delta^i z^w_t. \end{aligned}$$

Real Interest Rates This two-factor model implies the following real short rate process:

$$\begin{aligned} r_t^i &= -E_t(m_{t+1}^i) - \frac{1}{2}Var_t(m_{t+1}^i), \\ &= \left(\lambda^i - \frac{1}{2}\gamma^i\right) z_t^i + \left(\tau^i - \frac{1}{2}\delta^i\right) z_t^w. \end{aligned} \tag{5.1}$$

The real short rate depends both on country-specific factors and on a global factor. Note that its unconditional mean, autocorrelation and variance are:

$$\begin{aligned} E(r^i) &= (\lambda_i - \frac{1}{2}\gamma^i)\theta^i + \left(\tau^i - \frac{1}{2}\delta^i\right)\theta^w, \\ Autocorr.(r^i) &= (\lambda_i - \frac{1}{2}\gamma^i)\phi^i + \left(\tau^i - \frac{1}{2}\delta^i\right)\phi^w, \\ Var(r^i) &= \left(\lambda^i - \frac{1}{2}\gamma^i\right)^2 (\sigma^i)^2 + \left(\tau^i - \frac{1}{2}\delta^i\right)^2 (\sigma^w)^2. \end{aligned}$$

Real Exchange Rates We assume that financial markets are complete, but that some frictions in the goods markets prevent perfect risk-sharing across countries. As a result, the change in the real exchange rate Δq^i between the home country and country i is:

$$\begin{aligned} \Delta q_{t+1}^i &= m_{t+1} - m_{t+1}^i, \\ &= \lambda^i z_t^i + \sqrt{\gamma^i z_t^i} u_{t+1}^i - \lambda z_t - \sqrt{\gamma z_t} u_{t+1} + (\tau^i - \tau) z_t^w + (\sqrt{\delta^i} - \sqrt{\delta})\sqrt{z_t^w} u_{t+1}^w, \end{aligned}$$

where q^i is measured in country i goods per home country good. An increase in q^i means a real depreciation of the foreign currency. For the home country (the US), we drop the superscript. Note that the unconditional mean and conditional and unconditional variance of the change in the real exchange rate are:

$$\begin{aligned} E(\Delta q_{t+1}^i) &= \lambda^i\theta^i - \lambda\theta + (\tau^i - \tau)\theta^w, \\ Autocor.(\Delta q_{t+1}^i) &= \lambda^i\phi^i - \lambda\phi + (\tau^i - \tau)\phi^w, \\ Var_t(\Delta q_{t+1}^i) &= \gamma^i z_t^i + \gamma z_t + (\sqrt{\delta^i} - \sqrt{\delta})^2 z_t^w, \\ Var(\Delta q_{t+1}^i) &= \gamma^i\theta^i + \gamma\theta + (\sqrt{\delta^i} - \sqrt{\delta})^2\theta^w. \end{aligned}$$

Currency Excess Returns The log currency excess return rx^i for a home investor who buys risk-free bonds in country i is:

$$\begin{aligned} rx_{t+1}^i &= -\Delta q_{t+1}^i + r_t^i - r_t, \\ &= -\frac{1}{2}\gamma^i z_t^i - \sqrt{\gamma^i z_t^i} u_{t+1}^i + \frac{1}{2}\gamma z_t + \sqrt{\gamma z_t} u_{t+1} + (\frac{1}{2}\delta - \frac{1}{2}\delta^i) z_t^w - (\sqrt{\delta^i} - \sqrt{\delta})\sqrt{z_t^w} u_{t+1}^w. \end{aligned}$$

As a result, in this model, the expected log currency excess return is:

$$E_t[rx^i_{t+1}] = \frac{1}{2}[\gamma z_t - \gamma^i z^i_t + \left(\delta - \delta^i\right) z^w_t].$$

Note that this result is consistent with Backus et al. (2001) who show that in complete markets the expected log currency excess return is

$$E_t[rx^i_{t+1}] = \frac{1}{2}Var_t(m_{t+1}) - \frac{1}{2}Var_t(m^i_{t+1}).$$

The conditional variance of the log currency excess return is:

$$Var_t[rx^i_{t+1}] = \gamma^i z^i_t + \gamma z_t + (\sqrt{\delta^i} - \sqrt{\delta})^2 z^w_t.$$

Forward premium puzzle Why does this model reproduce the forward premium puzzle? The regression coefficient of log currency excess returns on interest rate differentials is:

$$\beta^i = \frac{-\frac{1}{2}\gamma(\lambda - \frac{1}{2}\gamma)\sigma^2 - \frac{1}{2}\gamma^i(\lambda^i - \frac{1}{2}\gamma^i)\sigma^{i^2} + \frac{1}{2}(\delta - \delta^i)[\tau^i - \tau - \frac{1}{2}(\delta^i - \delta)]\sigma^{w^2}}{(\lambda - \frac{1}{2}\gamma)^2\sigma^2 + (\lambda^i - \frac{1}{2}\gamma^i)^2\sigma^{i^2} + [\tau^i - \tau - \frac{1}{2}(\delta^i - \delta)]^2\sigma^{w^2}}.$$

The UIP coefficient of a regression of changes in exchange rates on real interest rate differentials $r^i - r$ is simply $1 - \beta^i$. Consider the simplest case in which the home and foreign currency share all SDF parameters ($\lambda^i = \lambda,\ \gamma^i = \gamma,\ \tau^i = \tau,\ \delta^i = \delta$). In this case, the interest rate differential between country i and the home country is given by:

$$r^i_t - r_t = \left(\lambda - \frac{1}{2}\gamma\right)\left(z^i_t - z_t\right),$$

while the currency risk premium is equal to:

$$E_t[rx^i_{t+1}] = \left(-\frac{1}{2}\gamma\right)\left(z_{i,t} - z_t\right).$$

It is easy to check that the slope coefficient is given by $\beta = -\frac{1}{2}\gamma/[\lambda - \frac{1}{2}\gamma]$ and the slope coefficient in the UIP regression is given by $\lambda/[\lambda - \frac{1}{2}\gamma]$. So, in this case, we can generate negative UIP slope coefficients if $0 < \lambda < \frac{1}{2}\gamma$. When $\lambda = 0$, the slope coefficient in a projection of excess returns on the forward discount is one, and the slope coefficient in the UIP regression is zero. In this case, the mean SDF is a constant in both countries, exchange rates follow a random walk, and all of the predictability in returns comes from the forward discount.

Risk Factors Suppose we have a large set P_j of currencies in each portfolio j. Define the average $\overline{m^j}$ of all countries' SDF m's in portfolio j as:

$$\overline{m^j}_{t+1} = \frac{1}{N_j} \sum_{i \in P^j} m^i_{t+1},$$

where N_j is the number of currencies in portfolio j. Similarly, let $\overline{\sqrt{\gamma^j}}$ denote the average $\sqrt{\gamma}$ in portfolio j. What is our risk factor HML in this model? Let us assume that the country-specific shocks u^i_{t+1} average out in each portfolio. Then, our risk factor HML is:

$$rx^{HML}_{t+1} = \left(\overline{\sqrt{\delta^L}} - \overline{\sqrt{\delta^H}}\right) \sqrt{z^w_t} u^w_{t+1} + \psi^{HML}_t,$$

where ψ^{HML}_t summarizes the conditional mean of the risk factor ($\psi^{HML}_t = \frac{1}{2}(\overline{\gamma^L z^L_t} - \overline{\gamma^H z^H_t}) + \frac{1}{2}(\overline{\delta^L} - \overline{\delta^H}) z^w_t$). We know from equation (5.1) that on average lower interest rate currencies will have higher exposure to the world volatility factor: $\overline{\sqrt{\delta^L}} > \overline{\sqrt{\delta^H}}$. As a result, the return on HML measures the stochastic discount factors' exposure to the common shock u^w_{t+1}.

What is our risk factor RX in this model? Let us assume again that country-specific shocks average out. RX measures (mostly) the dollar-specific factor:

$$rx^{RX}_{t+1} = \left(\sqrt{\delta} - \overline{\sqrt{\delta}}\right) \sqrt{z^w_t} u^w_{t+1} + \sqrt{\gamma}\sqrt{z_t} u_{t+1} + \psi^{RX}_t,$$

where ψ^{RX}_t is the conditional mean of the risk factor RX ($\psi^{RX}_t = \frac{1}{2}(\gamma z_t - \overline{\gamma z_t}) + \frac{1}{2}(\delta - \overline{\delta}) z^w_t$). Note that average (denoted $\overline{\cdot}$) are taken over all currencies here and not only over a particular portfolio. When $\delta = \overline{\delta}$, then rx^{RX}_{t+1} only depends on the home country or dollar specific factor u_{t+1}.

Inflation rates and nominal interest rates The log of the nominal pricing kernel in country i is simply given by the real pricing kernel less the rate of inflation:

$$m^{i,\$}_{t+1} = m^i_{t+1} - \pi^i_{t+1}.$$

We assume that inflation is composed of a country-specific component and a global component. Both components follow AR(1) processes:

$$\begin{aligned} \pi^w_{t+1} &= (1 - \rho^w)\overline{\pi}^w + \rho^w \pi^w_t + \sigma^{w\$} \epsilon^w_{t+1}, \\ \pi^{ci}_{t+1} &= (1 - \rho^i)\overline{\pi}^i + \rho^i \pi^i_t + \sigma^{i\$} \epsilon^i_{t+1}, \end{aligned}$$

where the innovations ϵ_t^w and ϵ_t^i are also $i.i.d$ gaussian, with zero mean and unit variance. Inflation in country i is a weighted average of these two components:

$$\pi_{t+1}^i = \mu^i \pi_{t+1}^{ci} + (1-\mu^i)\pi_{t+1}^w.$$

The conditional mean, autocorrelation and variance of the inflation is:

$$\begin{aligned} E_t(\pi_{t+1}^i) &= \mu^i[(1-\rho^i)\overline{\pi}^i + \rho^i \pi_t^i] + (1-\mu^i)[(1-\rho^w)\overline{\pi}^w + \rho^w \pi_t^w], \\ Autocor.(\pi_{t+1}^i) &= \mu^i \rho^i + (1-\mu^i)\rho^w, \\ Var_t(\pi_{t+1}^i) &= (\mu^i)^2(\sigma^{i\$})^2 + (1-\mu^i)^2(\sigma^{w\$})^2. \end{aligned}$$

The unconditional mean inflation rate is simply: $E(\pi_{t+1}^i) = \mu^i \overline{\pi}^i + (1-\mu^i)\overline{\pi}^w$. The nominal short rate is:

$$r_t^{i,\$} = r_t^i + E_t(\pi_{t+1}^i) - \frac{1}{2} Var_t(\pi_{t+1}^i).$$

6 Conclusion

In this paper, we show that currency markets offer large and significant excess returns. These currency excess returns are predictable by macroeconomic and financial variables. A single return-based factor explains the cross-section of average currency excess returns, consistently with the notion that carry trade profits are compensation for systematic risk. These results take into account bid-ask spreads and they are robust: they remain valid on small and large sub-samples of developed and emerging countries and from different foreign investors' perspectives.

To establish these results, we collect spot and forward rates and build portfolios of foreign currencies sorted on forward discounts. These portfolios offer a large cross-section of excess returns. A strategy that goes long in high interest rate currencies and short in low interest rate currencies earns a Sharpe ratio of 0.6 over the 1983-2007 period. These excess returns are predicted by their corresponding forward rates, or even better, by the average of all forward rates. We use macroeconomic indices, such as the industrial production index or the employment index, and financial variables such as the default spread or the option-implied volatility index, to show that predicted excess returns on high (low) interest rate currencies are counter-cyclical (pro-cyclical). We consider the return on a zero-cost strategy that goes long in the last portfolio and short in the first portfolio. We refer to this return as HML_{FX} (for high-minus-low) and use it as a risk factor. This single risk factor explains about 80 percent of the variation in average excess returns on these portfolios of currency forward contracts.

HML_{FX} betas are highly significant, and the market price of risk is in line with the average excess return on this risk factor. The average currency market return explains the level of the portfolio returns, but not the cross-section. Stock market betas are also significant, but not high enough on average to explain currency excess returns. We find however evidence that they tend to increase dramatically during crisis.

As a result, we conclude that currency excess returns reflect risk premia for exposure to aggregate risk. Identifying the economic mechanism that drives the relationship between macroeconomic risk and asset prices is therefore key to understanding the dynamics of currency markets.

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Table 1: Currency Portfolios - US Investor

Portfolio	1	2	3	4	5	6	1	2	3	4	5
	Panel I: All Countries						Panel II: Developed Countries				
	Spot change: Δs^j						Δs^j				
Mean	-0.61	-0.82	-1.24	-2.34	-0.71	2.11	-1.18	-2.16	-3.57	-1.95	-0.66
Std	8.10	7.29	7.40	7.42	7.79	9.19	10.11	9.75	9.21	8.98	9.07
	Forward Discount: $f^j - s^j$						$f^j - s^j$				
Mean	-3.90	-1.29	-0.14	0.96	2.58	7.88	-3.10	-1.03	0.07	1.13	3.96
Std	1.59	0.50	0.49	0.53	0.59	2.10	0.79	0.64	0.66	0.68	0.77
	Excess Return: rx^j (without b-a)						rx^j (without b-a)				
Mean	-3.29	-0.47	1.10	3.30	3.28	5.77	-1.28	1.67	4.14	3.58	5.23
Std	8.28	7.36	7.45	7.53	7.91	9.30	10.22	9.81	9.36	9.05	9.21
SR	-0.40	-0.06	0.15	0.44	0.42	0.62	-0.13	0.17	0.44	0.40	0.57
	Net Excess Return: rx^j_{net} (with b-a)						rx^j_{net} (with b-a)				
Mean	-2.06	-1.43	-0.18	1.93	1.77	2.96	-0.15	0.61	2.73	2.31	3.51
Std	8.27	7.36	7.42	7.48	7.90	9.30	10.23	9.80	9.32	9.05	9.18
SR	-0.25	-0.20	-0.02	0.26	0.22	0.32	-0.01	0.06	0.29	0.25	0.38
	High-minus-Low: $rx^j - rx^1$ (without b-a)						$rx^j - rx^1$ (without b-a)				
Mean		2.82	4.40	6.59	6.58	9.06		2.95	5.42	4.86	6.51
Std		5.40	5.51	6.68	6.39	8.98		6.40	6.36	7.30	8.52
SR		0.52	0.80	0.99	1.03	1.01		0.46	0.85	0.67	0.76
	High-minus-Low: $rx^j_{net} - rx^1_{net}$ (with b-a)						$rx^j_{net} - rx^1_{net}$ (with b-a)				
Mean		0.62	1.87	3.99	3.82	5.02		0.76	2.88	2.46	3.66
Std		5.40	5.53	6.65	6.40	9.01		6.44	6.36	7.33	8.55
SR		0.12	0.34	0.60	0.60	0.56		0.12	0.45	0.34	0.43

Notes: This table reports, for each portfolio j, the average change in log spot exchange rates Δs^j, the average log forward discount $f^j - s^j$, the average log excess return rx^j without bid-ask spreads, the average log excess return rx^j_{net} with bid-ask spreads, and the average return on the long short strategy $rx^j_{net} - rx^1_{net}$ and $rx^j - rx^1$ (with and without bid-ask spreads). Log currency excess returns are computed as $rx^j_{t+1} = -\Delta s^j_{t+1} + f^j_t - s^j_t$. All moments are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations. The portfolios are constructed by sorting currencies into six groups at time t based on the one-month forward discount (i.e nominal interest rate differential) at the end of period $t-1$. Portfolio 1 contains currencies with the lowest interest rates. Portfolio 6 contains currencies with the highest interest rates. Panel I uses all countries, panel II focuses on developed countries. Data are monthly, from Barclays and Reuters (Datastream). The sample period is 11/1983 - 08/2007.

Table 2: Asset Pricing - US Investor

Panel I: Factor Prices and Loadings

	All Countries							Developed Countries						
	$\lambda_{HML_{FX}}$	λ_{RX}	$b_{HML_{FX}}$	b_{RX}	R^2	$RMSE$	χ^2	$\lambda_{HML_{FX}}$	λ_{RX}	$b_{HML_{FX}}$	b_{RX}	R^2	$RMSE$	χ^2
GMM_1	5.70	1.02	0.61	0.20	70.82	0.96		4.12	1.88	0.54	0.30	82.83	0.52	
	[2.38]	[1.74]	[0.25]	[0.33]			14.32	[2.22]	[2.09]	[0.27]	[0.25]			52.42
GMM_2	5.28	0.24	0.56	0.05	51.09	1.25		4.42	2.70	0.59	0.41	39.04	0.98	
	[2.25]	[1.68]	[0.24]	[0.32]			15.70	[2.17]	[2.00]	[0.26]	[0.23]			56.67
FMB	5.70	1.02	0.61	0.20	70.82	0.96		4.12	1.88	0.54	0.30	74.25	0.52	
	[1.85]	[1.36]	[0.20]	[0.26]			12.42	[1.76]	[1.74]	[0.21]	[0.20]			54.67
	(1.85)	(1.36)	(0.20)	(0.26)			13.73	(1.76)	(1.74)	(0.21)	(0.20)			55.84
$Mean$	**5.56**	**1.03**						**4.00**	**1.88**					

Panel II: Factor Betas

	All Countries						Developed Countries					
$Portfolio$	α_0^j	$\beta^j_{HML_{FX}}$	β^j_{RX}	R^2	$\chi^2(\alpha)$	$p-value$	α_0^j	$\beta^j_{HML_{FX}}$	β^j_{RX}	R^2	$\chi^2(\alpha)$	$p-value$
1	−0.51	−0.39	1.06	91.00			−0.06	−0.50	0.99	95.05		
	[0.53]	[0.02]	[0.03]				[0.49]	[0.02]	[0.02]			
2	−1.35	−0.13	0.96	78.00			−0.71	−0.13	1.02	82.47		
	[0.78]	[0.03]	[0.05]				[0.83]	[0.05]	[0.04]			
3	−0.09	−0.12	0.95	74.00			0.91	−0.02	1.01	85.51		
	[0.84]	[0.03]	[0.05]				[0.85]	[0.04]	[0.04]			
4	1.56	−0.02	0.93	69.00			−0.09	0.15	0.98	81.89		
	[0.87]	[0.04]	[0.06]				[0.86]	[0.04]	[0.04]			
5	0.90	0.05	1.03	76.00			−0.06	0.50	0.99	93.68		
	[0.82]	[0.04]	[0.05]				[0.49]	[0.02]	[0.02]			
6	−0.51	0.61	1.06	93.00								
	[0.53]	[0.02]	[0.03]									
All					6.67	34.00					1.88	0.86

Notes: The panel on the left reports results for all countries. The panel on the right reports results for the developed countries. Panel I reports results from GMM and Fama-McBeth asset pricing procedures. Market prices of risk λ, the adjusted R^2, the square-root of mean-squared errors $RMSE$ and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes the vector of factor loadings. Excess returns used as test assets and risk factors take into account bid-ask spreads. All excess returns are multiplied by 12 (annualized). The standard errors in brackets are Newey and West (1987) standard errors computed with the optimal number of lags according to Andrews (1991). Shanken (1992)-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure. Panel II reports OLS estimates of the factor betas. R^2s and p-values are reported in percentage points. The χ^2 test statistic $\alpha' V_\alpha^{-1} \alpha$ tests the null that all intercepts are jointly zero. This statistic is constructed from the Newey-West variance-covariance matrix (1 lag) for the system of equations (see Cochrane (2001), p. 234). Data are monthly, from Barclays and Reuters in Datastream. The sample period is 11/1983 - 08/2007.

Table 3: Beta-Sorted Currency Portfolios - US Investor

Portfolio	1	2	3	4	5	6	1	2	3	4	5
	Panel I: Developed and Emerging Countries						Panel II: Developed Countries				
	Spot change: Δs^j						Spot change: Δs^j				
$Mean$	-1.36	-1.15	-1.24	-1.76	-1.42	0.12	-1.17	-1.74	-1.21	-2.27	0.50
Std	8.69	7.85	7.37	6.80	8.09	7.39	8.74	8.11	8.14	7.93	7.47
	Discount: $f^j - s^j$						Discount: $f^j - s^j$				
$Mean$	-1.45	-0.36	0.81	0.99	1.49	3.18	-1.42	-0.51	1.01	1.31	4.21
Std	0.78	0.56	1.24	0.64	0.81	1.28	0.69	0.60	0.72	0.82	1.67
	Excess Return: rx^j (without b-a)						Excess Return: rx^j (without b-a)				
$Mean$	-0.09	0.79	2.04	2.75	2.91	3.06	-0.25	1.22	2.22	3.58	3.71
Std	8.84	7.87	7.42	6.77	8.11	7.42	8.82	8.15	8.19	7.88	7.89
SR	-0.01	0.10	0.28	0.41	0.36	0.41	-0.03	0.15	0.27	0.45	0.47
	High-minus-Low: $rx^j - rx^1$ (without b-a)						Excess Return: rx^j (without b-a)				
$Mean$		0.87	2.13	2.84	2.99	3.15		1.47	2.47	3.83	3.96
Std		5.25	6.21	7.35	8.90	9.14		5.17	5.94	7.86	8.74
SR		0.17	0.34	0.39	0.34	0.34		0.28	0.42	0.49	0.45

Notes: This table reports, for each portfolio j, the average change in the log spot exchange rate Δs^j, the average log forward discount $f^j - s^j$, the average log excess return rx^j without bid-ask spreads and the average returns on the long short strategy $rx^j - rx^1$. The left panel uses our sample of developed and emerging countries. The right panel uses our sample of developed countries. Log currency excess returns are computed as $rx^j_{t+1} = -\Delta s^j_{t+1} + f^j_t - s^j_t$. All moments are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations. Portfolios are constructed by sorting currencies into six groups at time t based on slope coefficients β^i_t. Each β^i_t is obtained by regressing currency i log excess return rx^i on HML_{FX} on a 36-period moving window that ends in period $t-1$. The first portfolio contains currencies with the lowest βs. The last portfolio contains currencies with the highest βs. Data are monthly, from Barclays and Reuters (Datastream). The sample period is 11/1983 - 08/2007.

Table 4: Return Predictability: One-Month Ahead

Portfolio	γ_f	R^2	$\gamma_{\mathbf{f}}$	R^2	γ_f	R^2	$\gamma_{\mathbf{f}}$	R^2
	Panel I: No Bid-Ask Spreads				Panel II: With Bid-Ask Spreads			
1	1.08	4.29	3.76	8.35	1.02	3.83	3.70	8.11
NW	[0.33]		[0.64]		[0.32]		[0.64]	
HH	[0.23]		[0.57]		[0.23]		[0.57]	
VAR	[0.36]		[0.73]		[0.35]		[0.73]	
2	2.50	2.83	2.41	4.35	2.53	2.91	2.40	4.30
NW	[0.98]		[0.70]		[0.96]		[0.69]	
HH	[0.92]		[0.68]		[0.91]		[0.68]	
VAR	[1.02]		[0.72]		[1.03]		[0.71]	
3	2.05	1.80	2.03	3.01	2.00	1.72	1.98	2.87
NW	[1.04]		[0.65]		[1.04]		[0.65]	
HH	[1.02]		[0.63]		[1.02]		[0.63]	
VAR	[0.98]		[0.69]		[0.98]		[0.68]	
4	3.57	6.36	2.31	3.79	3.36	5.74	2.18	3.44
NW	[0.87]		[0.65]		[0.86]		[0.64]	
HH	[0.81]		[0.64]		[0.80]		[0.63]	
VAR	[0.93]		[0.73]		[0.92]		[0.73	
5	3.12	5.43	2.75	4.88	2.95	4.86	2.65	4.54
NW	[0.91]		[0.74]		[0.92]		[0.75]	
HH	[0.93]		[0.76]		[0.94]		[0.76]	
VAR	[0.84]		[0.75]		[0.84]		[0.78]	
6	0.72	2.65	3.12	4.59	0.57	1.68	2.79	3.67
NW	[0.21]		[0.84]		[0.20]		[0.84]	
HH	[0.21]		[0.85]		[0.20]		[0.85]	
VAR	[0.32]		[0.94]		[0.30]		[0.94]	

Notes: This table reports summary statistics for return predictability regressions at a one-month horizon. In the left panel, we use gross excess returns (without bid-ask spreads). In the right panel, we use net excess returns (with bid-ask spreads). For each portfolio j, we report the R^2, and the slope coefficient in the time-series regression of the log currency excess return on the portfolio-specific log forward discount (γ_f)or the average log forward discount ($\gamma_{\mathbf{f}}$). The Newey and West (1987) NW standard errors are computed with the optimal number of lags following Andrews (1991). The Hansen and Hodrick (1980) HH standard error are computed with one lag. The bootstrapped standard errors VAR are computed by drawing from the residuals of a VAR with one lag. All the returns are annualized and reported in percentage points. Data are monthly, from Barclays and Reuters (Datastream). The sample period is 11/1983 - 08/2007.

Table 5: Return Predictability: Longer Horizons

Portfolio	*1-month*	*2-month*	*3-month*	*6-month*	*12-month*
Panel I: All Countries					
Subpanel A: Overlapping Data					
Forward Discount					
1	4.29	4.71	8.35	26.62	26.85
6	2.65	3.24	4.03	6.40	11.50
Average Forward Discount					
1	8.35	13.93	19.23	32.38	35.40
6	4.59	6.44	8.82	13.68	19.10
Subpanel B: No Overlapping Data					
Forward Discount					
1	4.29	2.57	9.10	25.41	28.55
6	2.65	3.85	4.50	7.20	14.59
Average Forward Discount					
1	8.35	14.97	19.86	35.74	31.44
6	4.59	6.99	8.02	16.19	25.75
Panel II: Developed Countries					
Subpanel A: Overlapping Data					
Forward Discount					
1	1.91	3.73	7.57	15.45	17.84
5	3.79	6.17	8.07	13.19	15.30
Average Forward Discount					
1	3.02	6.64	10.92	19.61	21.32
5	3.17	5.69	8.10	12.99	11.72
Subpanel B: No Overlapping Data					
Forward Discount					
1	4.29	2.57	9.10	25.41	28.55
5	5.43	10.67	12.51	37.56	24.30
Average Forward Discount					
1	8.35	14.97	19.86	35.74	31.44
5	4.88	8.89	12.25	32.17	17.18

Notes: In Panel A, we report the R^2 in the time-series regressions of the log k-period currency excess return on the log forward discount for each portfolio j: $rx^{j,k}_{net,t+k} = \gamma^j_0 + \gamma^j_1(f^{j,k}_t - s^j_t) + \eta^j_t$. In Panel B, we report the R^2 in the time-series regression the log k-period currency excess return on the linear combination of log forward discounts for each portfolio j: $rx^{j,k}_{net,t+k} = \gamma^j_0 + \gamma^j_1\iota'(\mathbf{f}^k_t - \mathbf{s}^k_t) + \eta^j_t$ for each portfolio j. Data are monthly, from Barclays and Reuters (Datastream). The sample period is 11/1983 - 08/2007. Panel I uses overlapping data. Panel II does not use overlapping data.

Table 6: Contemporaneous Correlations Between Expected Excess Returns or Forward Discounts and Macroeconomic and Financial Variables

	IP	Pay	$Help$	$spread$	$slope$	vol
Portfolio	Panel I: Expected Excess Returns					
1	0.18	0.02	0.21	−0.21	0.04	−0.13
	[0.08]	[0.01]	[0.21]	[0.05]	[0.09]	[0.06]
2	−0.58	−0.71	−0.43	0.35	0.42	−0.02
	[0.09]	[0.03]	[0.13]	[0.05]	[0.12]	[0.06]
3	−0.62	−0.66	−0.40	0.34	0.47	0.04
	[0.11]	[0.04]	[0.15]	[0.05]	[0.11]	[0.05]
4	−0.58	−0.53	−0.33	0.27	0.41	0.12
	[0.14]	[0.05]	[0.15]	[0.04]	[0.10]	[0.05]
5	−0.52	−0.41	−0.28	0.29	0.36	0.19
	[0.12]	[0.04]	[0.12]	[0.04]	[0.09]	[0.05]
6	−0.15	−0.10	−0.08	0.18	0.13	0.21
	[0.09]	[0.04]	[0.08]	[0.03]	[0.08]	[0.05]
Maturity	Panel II: Average Forward Discount					
1	−0.32	−0.36	−0.15	0.18	0.32	0.11
	[0.12]	[0.04]	[0.15]	[0.04]	[0.08]	[0.06]
2	−0.47	−0.50	−0.28	0.27	0.38	0.16
	[0.15]	[0.05]	[0.15]	[0.04	[0.09]	[0.07]
3	−0.53	−0.55	−0.35	0.31	0.40	0.19
	[0.16]	[0.05]	[0.15]	[0.05]	[0.09]	[0.08]
6	−0.56	−0.60	−0.42	0.35	0.38	0.23
	[0.18]	[0.05]	[0.14]	[0.05]	[0.10]	[0.10]
12	−0.51	−0.61	−0.41	0.28	0.39	0.19
	[0.19]	[0.05]	[0.17]	[0.06]	[0.11]	[0.11]

Notes: Panel I reports the contemporaneous correlation $Corr\left[\widehat{E}_t rx^j_{t+1}, x_t\right]$ of forecasted excess returns using the portfolio forward discount with different variables x_t: the 12-month percentage change in industrial production ($\Delta \log IP_t$), the 12-month percentage change in the total US non-farm payroll ($\Delta \log Pay_t$), and the 12-month percentage change of the Help-Wanted index ($\Delta \log Help_t$), the default spread ($spread_t$), the slope of the yield curve ($slope_t$) and the CBOE $S\&P$ 500 volatility index (vol_t). Panel II reports the contemporaneous correlation of the average forward discount with these variables. Data are monthly, from Datastream and Global Financial Data. The sample period is 11/1983 - 08/2007.

Table 7: Forecasting Excess Returns with Industrial Production and Forward Discounts

	γ_{IP}	γ_f	W	R^2	γ_{IP}	$\gamma_{\mathbf{f}}$	W	R^2	γ_{IP}	γ_f	W	R^2	γ_{IP}	$\gamma_{\mathbf{f}}$	W	R^2
	All Countries								Developed Countries							
1	−0.91	2.29		31.01	−0.84	3.30		39.71	−1.27	1.33		23.80	−1.09	1.88		25.55
NW	[0.61]	[1.23]	39.27		[0.27]	[0.82]	43.98		[0.72]	[1.18]	19.92		[0.55]	[0.95]	21.31	
HH	[0.81]	[1.68]	22.72		[0.53]	[1.51]	25.28		[0.79]	[1.34]	17.67		[0.59]	[1.04]	19.53	
12 lag VAR	[0.72]	[1.34]	49.41		[0.60]	[1.08]	63.33		[0.90]	[1.54]	33.02		[0.89]	[1.49]	31.58	
No overlap	[0.81]	[1.68]	22.72		[0.53]	[1.51]	25.28		[0.97]	[1.58]	12.07		[0.85]	[1.52]	13.57	
2	−0.98	0.74		19.58	−0.90	1.15		21.77	−1.92	−0.20		21.76	−1.39	1.14		23.43
NW	[0.53]	[1.03]	17.04		[0.36]	[0.69]	17.85		[0.84]	[1.43]	17.43		[0.61]	[1.25]	18.73	
HH	[0.68]	[1.71]	4.95		[0.47]	[1.51]	6.20		[0.93]	[1.62]	15.19		[0.66]	[1.41]	16.40	
12 lag VAR	[0.52]	[1.10]	22.76		[0.48]	[0.92]	63.33		[0.88]	[1.57]	42.32		[0.89]	[1.50]	31.58	
No overlap	[0.68]	[1.71]	4.95		[0.47]	[1.51]	6.20		[1.02]	[2.09]	11.86		[0.83]	[2.12]	12.64	
3	−1.15	1.32		31.08	−1.12	1.70		34.09	−1.67	0.76		31.42	−1.65	0.84		31.47
NW	[0.36]	[0.95]	28.74		[0.29]	[0.82]	30.18		[0.43]	[0.87]	41.95		[0.45]	[0.99]	42.02	
HH	[0.74]	[1.61]	14.68		[0.62]	[1.57]	18.62		[0.46]	[0.93]	37.50		[0.48]	[1.09]	37.71	
12 lag VAR	[0.52]	[1.05]	42.84		[0.46]	[0.91]	47.84		[0.66]	[0.94]	51.62		[0.67]	[1.08]	48.63	
No overlap	[0.74]	[1.61]	14.68		[0.62]	[1.57]	18.62		[0.70]	[1.68]	94.11		[0.63]	[1.53]	91.70	
4	−1.19	1.07		32.32	−1.18	1.28		33.15	0.92		33.43	−1.40	1.15		33.97	
NW	[0.28]	[0.71]	33.85		[0.27]	[0.75]	32.62		[0.46]	[0.99]	55.90		[0.49]	[1.19]	53.24	
HH	[0.46]	[1.61]	11.45		[0.31]	[1.59]	23.81		[0.50]	[1.07]	54.70		[0.54]	[1.31]	51.81	
12 lag VAR	[0.45]	[0.75]	38.49		[0.45]	[0.83]	40.19		[0.57]	[0.87]	49.02		[0.56]	[1.03]	60.12	
No overlap	[0.46]	[1.61]	11.45		[0.31]	[1.59]	23.81		[0.64]	[1.67]	52.75		[0.60]	[1.96]	96.17	
5	−1.70	1.31		41.16	−1.71	1.08		38.85	−1.74	0.75		34.56	−2.12	−0.34		33.27
NW	[0.30]	[0.66]	45.68		[0.34]	[0.81]	40.85		[0.39]	[1.20]	41.57		[0.52]	[1.43]	49.22	
HH	[0.55]	[1.04]	33.08		[0.73]	[1.77]	15.74		[0.70]	[1.16]	42.65		[0.77]	[1.32]	48.11	
12 lag VAR	[0.49]	[0.80]	63.93		[0.52]	[1.00]	55.47		[0.42]	[1.35]	37.57		[0.57]	[1.61]	45.56	
No overlap	[0.55]	[1.04]	33.08		[0.73]	[1.77]	15.74		[0.46]	[1.51]	39.58		[0.72]	[1.95]	39.59	
6	−1.51	1.18		28.55	−1.07	2.10		25.44								
NW	[0.42]	[0.44]	27.07		[0.50]	[1.38]	19.16									
HH	[0.50]	[0.55]	13.68		[0.56]	[1.51]	11.21									
12 lag VAR	[0.66]	[0.75]	41.02		[0.78]	[1.72]	38.20									
No overlap	[0.50]	[0.55]	13.68		[0.56]	[1.51]	11.21									

Notes: This table reports forecasting results obtained on currency portfolios using the 12-month change in Industrial Production and either the portfolio forward discount or the average forward discount. The left panel uses our sample of developed and emerging countries. The right panel uses our sample of developed countries. The Newey and West (1987) (NW) standard errors are computed with the optimal number of lags. The Hansen and Hodrick (1980) (HH) standard errors are computed with 12 lags for the 12-month returns. For the bootstrapped standard errors, the VAR uses 12 lags for the 12-month returns. All the returns are annualized and reported in percentage points. Data are monthly, from Datastream and Global Financial Data. The sample period is 11/1983 - 04/2007.

Table 8: Spreads Predictability with Forward Discount Spreads

Portfolio	$\gamma_{sp,f}$	R^2	$\gamma_{\mathbf{sp,f}}$	R^2	*Portfolio*	$\gamma_{sp,f}$	R^2	$\gamma_{\mathbf{sp,f}}$	R^2
2	9.11	4.90	6.99	3.14	3	7.37	3.07	5.98	2.21
NW	[2.67]		[2.52]			[2.28]		[2.49]	
HH	[2.44]		[0.23]			[2.40]		[2.52]	
VAR	[3.41]		[3.10]			[3.79]		[3.41]	
4	9.21	3.28	6.88	1.99	5	6.77	2.13	5.86	1.58
NW	[2.37]		[2.50]			[2.82]		[2.91]	
HH	[2.37]		[2.38]			[0.96]		[1.42]	
VAR	[4.02]		[3.54]			[3.39]		[3.37]	
6	3.51	0.72	8.08	1.53					
NW	[3.08]		[3.51]						
HH	[3.06]		[3.13]						
VAR	[3.08]		[4.49]						

Notes: Column 1 reports the one-month forecasted excess returns using the one-month forward discount spread. Column 2 reports the one-month forecasted excess returns using the one-month average forward discount spread. The Newey and West (1987) (NW) standard errors are computed with the optimal number of lags. The Hansen and Hodrick (1980) (HH) standard errors are computed with 1 lag for the n-month returns. The VAR uses 1 lag. All the returns annualized and reported in percentage points. Data are monthly from Datastream. The sample period is 11/1983 - 08/2007.

Table 9: Conditional Asset Pricing

Panel I: Conditional HML_{FX}									
	λ_{RX}	$\lambda_{HML_{FX}}$	$\lambda_{HML_{FX}z}$	b_{RX}	$b_{HML_{FX}}$	$b_{HML_{FX}z}$	R^2	$RMSE$	χ^2
GMM_1	2.57	8.77	20.96	0.14	2.12	-0.43	90.06	1.52	
	[3.27]	[3.62]	[8.51]	[0.17]	[2.40]	[0.78]			18.66
GMM_2	1.56	7.51	21.77	0.06	0.56	0.08	82.96	2.00	
	[2.95]	[2.68]	[7.71]	[0.15]	[0.82]	[0.27]			50.76
FMB	2.95	2.68	7.71	0.15	0.82	0.27			
	[2.77]	[2.56]	[5.86]	[0.15]	[2.00]	[0.65]			20.07
	(2.77)	(2.62)	(5.87)	(0.15)	(2.09)	(0.68)			26.67
$Mean$	**2.54**	**6.32**	**21.17**						

Panel II: Conditional CAPM									
	λ_{RX}	λ_{R^m}	$\lambda_{R^m z}$	b_{RX}	b_{R^m}	$b_{R^m z}$	R^2	$RMSE$	χ^2
GMM_1	2.33	44.64	112.93	0.18	4.79	-0.97	92.33	1.34	
	[4.04]	[22.24]	[61.76]	[0.21]	[2.94]	[0.74]			30.44
GMM_2	0.36	21.48	64.69	0.05	1.27	-0.14	32.06	3.98	
	[3.52]	[16.34]	[44.52]	[0.18]	[1.91]	[0.45]			70.70
FMB	2.33	44.64	112.93	0.18	4.77	-0.96	91.59	1.34	
	[2.77]	[12.01]	[35.34]	[0.14]	[1.53]	[0.40]			2.31
	(2.77)	(16.86)	(49.28)	(0.14)	(2.15)	(0.56)			40.00
$Mean$	**2.54**	**7.46**	**21.38**						

Notes: This table reports results from GMM and Fama-McBeth asset pricing procedures. Market prices of risk λ, the adjusted R^2, the square-root of mean-squared errors $RMSE$ and the p-values of χ^2 tests are reported in percentage points. In the top panel, the risk factors are the average return on the currency market RX, HML_{FX} and $HML_{FX}z$, which is HML_{FX} multiplied by the lagged value of the VIX index (scaled by its standard deviation). b_{RX}, $b_{HML_{FX}}$ and $b_{HML_{FX}z}$ represent the corresponding factor loadings. In the bottom panel, the risk factors are the average return on the currency market RX, the value-weighted stock market excess return R^m and $R^m z$, which is R^m multiplied by the lagged value of the VIX index (scaled by its standard deviation). b_{RX}, $b_{R^m z}$ and b_{R^m} represent the corresponding factor loadings. The portfolios are constructed by sorting currencies into six groups at time t based on the interest rate differential at the end of period $t-1$. Portfolio 1 contains currencies with the lowest interest rates. Portfolio 6 contains currencies with the highest interest rates. In both panels, we use 12 test assets: the original 6 portfolios and 6 additional portfolios obtained by multiplying the original set by the conditioning variable (VIX). Data are monthly, from Barclays and Reuters (Datastream). The sample is 03/1986-08/2007. Standard errors are reported in brackets. Shanken-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure.

Table 10: Asset Pricing - CAPM

Panel I: Factor Prices and Loadings

	All Countries							Developed Countries						
	λ_{R^m}	λ_{RX}	b_{R^m}	b_{RX}	R^2	$RMSE$	χ^2	λ_{R^m}	λ_{RX}	b_{R^m}	b_{RX}	R^2	$RMSE$	χ^2
GMM_1	40.72	1.01	1.55	0.26	64.06	1.07		24.34	1.86	0.93	0.28	25.79	1.08	
	[17.77]	[2.03]	[0.68]	[0.38]			20.34	[15.45]	[2.27]	[0.59]	[0.27]			29.13
GMM_2	28.79	0.11	1.09	0.07	30.47	1.49		22.80	2.62	0.87	0.36	−12.14	1.32	
	[16.52]	[1.97]	[0.63]	[0.37]			28.28	[14.86]	[2.24]	[0.56]	[0.26]			30.72
FMB	40.72	1.01	1.54	0.25	64.06	1.07		24.34	1.86	0.92	0.27	−11.27	1.08	
	[13.33]	[1.36]	[0.50]	[0.26]		8.73		[12.36]	[1.74]	[0.47]	[0.20]			7.96
	(16.85)	(1.36)	(0.64)	(0.26)			28.98	(13.63)	(1.74)	(0.51)	(0.20)			13.85

Panel II: Factor Betas

$Portfolio$	α_0^i	β_m^i	β_{RX}^i	R^2	$\chi^2(\alpha)$	$p(\%)$	α_0^i	β_m^i	β_{RX}^i	R^2	$\chi^2(\alpha)$	$p(\%)$
1	−2.29	−0.05	1.07	0.75			−1.86	−0.04	1.07	79.24		
	[1.08]	[0.01]	[0.05]				[0.95]	[0.02]	[0.04]			
2	−1.87	−0.02	0.96	0.76			−0.99	−0.04	1.04	81.55		
	[0.79]	[0.01]	[0.05]				[0.86]	[0.02]	[0.04]			
3	−0.65	−0.01	0.95	0.72			1.05	−0.03	1.02	85.67		
	[0.85]	[0.02]	[0.05]				[0.82]	[0.01]	[0.03]			
4	1.59	−0.02	0.93	0.69			0.04	0.06	0.96	81.22		
	[0.84]	[0.02]	[0.06]				[0.90]	[0.02]	[0.04]			
5	0.89	0.04	1.03	0.76			1.76	0.04	0.92	73.25		
	[0.86]	[0.02]	[0.05]				[1.06]	[0.02]	[0.05]			
6	2.34	0.07	1.06	0.60								
	[1.23]	[0.02]	[0.06]									
					12.76	4.00					19.00	0.00

Notes: The panel on the left reports results for all countries in the sample. The panel on the right reports results for developed countries. The top panel reports results from GMM and Fama-McBeth asset pricing procedures. Market prices of risk λ, the adjusted R^2, the square-root of mean-squared errors $RMSE$ and the p-values of χ^2 tests are reported in percentage points. b_1 represents the factor loading. The bottom panel reports results OLS estimates of the factor betas. The intercept α_0 β, and the R^2 are reported in percentage points. The standard errors in brackets are Newey-West standard errors computed with the optimal number of lags. The χ^2 test statistic $\alpha' V_\alpha^{-1} \alpha$ tests the null that all intercepts are jointly zero. This statistic is constructed from the Newey-West variance-covariance matrix (1 lag) for the system of equations (Cochrane (2001), p. 234). Data are monthly, from Barclays and Reuters in Datastream. The sample period is 11/1983 - 08/2007. Excess returns used as test assets take into account bid-ask spreads. All excess returns are multiplied by 12 (annualized). Standard errors are reported in brackets. Shanken-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure.

Table 11: CAPM: Subprime Crisis

Portfolio	12-month window				6-month window				3-month window			
	α_m^i	β_m^i	$p(\%)$	R^2	α_m^i	β_m^i	$p(\%)$	R^2	α_m^i	β_m^i	$p(\%)$	R^2
HML_{FX}	0.25	0.51	0.00	19.90	0.11	0.59	0.00	45.61	-0.20	0.58	0.00	23.67
	[0.41]	[0.11]			[0.54]	[0.08]			[1.12]	[0.10]		
1		-0.11	11.42	3.14		-0.14	0.89	12.12		-0.06	50.06	1.84
		[0.07]				[0.05]				[0.10]		
2		0.15	9.09	5.01		0.19	0.32	18.53		0.20	1.94	14.99
		[0.09]				[0.06]				[0.09]		
3		0.13	4.71	5.96		0.16	0.07	18.37		0.16	1.84	11.55
		[0.07]				[0.05]				[0.07]		
4		0.16	0.01	16.16		0.21	0.00	31.39		0.28	0.12	30.70
		[0.04]				[0.03]				[0.09]		
5		0.18	0.01	17.08		0.24	0.00	33.32		0.20	0.70	14.64
		[0.05]				[0.03]				[0.07]		
6		0.40	0.06	17.08		0.44	0.00	33.32		0.52	0.00	14.64
		[0.12]				[0.11]				[0.11]		

Notes: This table reports OLS estimates of the CAPM betas. Test assets are our 6 currency portfolios and our carry risk factor HML_{FX}. The intercept α, the slope coefficients β, and the R^2 are reported in percentage points. The standard errors in brackets are Newey-West standard errors computed with 20 lags. The p-value is for a t-test on the slope coefficient. The portfolios are constructed by sorting currencies into six groups at time t based on the forward discounts at the end of period $t-1$. Portfolio 1 contains currencies with the lowest interest rates. Portfolio 6 contains currencies with the highest interest rates. Data are daily, from Barclays and Reuters in Datastream. The returns are are 1-month returns. The sample period is 253 days (1 year), 129 days (6 months) and 63 days (1 quarter) before and including date 08/31/2007.

Table 12: CAPM: Other Crisis

$Portfolio$	β_m^i	$p(\%)$	R^2	β_m^i	$p(\%)$	R^2	β_m^i	$p(\%)$	R^2
$Sample$	26-May-1998			02-Aug-1995			10-Oct-1999		
	Panel I: 6-month window								
HML_{FX}	1.14	0.00	22.12	1.21	0.02	10.94	0.68	0.00	34.26
	[0.17]			[0.32]			[0.10]		
1	0.03	85.49	0.11	−1.21	0.08	18.05	−0.25	1.85	34.70
	[0.14]		[0.00]	[0.36]			[0.11]		
2	−0.05	75.45	0.60	−0.90	8.83	8.50	−0.08	35.93	5.36
	[0.16]			[0.53]			[0.09]		
3	0.21	11.08	10.95	−0.89	7.93	12.00	0.06	52.27	2.13
	[0.13]			[0.51]			[0.09]		
4	0.28	2.84	13.75	−0.48	5.70	11.86	−0.05	0.57	7.79
	[0.13]			[0.25]			[0.02]		
5	0.52	0.00	25.25	−0.55	5.35	10.23	−0.00	94.71	0.02
	[0.11]			[0.28]			[0.06]		
6	1.17	0.00	25.25	−0.00	99.96	10.23	0.42	0.00	0.02
	[0.28]			[0.14]			[0.08]		
	Panel II: 3-month window								
HML_{FX}	1.41	0.00	6.28	1.22	0.00	32.95	0.60	0.00	56.55
	[0.23]			[0.25]			[0.13]		

Notes: This table reports results OLS estimates of the factor betas. In Panel I, the sample period is 129 days (6 months) before and including the mentioned date. In Panel II, the sample is 63 days (3 months) before and including the mentioned date. The intercept α_0 β, and the R^2 are reported in percentage points. The standard errors in brackets are Newey-West standard errors computed with the optimal number of lags. The p-value is for a t-test on the slope coefficient. The portfolios are constructed by sorting currencies into six groups at time t based on the the currency excess return at the end of period $t-1$. The returns are 1-month returns, and take into account bid-ask spreads. Portfolio 1 contains currencies with the lowest previous excess return. Portfolio 6 contains currencies with the highest previous excess return. Data are daily, from Barclays and Reuters in Datastream.

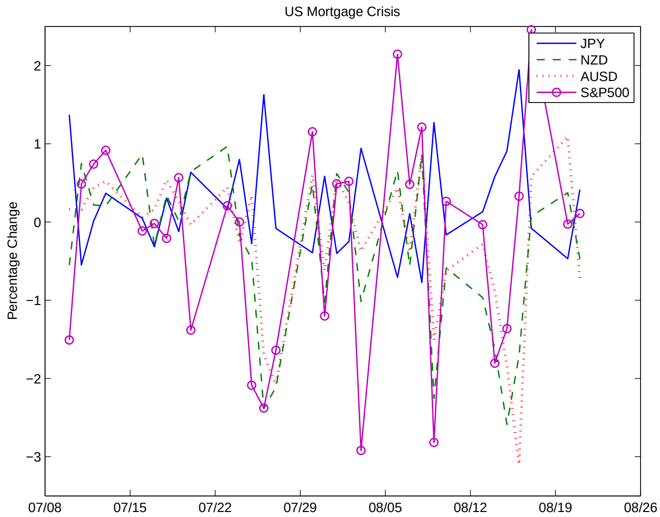

Figure 1: The Carry Trade and the US Stock Market during the Mortgage Crisis.

This figure plots the daily percentage change in exchange rate for yen, New-Zealand dollar, the Australian dollar and the daily S&P 500 return.

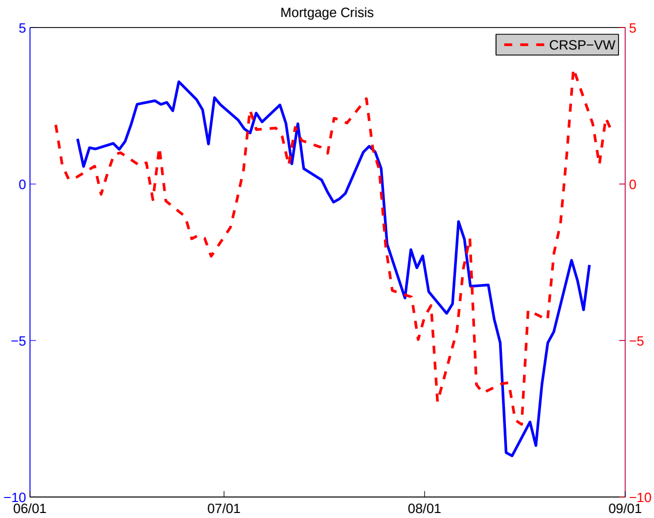

Figure 2: The Carry Trade and the US Stock Market during the Mortgage Crisis.

This figure plots the one-month HML_{FX} at daily frequency against the one-month return on the CRSP-VW index at daily frequency. The sample is 06/01/07-09/01/07.

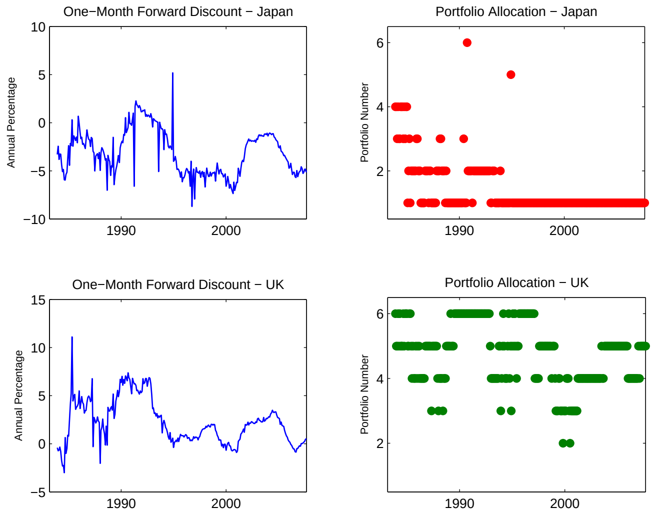

Figure 3: Portfolio Allocation for the UK pound and the Japanese yen.

This figure plots, for the UK pound and the Japanese yen, the one-month forward discount and the portfolio to which the currency was allocated. Data are monthly. The sample is 11/1983 - 08/2007.

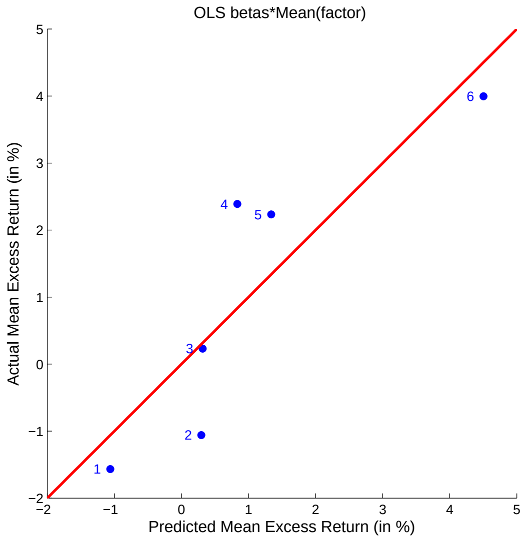

Figure 4: Predicted against Actual Excess Returns.

This figure plots realized average excess returns on the vertical axis against predicted average excess returns on the horizontal axis. We regress each actual excess return on a constant and the risk factors RX and HML_{FX} to obtain the slope coefficient β^j. Each predicted excess returns is obtained using the OLS estimate of β^j times the sample mean of the factors. All returns are annualized. The date are monthly. The sample is 11/1983 - 08/2007.

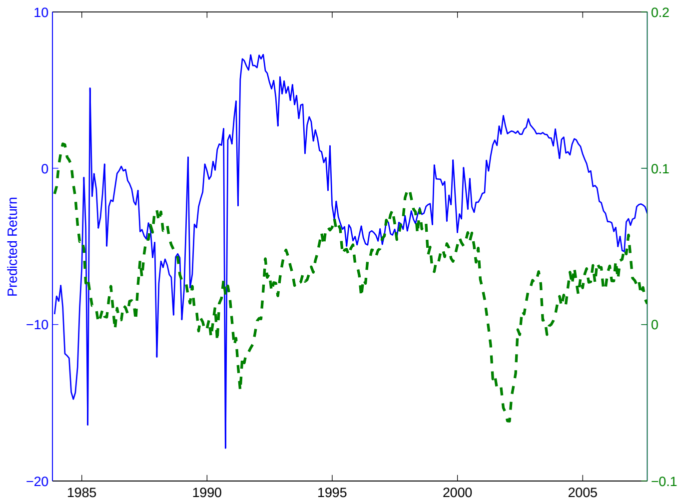

Figure 5: Forecasted Excess Return in Currency Markets and US Business Cycle.

This figure plots the one-month ahead forecasted excess returns on portfolio 2 ($\widehat{E}_t rx^2_{t+1}$). All returns are annualized. The dashed line is the year-on-year log change in US Industrial Production Index.