Country Fundamentals and the Cross-Section of Currency Excess Returns

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Abstract

The uncovered interest parity (UIP) fails to explain currency returns. High-yield currencies have higher returns than what the UIP predicts, and low-yield currencies have lower returns than what the UIP predicts. This makes so-called carry trades profitable. The magnitude of currency excess returns—returns over the UIP prediction—varies significantly across currencies. We attempt to explain the cross-section of currency returns using country fundamentals, i.e. variables indicating macroeconomic condition and policy orientation. A linear factor model framework is adopted in this paper. We construct factor-mimicking portfolios out of these variables, and examine whether the returns to these portfolios explain currency returns. We compare the performance of country-fundamental factors with that of alternative, investment-style factors.

Keywords

Uncovered interest parity, carry trades, cross-section of currency excess returns, country fundamentals

JEL Classification

F31, G12, G15

1. Introduction

The uncovered interest parity (UIP) states that a forward exchange rate is an unbiased predictor of a spot exchange rate. It is based on a no-arbitrage argument: making a deposit of $1 in a US bank should give you the same return as exchanging $1 into a foreign currency, say, euro, and keeping the proceed in a euro deposit. The return from the former is (1+i), where i is the dollar deposit rate. The return from the latter, in dollar terms, is $(1+i^*)S_{t+1}/S_t$, where i^* is the euro deposit rate, and S_t and S_{t+1} are the current and future exchange rates between dollar and euro expressed as the number of dollars per euro. The equivalence between these two returns gives us a UIP formula:

$$\frac{1+\mathrm{i}}{1+\mathrm{i}^*}=\mathrm{E_t}\left(\frac{\mathrm{S_{t+1}}}{\mathrm{S_t}}\right) \tag{1}$$

A more conventional UIP version is obtained if we substitute $\mathrm{F_t/S_t}$ for $(1+\mathrm{i})/(1+\mathrm{i}^*)$, where $\mathrm{F_t}$ is the current forward rate. The substitution is possible due to the covered interest parity, which is based on another no-arbitrage argument involving the forward contract.[1] After the substitution, the UIP is stated as

$$\frac{\mathrm{F_t}}{\mathrm{S_t}}=\mathrm{E_t}\left(\frac{\mathrm{S_{t+1}}}{\mathrm{S_t}}\right) \tag{2}$$

The empirical performance of the UIP has been disappointing. Unconditional and conditional versions of (1) and (2) have been rejected by data.[2] In recent years, the persistent profits of so-called carry trades have been linked to the failure of the UIP[3]. Carry traders borrow in a low-interest currency and simultaneously lend in a high-interest currency, their profit being $\mathrm{S_{t+1}/S_t}-(1+\mathrm{i})/(1+\mathrm{i}^*)$ when $\mathrm{i}^*>\mathrm{i}$. Alternatively, carry traders take a long forward position in a high-interest currency against a low-interest currency, their profit being $\mathrm{S_{t+1}/S_t}-\mathrm{F_t/S_t}$. Thus, persistent carry profits invalidate (1) and (2).

As with many other anomalies in the financial markets, there have been two strands of explanations for the failure of the UIP: risk-based explanations and behavioral explanations. The risk-based explanation would emphasize the role of exchange rate risk. Note that the no-arbitrage argument behind the UIP is not a true no-arbitrage argument. A violation of the UIP creates a profit opportunity, but this profit is not a true arbitrage profit. The future spot rate $\mathrm{S_{t+1}}$ is uncertain at time t, and a positive profit to an 'arbitrageur' can be a reward for bearing exchange rate risk. In terms of carry traders, buying a high-interest currency involves a risk that the value of the high-interest currency may fall more than predicted by the current forward rate. On the other hand, the behavioral explanation emphasizes biases of investors. Carry profits are linked to the unwillingness of international investors to invest in high interest currencies, possibly due to home bias, or due to an incorrect evaluation of the risks involved in investing in high-interest currencies.

In this paper, we focus on the cross-section of currency excess returns. We define currency excess returns as the currency returns in excess of the UIP as formulated in (2), i.e. $\mathrm{S_{t+1}/S_t}-\mathrm{F_t/S_t}$. We first confirm the failure of the UIP in our sample, and show that excess returns vary

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[1] Putting \$1 into a dollar deposit pays the same return as exchanging \$1 into $1/\mathrm{S_t}$ euros, putting the proceeds into a euro deposit, and selling forward $(1+\mathrm{i}^*)/\mathrm{S_t}$ euros for $\mathrm{F_t}$ dollars. The former pays $(1+\mathrm{i})$ dollars, and the latter pays $(1+\mathrm{i}^*)\mathrm{F_t/S_t}$. Thus, $1+\mathrm{i}=(1+\mathrm{i}^*)\mathrm{F_t/S_t}$.

[2] See, for example, Hansen and Hodrick (1980) and Fama (1984).

[3] See, for example, Brunnermeiser, Nagel, Pedersen (2008), Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011).

significantly across currencies. Then we attempt to explain the cross-section of currency excess returns. We take a risk-based view. We adopt the framework of the linear factor model, and utilize country fundamentals as well as the returns of popular investment styles as potential factors.

Our approach was motivated by a recent work of Lustig, Roussanov, and Verdelhan (2008) and also a work of Lustig and Verdelhan (2007). They explained the cross-section of currency returns with each currency's exposure to a common factor—the global carry profits in case of Lustig, Roussanov, and Verdelhan (2008), and the global consumption growth in case of Lustig and Verdelhan (2007). We extend their framework, and include country fundamentals—default risk, exchange regime, the degree of capital control, and the size of capital market—as additional factors.

Other authors have examined the cross-section of currency returns as well. For example, Frankel and Poonawala (2010) explained the cross-section of currency returns with the forward rate, F_t/S_t. The idea that the cross-sectional variation is related to the forward rate has been around for some time. However, using the forward rate as an explanatory variable in a panel regression is not compatible with a risk-based view of currency excess returns. The regression model of Frankel and Poonawala is a characteristics model in the spirit of Daniel and Titmann (1997), rather than a risk-factor model in the spirit of Fama and French (1992, 1993). The study by Ito and Chinn (2007) has a similar limitation. We did adopt many explanatory variables from their study, and transformed them so that they fit the linear factor model framework.

In addition to country-fundamental factors, we took the investment-style factors used by Pojarliev and Levich (2008, 2010, 2011), and compared the effectiveness of their factors to ours. The factors used by Pojarliev and Levich are returns to popular currency strategies such as carry, value, trend following, and volatility. Note that Pojarliev and Levich used these factors to explain the performance of currency fund managers, not the currencies themselves. Thus, the estimation of a model based on these factors is of interest in its own right as well.

Our main findings can be summarized as follows.

- The UIP is violated by emerging market (EM) currencies as well as developed market (DM) currencies, which confirms the results of existing research.
- When currencies are sorted based on fundamentals—forward discount, exchange regime, the degree of capital control, and the size of capital markets,—there are persistent return differences between high-ranked currencies and low-ranked currencies. When currencies are sorted by default risk, the return differences between high-ranked currencies and low-ranked currencies are not persistent. As far as forward discount is concerned, this pattern has been discussed extensively in the literature. The same cannot be said about the other fundamental variables.
- Forward discount, the degree of capital control, and the size of capital markets are significant factors, i.e. they help to explain the cross-section of currency excess returns.

The significance of the forward discount has been already reported by the literature; the significance of other variables in this context has not been discussed in the literature. When we split the sample into DM currencies and EM currencies, we also find that exchange regime is a significant factor in both cases, though with opposite signs. We estimate two three-factor models—one model including the forward rate, default risk, and exchange regime and another model replacing default risk with the size of capital markets—for each currency. We find that the model cannot be rejected for 13 out of 19 currencies.

- Investment-style factors of Pojarliev and Levich are mostly not significant as pricing factors. When a three factor model was estimated for individual currencies, the model was rejected except for five currencies. Certainly, country fundamentals are better factors than investment style returns.

The rest of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes data and methodology. Section 4 discusses unconditional and conditional tests of UIP and the persistence of carry profits. Section 5 presents and discusses linear factor models based on country fundamentals. Section 6 discusses linear factor models based on investment style returns, and section 7 concludes.[4]

2. Literature Review

The empirical failure of the UIP was reported as soon as enough data on floating exchange rate regime accumulated. Hansen and Hodrick (1980) reported the rejection of the UIP using exchange rates among major currencies from 1970s.[5] The study by Fama (1984) was based on similar period and currencies, and the failure of the UIP was confirmed once again. The focus of the paper, though, was on documenting the time variation in the risk premium.

EM currency data were soon included in the analysis. Bansal and Dahlquist (2000) reported that the violation of UIP is not as significant in EM data, which was confirmed by Frankel and Poonawala (2010). Flood and Rose (2002) and Burnside, Eichenbaum, and Rebelo (2007) reported strong violation of UIP in EM data. Gilmore and Hayashi (2011) resolved these contradictory findings. If one looks at country-by-country and average across countries, one gets the result of the former, i.e. no significant violation of UIP. If one selects high yielding countries, then one gets the result of the latter, i.e. significant violation of UIP. That is, there is large variation among EM

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[4] We present further details on variable construction in appendix.

[5] They also obtained the same conclusion using data from the 1920s, which were more limited in scope.

currencies, with high yield EM currencies with significant carry profits driving the pattern.

While Fama (1984) pointed to the possible role of risk premium in explaining currency excess returns, more serious efforts to explain currency excess returns and carry profits began later. Brunnermeiser, Nagel, and Pedersen (2008) provided more concrete meaning to the currency risk by relating it to the risk of currency crashes. Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011) explained carry profits in terms of the peso problem, "the effect of the inference caused by low probability events that do not occur in the sample." Their idea is that, in a long-enough period of sample, there would not be significant carry profits.

Burnside, Eichenbaum, Kleshchelski, and Rebelo argued that linear factor models do not explain carry profits. Note, however, that their main interest was explaining time-variation rather than cross-sectional variation. Also, what they tested was whether currency portfolio returns fit within the system of equity returns. Their analysis leaves a room for a currency factor model not based on equity factors. Lustig, Roussanov, and Verdelhan (2008) indeed showed that a single factor model based on global carry returns does a good job of explaining the cross-section of currency excess returns. Lustig and Verdelhan (2007) showed that a consumption-CAPM type model also explains the cross-section of currency excess returns.

We borrow our main question from Ito and Chinn (2007), who examined the role of macroeconomic and policy variables in explaining the cross-section of currency excess returns. The methodology of Ito and Chinn, however, is not compatible with a risk model. Their model is a characteristics model in the spirit of Daniel and Titmann (1997), who explained the cross-section of stock returns using firm characteristics. Our approach is more in line with the three-factor model of Fama and French (1992, 1993), who explained the cross-section of stock returns in terms of individual firms' exposures to common risk.

We took the investment-style factors used by Pojarliev and Levich (2008, 2010, 2011). They, in a series of very original papers, applied a factor model framework to evaluate currency fund managers. We take their model and apply it to currencies, not currency managers. Interestingly, this model does not 'work' very well with currencies. Our interpretation is that 'fundamental factors' are more effective in explaining the cross-section of currency returns than 'style factors' are.

Somewhat related to our study is the literature on the default risk in the currency markets. Coffey, Hrung, and Sarkar (2009) and Fong, Valente, and Fung (2010) examined whether measures of default risk can explain the violation of the CIP. Melvyn and Taylor (2009) examined the role of default risk in explaining the time-variation in carry profits. We include a measure of default risk—called the distance to default—into our analysis of the cross-section of currency excess returns.

3. Data and Methodology

We define a currency excess return as the ratio of a spot rate S_{t+1} over a lagged forward rate F_t minus one. The spot rates and the forward rates were collected from Bloomberg, and they were supplemented by data from Reuters.

We measure country fundamentals in terms of the forward discount (FD), the average distance-to-default (DD), the average stock beta (SB), a measure of capital control (CC), a measure of exchange regime (ER), the size of domestic credit (DC), and per-capita income (PI). To construct these variables, we collected deposit rates from Reuters, stock market data from MSCI, and other macroeconomic variables from World Bank' *World Development Indicators*, Chinn and Ito (2008), and Ilzetzki, Reinhart and Rogoff (2008).[6] We also collected firm-level stock prices and accounting data from IDC and Worldscope.

We collected data for every country that is a member of MSCI All Country Index, which includes all the major capital markets in the world that are open to foreign investment. Data availability, however, forced us to exclude certain countries/currencies from our analysis. We test the UIP for 13 developed-market currencies and 22 emerging-market currencies using monthly data from February 1996 to December 2010. The sample is not balanced; i.e. different series have different start date. The estimation of factor models uses a smaller subset, a balanced panel of 19 currencies (11 DM and 8 EM currencies) and 120 months from January 2001 to December 2010.[7]

For the robustness check, we repeated all of our analysis using the exchange rate data of Gilmore and Hayashi (2011), which are known to be more accurate than public exchange rate data. The data set of Gilmore and Hayashi include 20 currencies for the period between 1996 and 2010. Only 16 of these 20 currencies could be used in our analysis due to the lack of stock market and macroeconomic data. The results were mostly comparable to those based on our exchange rate data.

In the following sections, we present two types of empirical analysis—the test of UIP and the

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[6] See the appendix for the details on data sources and variable construction procedures.

[7] The following 19 currencies are included in the factor model estimation (3-digit currency codes are in parentheses): Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), Chinese yuan (CNY), Czech koruna (CZK), Danish kroner (DKK), euro (EUR), British pound (GBP), Hong Kong dollar (HKD), Hungarian forint (HUF), Indonesian rupee (IDR), Japanese yen (JPY), Korean won (KRW), Mexican peso (MXN), Norwegian krone (NOK), Philippine peso (PHP), Polish zloty (PLN), Swedish krona (SEK), Singapore dollar (SGD). In the test of the UIP, additional 15 currencies are included: New Zealand dollar (NZD), Brazilian lira (BRL), Chilean peso (CLP), Colombian peso (COP), Egyptian pound (EGP), Israeli shekel (ILS), Indian rupee (INR), Moroccan dirham (MAD), Malaysian ringgit (MYR), Peruvian neuvo sol (PEN), Russian ruble (RUB), Thai baht (THB), Turkish lira (TRY), Taiwanese dollar (TWD), and South African rand (ZAR).

estimation of linear factor models. The test of UIP, in turn, has two flavors—the unconditional test and the conditional test. In the unconditional test of UIP, we examine whether the unconditional mean of the excess currency return is different from zero. That is, the null hypothesis is:

$$\mathrm{E}\left(\frac{S_{i,t+1}-F_{i,t}}{S_{i,t}}\right)=0 \tag{3}$$

for each currency i.[8] We employ the conventional t test; i.e. we construct the t statistic out of the sample mean and the sample standard deviation. In the conditional test of UIP, we examine whether the forward discount is correlated with the excess currency return. That is, the null hypothesis is

$$\beta_i = 0 \tag{4}$$

where β_i is the slope coefficient in the regression of the excess return of currency i on the forward discount of currency i, i.e.

$$\frac{S_{i,t+1}-F_{i,t}}{S_{i,t}}=\alpha_i+\beta_i\left(\frac{F_{i,t}}{S_{i,t}}-1\right)+\varepsilon_{i,t+1} \tag{5}$$

The conventional t test is employed again.

A linear factor model, sometimes also called a stochastic discount factor (SDF) model, specifies that any excess return is orthogonal to a stochastic discount factor, which is a linear function of a small number of common factors. Let $R_{i,t+1}$ be the excess return of currency i, i.e., $R_{i,t+1}=(S_{i,t+1}-F_{i,t})/S_{i,t}$. Let M_{t+1} be the stochastic discount factor, which is a linear function of factors f_{t+1}, i.e.,

$$M_{t+1}\equiv 1-b'(f_{t+1}-\mu) \tag{6}$$

μ is the mean of the factor returns, and b is a vector of 'factor loadings'. The orthogonality condition can be stated as:

$$\mathrm{E}\left[M_{t+1}R_{i,t+1}\right]=0 \tag{7}$$

for all i. The main parameters of the interest is factor prices, λ, which is defined as

[8] We could have defined the excess return as $(S_{i,t+1}-F_{i,t})/F_{i,t}$ so that the forward rate, not the spot rate is in the denominator. This formulation would have been simpler from the algebraic point of view. However, from a real-life investor's point of view, the use of the spot rate in the denominator makes more sense. If an investor buys one unit of foreign currency in the forward market, at the forward price of $F_{i,t}$, then the profit at time t+1 is $S_{i,t+1}-F_{i,t}$. The rate of return calculation depends on the amount of equity that the investor committed at the time of initiating the forward contract. Given that the investor has the exposure to one unit of foreign currency, the investor may want to keep the *current,* rather than forward, value of one unit of foreign currency as the equity of the investment, if the investor wants to keep the foreign exposure to zero. In this case, the amount of equity would be $S_{i,t}$, not $F_{i,t}$.

$$\lambda = \mathrm{var}(f_{t+1})\ b \tag{8}$$

λ can be estimated by the generalized method of moments of Hansen (1982).[9]

The GMM estimation of the linear factor model above is equivalent to two-stage estimation procedure of Fama and MacBeth (1973) if the second stage estimation is appropriately performed. In the first step of Fama-MacBeth methodology, time series of excess returns $R_{i,t+1}$ are regressed on time-series of factor returns f_{t+1}, and coefficient estimates β_i are obtained.[10] In the second stage, cross-section of (average) excess returns are regressed on cross-section of (lagged) β_i, and coefficient estimates are interpreted as factor prices. The relationship between the GMM estimation and the two-stage estimation becomes clearer once we rewrite the orthogonality condition (7) in terms of covariance between $R_{i,t+1}$ and f_{t+1}:

$$\begin{aligned} E(R_{i,t+1}) &= \mathrm{cov}(R_{i,t+1}, f_{t+1}')[\mathrm{var}(f_{t+1})]^{-1}\mathrm{var}(f_{t+1})\ b \\ &= \beta_i\lambda \end{aligned} \tag{9}$$

We carry out the first stage of Fama-MacBeth methodology to report the estimate of β_i as well as the constant term. The significance of the constant term is another indicator of the validity of the linear factor model.

Factor returns f_{t+1} were constructed in the conventional way, i.e. as in the three factor model of Fama and French (1992, 1993). Using each variable x measuring country/currency fundamentals, we sorted all currencies and created three portfolios out of the sort: high x portfolio, middle x portfolio, and low x portfolio. We then calculated the equal-weighted portfolio returns. Finally, the return to factor x was calculated as the 'high-minus-low' return, i.e. the high portfolio return minus the low portfolio return. Seven variables were used as x: the forward discount (FD), the average distance-to-default (DD), the average stock beta (SB), a measure of capital control (CC), a measure of exchange regime (ER), the size of domestic credit (DC), and per-capita income (PI).

To summarize, our estimation of factor models proceeded in three steps. In the first step, we calculated factor returns f_{t+1} out of the high-minus-low return after sorting currencies by country/currency fundamental. In the second step, we estimated factor prices λ by GMM. In the third step, we estimated factor betas β_i by OLS.

4. UIP and Carry Profits

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[9] See Cochrane (1996) and Kan and Zhou (1999) on the GMM estimation of the linear factor model.

[10] This β_i has nothing to do with β_i from the conditional test of UIP. We do not introduce separate notations in the hope that no confusion will arise.

We tested the unconditional and conditional versions of the UIP for each currency in our sample. The unconditional UIP was rejected for about half of EM currencies, though it was not rejected for DM currencies. The conditional UIP was rejected for about half of EM currencies and also for about half of DM currencies. These results are consistent with those of the previous research.

Table 1 reports the test of the unconditional UIP, as stated in (3), for each currency in the sample. In the table, XR means the currency excess return $(S_{i,t+1} - F_{i,t})/S_{i,t}$, while FD means the forward discount $F_{i,t}/S_{i,t} - 1$. Both XR and FD are annualized.

The column with heading 'T stat' is of our primary interest. It is the value of the t statistic under the null hypothesis that XR has zero mean. A high T statistic leads to the rejection of the unconditional UIP. It can be seen that the unconditional UIP is not rejected in any of 12 DM currencies. However, it is rejected for 13 out of 22 EM currencies.

The mean of XR is mostly positive. Recall that the exchange rate is quoted as the US dollar price of the non-US dollar currency. Thus, a positive value of XR means that the non-US dollar currency appreciated more than predicted by the forward rate. The mean of FD is mostly negative, and the probability of FD being negative is higher than 50% for most currencies. A negative value of FD means that the non-US dollar currency is expected to depreciate. This happens if the interest rate of the non-US dollar currency is higher than that of the US dollar. Considering both XR and FD, one can observe the following pattern: non-US dollar currencies had higher interest rates than US dollar, and either appreciated over time or depreciated, but not as much as predicted by forward rates.

This pattern is consistent with carry profits. A buy-and-hold carry trader would take a long forward position in non-US currencies against US dollar, as the former have higher interest rates than the latter. The excess return XR in Table 1 is the profit to this buy-and-hold carry trader. Most likely, however, carry traders in real life do not follow a buy-and-hold strategy. They change the position depending on which currency has a higher interest rate at each rebalancing moment, and consequently the return to carry traders tends to be higher than reported in Table 1. In fact, carry profits tend to be significantly positive for more currencies when changing positions is allowed.

Note that we did not consider any 'crosses,' i.e. exchange rates between two non-US currencies. Given the dominant role of US dollar in the foreign exchange market, this does not seem problematic. We note, however, that currency traders do trade significant amount of crosses, and we do not fully capture this aspect in our analysis.

Table 2 reports the test of the conditional UIP as stated in (5). Of primary interest to us is the column with the heading 'Slope/T stat.' This column shows the value of the t statistic under the null hypothesis that the slope is zero, i.e. the forward discount does not help to predict currency excess returns. As can be seen in the table, this hypothesis is rejected for 6 out of 12 DM currencies, and for 11 out of 22 EM currencies.

The slope estimates are mostly negative: when the forward discount is large (i.e. interest differential is large), currency excess return is large as well. There is only one significant exception, the case of Russian rubles against US dollars. In all other cases, the forward discount helps to predict the magnitude of currency excess returns.

This pattern has been known to practitioners for some time, and has been used as a justification for the 'conditional carry strategy.' In the conditional carry strategy, position size is proportional to the size of forward discount. Whether a portfolio of such positions performs better than a portfolio of unadjusted position depends on the cross-sectional correlations among those positions. This is another motivation for the factor model that we develop in this paper. Once we have a factor model that explains the cross-section of currency excess returns, we could use this model to analyze the optimal weighting problem of carry positions.

Both tests of UIP show that there is a substantial variation across currencies. Annualized currency excess returns vary from -1% for Japanese yen to +19% for Thai baht. In the conditional test of UIP, the slope coefficients vary from -4.6 for Danish krone to 0.6 for Malaysian ringgit. That is, one percent drop in forward discount is expected to increase currency returns by as much as 4.6%, or decrease currency returns by up to 0.6%. Such significant variation across currencies is the subject of our analysis in the following sections.

5. Fundamental Factor Models of Currency Excess Returns

In this section, we discuss the estimates of 'fundamental factor models,' i.e. factor models based on country fundamentals. We first describe our choice of variables representing country fundamentals. Then we examine the returns to the factor-mimicking portfolios. Finally, we discuss the estimates of factor prices and betas.

We include variables to capture four aspects of country fundamentals—interest rates, default risk, foreign exchange policy, and the size of capital markets.

Previous studies such as Lustig, Roussanov, and Verdelhan (2008) used global carry profits as a common factor. Global carry profits are calculated from interest rate-sorted portfolios. So it is natural to consider interest rates in our analysis. Also, the conditional test of the UIP suggests that forward discount $F_{i,t}/S_{i,t}$, which is essentially an interest rate variable under the CIP, is an important explanatory variable. We use forward discount (FD) in our analysis as the variable representing interest rates.

The second aspect of country fundamentals that we consider is the default risk of banking system. Previous studies looked at the role of the default risk in the violation of CIP. Coffey, Hrung, and Sarkar (2009) attributed the failure of CIP during the financial crisis to the increased counter-party risk and the lack of funding. Fong, Valente, and Fung (2010) confirmed that the CIP breakdown is mainly due to the credit risk and the liquidity problem. While the object of our study is the UIP, not the CIP, we still believe that the default risk of banking system is relevant. When the banking system is in crisis, it will inevitably affect the currency risk and thus currency returns. With a similar idea, Melvyn and Taylor (2009) related the financial market stability to carry profits. As a proxy variable for default risk, we calculated the average distance-to-default (DD). Gropp, Vesala, and Vulpes (2006) and, especially, Chan-Lau, Jobert, Kong (2004) show that the DD is useful in predicting bank vulnerabilities in emerging markets. The idea of measuring the default risk from the implied market values of the total asset and the debt was first suggested by Black and Scholes (1973) and Merton (1974). The DD measure was initially developed for KMV, a company later absorbed by Moody's. Crosbie and Bohn (2003) describe Moody's KMV implementation of the DD. As an alternative measure of default risk, we also calculated the average of banking stock beta (SB). The beta of an individual bank was calculated from a traditional CAPM with the local stock market index as the proxy for the market portfolio. The betas of all the banks in one currency zone were averaged to obtain SB.

The third aspect of country fundamentals that we consider is foreign exchange policy. The motivation for looking at this is the observation that countries adopt different exchange rate regimes and many countries impose varying degrees of capital control as well. If the capital control is of the most extreme form and the currency is completely pegged to US dollar, then the currency risk can be limited. However, if there is high likelihood of capital control being imposed or lifted, then the currency risk may increase substantially. Notably, Ito and Chinn (2007) have shown that foreign exchange policy is relevant for currency returns. To capture foreign exchange policy, we take two variables, capital control (CC) and exchange regime (ER), from Ito and Chinn (2007) with some modification.[11] Flood and Rose (2002) also considered the effect of exchange regime to carry profits in DM and EM currencies.

We include variables to capture the size of the capital markets as well. Size effect is known to matter for equity returns. We hypothesize that size effect may matter for currency returns as well. Investing in a country with small capital markets may seem more risky than investing in a country with large capital markets. Also, the size of capital markets may affect the volatility of exchange rates more directly if market prices are affected by trading volume. We use domestic credit (DC) and per-capita income (PI) as proxies for the size of capital markets.

In sum, we collected 7 variables—FD, DD, SB, CC, ER, DC, PI—for each of 19 currencies in our balanced panel. We adjusted the sign each variable (i.e. multiply by -1 when necessary) such that a higher value is expected to have a more positive effect on currency returns. That is, FD is high if the currency has a high interest rate, DD is high if the default is more likely, SB is high if the beta is high, CC is high if there is more capital control, ER is high if exchange regime is farther away

[11] See the appendix.

from free floating, DC is high if domestic credits are small, PI is high if per-capita income is low.

At the end of each month of the sample period (December 2000 to December 2010), we sorted all currencies by each of 7 variables,[12] and created two portfolios for each sort, i.e. 7 x 2 = 14 portfolios in total. The high portfolio includes all currencies with above-median value of the sorting variable; the low portfolio includes all currencies with below-median value of the sorting variable. Finally, a long-short portfolio was created by taking a long position in the high portfolio and a short position in the low portfolio. We had 7 long-short portfolios, one for each of 7 variables. These portfolios are what we called the factor-mimicking portfolios. The returns to these portfolios were calculated by equally weighting each currency in the portfolio. We call these returns 'factor returns.'

Figure 1 shows the performances of the factor-mimicking portfolios, i.e. indexes made of factor returns. It is clear that all the factors, except DD and SB, accumulated substantial amount of returns over time. FD, CC, and DC have similar pattern in that they show a significant drop in 2008, followed by a recovery. ER continues to grow up to the end of 2008, after which its trend reversed. PI maintained the growth pattern throughout. DD and SB do not accumulate returns over a long time. The pattern exhibited by FD has been discussed extensively in the literature. Around the financial crisis 2008, carry traders faced unprecedented loss, and the profits accumulated since the middle of the decade were almost wiped out. Carry profits eventually came back. Figure 1 suggests that CC and DC factors have similar patterns, but not the other factors.

Table 3 reports the estimates of factor prices, λ in (8). All the estimates were obtained from GMM. In the first panel of Table 3, all 19 currencies were included in the estimation, while in the second (third) panel, only DM (EM) currencies were included. Each column in the table represents a separate estimation. For example, the first column shows the estimates from the model with FD, DD, and CC only, while the second column shows the estimates from the model with FD, DD, and ER. Given the relatively small sample size, we limited the number of factors in each estimation to three. To save space, we do not show the estimation results from all possible combinations.

In the first panel, we observe that four factors—FD, CC, DC, and PI—are persistently significant, across specifications. All of them are positive, as we expected. In the second and the third panels, one major difference is the significance of ER. What is interesting is that ER is significantly negative for DM currencies, while it is significantly positive for EM currencies. The unexpected sign of ER can be partly explained by the relative homogeneity of ER among DM currencies.

J statistics reported at the end of each panel test the hypothesis that all of the over-identifying restrictions in the GMM estimation are valid. To put it another way, these statistics

[12] Some of these variables (FD, DD, SB) are monthly, while the rest are annual. For the annual variable, we assigned the same value for every month in a year.

show whether the model is well specified. A lower value of the J statistic and a higher value of the associated p value indicate that the model is well specified. Statistically speaking, all the models in the first panel are rejected at the conventional significance level of 5%. However, we can still compare which model is relatively superior. It turns out that the model shown in column (2), which includes FD, DD, and ER, has the best model statistic. In the second panel and the third panel, many models are acceptable at the conventional significance level.[13] While model (2) does relatively well, model (5), which includes FD, ER, and DC, is the best in the last panel. Thus, for our estimation of betas, we focus on these two models, (2) and (5).

Table 4 lists the beta estimates for each currency. The first panel is based on the model including FD, DD, and ER. The second panel is based on the model including FD, ER, and DC. Whether betas are significant can be indicative of the usefulness of the models. FD is significant for most currencies, and DD and DC are significant for about half of the currencies. ER betas are less significant. Of more interest to us than the significance of betas is the significance of the intercept. A significant intercept indicates that the model fails to be a proper risk model: If the model is a proper risk model, any excess returns not correlated with risk factors should average out to be zero. In Table 4, the intercept is significant in 6 out of 19 currencies. While this is not an extraordinary performance, we still take this as a positive indication for the model. We comment further on this after we examine the estimation of alternative models in the next section.

6. Comparison to Investment Style Factors

In this section, we repeat the analysis of the previous section using investment-style factors. We take the style factors from Pojarliev and Levich (2008, 2010, 2011). They used four style factors—the carry factor, the momentum factor, the PPP factor, and the volatility factor.[14] While Pojarliev and Levich used these factors to evaluate currency fund managers, we use these factors to explain currency excess returns.

All of these factors were calculated by Deutsche Bank. Pojarliev and Levich used an alternative source for the momentum factor; this alternative series is not updated anymore,

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[13] We do note that the sample size, in the cross-sectional dimension, is quite small, and this makes statistical tests very weak. That is to say, the acceptance of our models was achieved very easily. In any case, our main interest is in the relative performance of alternative models, rather than in the absolute evaluation of models.

[14] Pojarliev and Levich used the terms "trend" and "value" rather than momentum and PPP. We use momentum and PPP, to be more explicit. These are the terms used by the data provider (Deutsche Bank) as well.

making it unsuitable to our study.

Figure 2 plots the indexes made from factor returns. Not surprisingly, the carry factor shows a pattern similar to that of our FD factor. These two factors were calculated in similar ways. Carry factor is based on 9 major currencies and three sorted portfolios, while our FD factor is based on 19 currencies and two sorted portfolios. Except the volatility factor, all the rest show a long-term growth pattern.

Table 5 shows the estimates of factor prices. The momentum factor is significant in some instances; otherwise, the other factors are not significant regardless of the specifications. J statistics and the associated p values also show low fits of the models. Table 6 shows the estimates of betas and the intercept. While betas are mostly significant, the intercept is also significant, for 14 out of 19 currencies. That is, the model is acceptable only for five out of 19 currencies. Recall that the fundamental factor models were acceptable for 13 out of 19 currencies. While the style factor models capture the major market movements, fundamental factor models do better job in explaining currency excess returns.

7. Conclusion

We estimated 'fundamental factor models' of currency excess returns using variables characterizing each country's default risk, exchange rate policy and size. We showed that the model has some explanatory power and a low rejection rate. As a way of comparison, we estimated 'style factor models' using factors of Pojarliev and Levich (2008, 2010, 2011). While style factors explain currency fund managers' performance very well, they do not explain currency excess returns as much as fundamental factors do.

The results show the relevance of country fundamentals in the determination of currency returns. Our analysis also illustrates a possibility of using an equity-risk-modeling-type approach in explaining currency excess returns. The analysis can be readily extended to the analysis of carry profits.

Appendix: Variable Construction Details

We measure the default risk of a bank by the distance-to-default of Gropp, Vesala, and Vulpes (2006). We then average the distance-to-default across banks within each currency area, and use the average as the measure of the default risk of that currency. For currency j at time t, the average distance-to-default is

$$\mathrm{ADD}_{j,t} = \frac{1}{K}\sum_{k} \mathrm{DD}_{k,t}$$

if there are K banks in currency j area. $\mathrm{DD}_{k,t}$ is the distance-to-default of bank k at time t and is defined as

$$\mathrm{DD}_{k,t} = \frac{\ln\frac{V}{D} + \left(r - \frac{\sigma_V{}^2}{2}\right)}{\sigma_V}$$

V is the market value of all the assets, σ_V is the standard deviation of V, D is the book value of the debt, and r is the risk-free rate. All the variables depend on time t, and V, σ_V, and D also depend on bank index j. We omitted subscripts for convenience.

While D and r are directly observable, V and σ are not. V and σ_V are computed from the option pricing formula. The intuition is that equity is a call option on the assets of the firm with the strike price equal to the face value of the debt. As we know the value of this option, we can infer the value of the assets from the option. V and σ_V are the solution to the system of nonlinear equations:

$$E = V\Phi\left[\frac{\ln\frac{V}{D} + \left(r + \frac{\sigma_V{}^2}{2}\right)}{\sigma_V}\right] - De^{-r}\Phi\left[\frac{\ln\frac{V}{D} + \left(r - \frac{\sigma_V{}^2}{2}\right)}{\sigma_V}\right]$$

$$\sigma_E E = \sigma_V V\Phi\left[\frac{\ln\frac{V}{D} + \left(r + \frac{\sigma_V{}^2}{2}\right)}{\sigma_V}\right]$$

In the above equations, E is the market value of equity, σ_E is the standard deviation of the stock return, and Φ is the cumulative distribution function for the standard normal distribution. Note that we would have liked to use the face value of the debt rather than the book value of the debt, as the face value corresponds to the 'strike price' of the option. This modification is justified by the consideration that the firm may avoid default even if the market value of the firm is slightly lower than the face value of the debt. The solution is found by numerical methods.

The distance-to-default measure was initially developed for KMV, a company later absorbed by Moody's. Crosbie and Bohn (2003) describe Moody's KMV implementation of the distance-to-default, which involves an estimation of the growth rate of asset value. We follow Gropp, Vesala, and Vulpes (2006) and Chan-Lau, Jobert, Kong (2004), and do not proceed with the estimation of the growth rate of asset value. Our approach is much simpler, but the resulting distance-to-default is certainly less accurate.

We measure the degree of capital control for each country by the financial openness index developed by Chinn and Ito (2008). Applying the method of principal components to the binary variables which codify the restrictions on the capital account transactions reported in the IMF' Exchange Arrangements and Exchange Restrictions (AREAR), they construct the annual index for 182 countries. The updated data up to 2009 is available at Chinn's internet homepage, http://web.pdx.edu/~ito/Chinn-Ito_website.htm. In our estimation, we assume the degree of the sample countries' capital control in 2010 is the same as in 2009.

Reinart and Rogoff (2004) developed a new system of classifying *de facto* exchange rate system, and constructed the regime index for 153 countries from 1946 to 2001. Their index was later updated up to 2007 by Ilzetzki, Reinhart and Rogoff (2008). Their classification mainly differs from others' in that it more focuses on market-determined exchange rates rather than the official rates. We basically use Reinart and Rogoff's annual coarse index for classifying the sample countries' exchange rate regimes. They are categorized into four groups: peg, crawling peg or band, managed float, and finally free floating exchange rate system. We extended the Reinhart and Rogoff's index to 2010 using the information on the exchange rate arrangements reported in IMF's AREAR. IMF adopted a revised system for the classification of exchange rate arrangements, and reported countries' *de facto* exchange rate regime since 1998 (Habermeier, Veyrune, and Anderson, 2009). Reinart and Rogoff's index was obtained at Reinhart's internet homepage, http://www.carmenreinhart.com/research/.

Carry, momentum, PPP, and volatility factors are from Deutsche Bank. They are 'G10 Currency Harvest USD,' 'FX Momentum USD,' 'FX PPP USD,' 'FX Volatility Index,' and can be downloaded from index.db.com.

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Table 1. Unconditional Test of UIP by Currency

XR is the currency excess return, and FD is the forward discount. Both XR and FD are annualized. Listed in the first column are 3-digit currency codes. See footnote 7 for the currency names. Significance at 5% is indicated with ** (positive) and √ √ (negative). Significance at 10% is indicated with * (positive) and √ (negative).

	Start	End	Obs	XR				FD	
	Date	Date		Mean	SD	T stat		Mean	Pr<0
Developed Markets									
AUD	Feb-96	Dec-10	179	0.047	0.128	1.432		-0.018	0.754
CAD	Feb-96	Dec-10	179	0.023	0.086	1.033		0.002	0.436
CHF	Feb-96	Dec-10	179	0.001	0.109	0.029		0.022	0.050
DKK	Feb-96	Dec-10	179	0.003	0.106	0.109		0.005	0.413
EUR	Feb-99	Dec-10	143	0.016	0.110	0.501		0.004	0.490
GBP	Feb-96	Dec-10	179	0.016	0.086	0.729		-0.010	0.816
HKD	Feb-96	Dec-10	179	-0.001	0.006	-0.535		0.000	0.296
JPY	Feb-96	Dec-10	179	-0.010	0.114	-0.344		0.035	0.011
NOK	Feb-96	Dec-10	179	0.021	0.111	0.743		-0.008	0.581
NZD	Feb-96	Dec-10	179	0.045	0.127	1.384		-0.027	0.844
SEK	Feb-96	Dec-10	179	0.004	0.116	0.139		0.005	0.402
SGD	Feb-96	Dec-10	179	-0.004	0.060	-0.239		0.012	0.212
Emerging Markets									
BRL	Aug-00	Dec-10	125	0.132	0.180	2.364	**	-0.109	0.960
CLP	May-98	Dec-10	152	0.021	0.112	0.658		-0.017	0.750
CNY	Jan-99	Dec-10	144	0.006	0.014	1.595		0.013	0.410
COP	Mar-99	Dec-10	142	0.041	0.124	1.125		-0.050	0.930
CZK	Jan-97	Dec-10	168	0.032	0.132	0.901		0.004	0.571
EGP	Apr-04	Dec-10	81	0.104	0.035	7.800	**	-0.094	0.988
HUF	Nov-97	Dec-10	158	0.091	0.139	2.361	**	-0.086	0.956
IDR	Jan-97	Dec-10	168	0.033	0.293	0.421		-0.087	0.911
ILS	Jan-02	Dec-10	108	0.048	0.091	1.589		-0.020	0.676
INR	Nov-97	Dec-10	158	0.045	0.062	2.606	**	-0.059	0.981
KRW	Jan-99	Dec-10	144	0.017	0.122	0.473		-0.004	0.611
MAD	Apr-04	Dec-10	81	0.065	0.094	1.803	*	-0.051	0.852
MXN	Jan-97	Dec-10	168	0.067	0.096	2.605	**	-0.094	0.899
MYR	May-05	Dec-10	68	0.042	0.061	1.642	*	-0.002	0.412
PEN	Aug-00	Dec-10	125	0.033	0.052	2.054	**	-0.012	0.704
PHP	Jan-97	Dec-10	168	0.048	0.093	1.944	**	-0.080	0.964
PLN	Sep-96	Dec-10	172	0.070	0.132	1.999	**	-0.066	0.866
RUB	Sep-01	Dec-10	112	0.048	0.079	1.874	*	-0.048	0.750
THB	Feb-96	Dec-10	179	0.091	0.147	2.387	**	-0.093	0.760
TRY	Apr-01	Dec-10	117	0.193	0.169	3.563	**	-0.219	0.991
TWD	Jan-97	Dec-10	168	0.006	0.058	0.400		-0.009	0.613
ZAR	Feb-96	Dec-10	179	0.049	0.164	1.150		-0.075	0.983

Table 2. Conditional Test of UIP by Currency

In the conditional test of UIP, currency excess returns are regressed on forward discounts. Listed in the first column are 3-digit currency codes. See footnote 7 for the currency names. Significance at 5% is indicated with ** (positive) and √√ (negative). Significance at 10% is indicated with * (positive) and √ (negative).

	Intercept				Slope				R sq
	Est	SE	T stat		Est	SE	T stat		
Developed Markets									
AUD	-0.003	0.004	-0.648		-4.284	1.837	-2.332	√√	0.030
CAD	0.002	0.002	1.297		-3.082	2.009	-1.534		0.013
CHF	0.008	0.004	2.080	**	-4.255	1.647	-2.584	√√	0.036
DKK	0.002	0.002	0.881		-4.589	1.758	-2.611	√√	0.037
EUR	0.003	0.003	1.005		-4.466	2.096	-2.130	√√	0.031
GBP	-0.001	0.002	-0.312		-2.429	1.872	-1.297		0.009
HKD	0.000	0.000	-0.326		-1.000	0.078	-12.738	√√	0.478
JPY	0.006	0.005	1.213		-2.269	1.400	-1.621		0.015
NOK	0.001	0.003	0.485		-0.885	1.207	-0.733		0.003
NZD	0.001	0.005	0.118		-1.413	1.737	-0.813		0.004
SEK	0.001	0.003	0.216		-0.520	1.534	-0.339		0.001
SGD	0.001	0.002	0.825		-1.604	0.895	-1.793	√	0.018
Emerging Markets									
BRL	0.010	0.009	1.173		-0.059	0.841	-0.070		0.000
CLP	0.002	0.003	0.698		0.205	0.846	0.243		0.000
CNY	0.001	0.000	3.600	**	-0.559	0.089	-6.248	√√	0.216
COP	0.003	0.004	0.756		-0.095	0.612	-0.155		0.000
CZK	0.002	0.003	0.829		0.562	1.216	0.462		0.001
EGP	0.001	0.002	0.705		-0.936	0.202	-4.638	√√	0.214
HUF	0.003	0.006	0.416		-0.700	0.733	-0.956		0.006
IDR	-0.003	0.006	-0.508		-0.823	0.178	-4.617	√√	0.114
ILS	0.001	0.003	0.439		-1.738	0.676	-2.570	√√	0.059
INR	-0.006	0.003	-2.194	√√	-1.997	0.489	-4.082	√√	0.097
KRW	0.001	0.003	0.366		-1.057	0.543	-1.948	√	0.026
MAD	0.008	0.005	1.728	*	0.597	0.824	0.724		0.007
MXN	-0.002	0.003	-0.631		-0.962	0.307	-3.138	√√	0.056
MYR	0.003	0.002	1.602		-0.494	0.637	-0.776		0.009
PEN	0.002	0.001	1.581		-0.563	0.446	-1.263		0.013
PHP	0.006	0.004	1.499		0.235	0.466	0.505		0.002
PLN	0.005	0.004	1.194		-0.099	0.600	-0.166		0.000
RUB	0.006	0.002	2.680	**	0.578	0.265	2.177	**	0.041
THB	0.001	0.003	0.180		-0.902	0.142	-6.374	√√	0.187
TRY	0.001	0.007	0.203		-0.801	0.309	-2.587	√√	0.055
TWD	0.000	0.001	0.149		-0.441	0.326	-1.353		0.011
ZAR	-0.014	0.007	-1.906		-2.873	1.030	-2.790	√√	0.042

Table 3. Prices of Fundamental Factors

Each column shows the result of a particular regression. FD is the forward discount, DD is the distance-to-default, SB is the stock beta, CC is the index of capital control, ER is the index of exchange regime, DC is the size of domestic credit, and PI is the per-capita income. Significance at 5% is indicated with ** (positive) and √√ (negative). Significance at 10% is indicated with * (positive) and √ (negative).

All Currencies

	(1)	(2)	(3)	(4)	(5)	(6)
FD	0.0019	0.0020	0.0019	0.0018	0.0018	0.0018
	[1.7268]	[1.8956]	[1.8605]	[1.5364]	[1.6852]	[1.6643]
	*	*	*		*	*
DD	-0.0003	-0.0002				
	[-0.5111]	[-0.2906]				
SB			0.0007			
			[1.0422]			
CC	0.0022			0.0020		
	[2.0499]			[1.9047]		
	**			*		
ER		0.0003	0.0003		0.0003	0.0003
		[1.1245]	[0.9424]		[1.1047]	[1.1377]
DC				0.0011	0.0011	
				[1.8997]	[1.9786]	
				*	**	
PI						0.0010
						[1.9402]
						*
# curncies	19	19	19	19	19	19
# months	120	120	120	120	120	120
J stat	34.94	34.01	34.33	36.15	34.35	34.37
P value	0.0040	0.0054	0.0049	0.0028	0.0049	0.0048

Table 3. Prices of Fundamental Factors [Continued]

DM Currencies

	(1)	(2)	(3)	(4)	(5)	(6)
FD	0.0008	0.0008	0.0009	0.0012	0.0009	0.0011
	[0.6747]	[0.6670]	[0.6933]	[0.9390]	[0.7573]	[0.8555]
DD	-0.0008	-0.0003				
	[-0.8016]	[-0.3016]				
SB			0.0002			
			[0.2822]			
CC	0.0011			0.0011		
	[1.0288]			[0.9823]		
ER		-0.0008	-0.0008		-0.0008	-0.0008
		[-1.9929]	[-2.1697]		[-2.1466]	[-2.2339]
		√√	√√		√√	√√
DC				0.0000	0.0001	
				[0.0299]	[0.1245]	
PI						-0.0002
						[-0.3051]
# curncies	11	11	11	11	11	11
# months	120	120	120	120	120	120
J stat	17.51	14.76	14.86	17.52	15.04	14.75
P value	0.0252	0.0640	0.0619	0.0251	0.0583	0.0641

Table 3. Prices of Fundamental Factors [Continued]

EM Currencies

	(1)	(2)	(3)	(4)	(5)	(6)
FD	0.0016	0.0026	0.0024	0.0016	0.0018	0.0016
	[1.2330]	[1.7466]	[1.7144]	[1.2204]	[1.0897]	[0.9219]
		*	*			
DD	0.0002	0.0009				
	[0.1742]	[0.5491]				
SB			-0.0001			
			[-0.0758]			
CC	0.0019			0.0019		
	[1.7067]			[1.7115]		
	*			*		
ER		0.0026	0.0022		0.0029	0.0029
		[3.0099]	[2.5290]		[2.9764]	[2.7540]
		**	**		**	**
DC				0.0009	0.0030	
				[0.9016]	[2.4386]	
					**	
PI						0.0032
						[1.7908]
						*
# curncies	8	8	8	8	8	8
# months	120	120	120	120	120	120
J stat	19.46	4.00	6.07	19.60	2.98	3.30
P value	0.0016	0.5497	0.2998	0.0015	0.7027	0.6539

Table 4. Betas of Fundamental Factors

The excess returns of each currency are regressed on factor returns. Listed in the first column are 3-digit currency codes. See footnote 7 for the currency names. FD is the forward discount, DD is the distance-to-default, ER is the index of exchange regime, and DC is the size of domestic credit. Significance at 5% is indicated with ** (positive) and √√ (negative). Significance at 10% is indicated with * (positive) and √ (negative). See footnote 7 for the currency name associated with each currency code.

	Intercept			FD			DD			ER			R2
	Est	T stat		Est	T stat		Est	T stat		Est	T stat		
AUD	0.007	2.555	**	2.506	6.123	**	-0.492	-0.928		-5.692	-5.407	√√	0.39
CAD	0.003	1.422		1.576	4.730	**	-0.572	-1.324		-2.445	-2.852	√√	0.23
CHF	0.004	1.327		0.112	0.268		0.412	0.758		-0.978	-0.907		0.02
CNY	0.000	0.608		-0.089	-1.606	√	0.085	1.179		-0.001	-0.007		0.03
CZK	0.006	1.665	*	1.411	2.922	**	1.082	1.728	*	1.067	0.859		0.09
DKK	0.003	1.176		1.056	2.641	**	0.923	1.781	*	-0.933	-0.907		0.10
EUR	0.003	1.122		1.060	2.651	**	0.906	1.749	*	-0.988	-0.961		0.10
GBP	0.001	0.489		1.353	4.139	**	0.200	0.473		0.253	0.301		0.13
HKD	0.000	-2.895	√√	0.011	0.501		-0.018	-0.668		0.021	0.378		0.01
HUF	0.009	2.576	**	2.589	5.139	**	1.840	2.818	**	0.745	0.575		0.23
IDR	0.003	0.759		0.907	1.665		3.470	4.914	**	-0.995	-0.711		0.21
JPY	0.002	1.101		-1.819	-5.859	√√	0.568	1.410		-3.525	-4.414	√√	0.32
KRW	0.001	0.503		1.856	4.578	**	1.738	3.309	**	-3.203	-3.073	√√	0.30
MXN	0.002	1.225		2.560	10.577	**	-0.047	-0.150		-1.153	-1.853	√	0.51
NOK	0.004	1.447		1.735	4.103	**	0.377	0.687		0.638	0.586		0.13
PHP	0.007	4.175	**	0.671	3.015	**	0.711	2.465	**	0.502	0.877		0.12
PLN	0.006	1.693	*	2.886	6.164	**	1.197	1.972	**	0.104	0.087		0.27
SEK	0.003	0.889		1.375	2.954	**	0.483	0.801		-0.802	-0.670		0.09
SGD	0.002	1.386		0.405	2.132	**	0.687	2.791	**	-1.287	-2.635	√√	0.17

Table 4. Betas of Fundamental Factors [Continued]

	Intercept			FD			ER			DC			R sq
	Est	T stat		Est	T stat		Est	T stat		Est	T stat		
AUD	0.008	2.628	**	2.159	4.309	**	-5.712	-5.456	√√	0.750	1.162		0.39
CAD	0.003	1.407		1.766	4.301	**	-2.123	-2.474	√√	-0.447	-0.844		0.22
CHF	0.004	1.301		0.165	0.319		-1.100	-1.021		-0.099	-0.148		0.01
CNY	0.000	0.601		-0.108	-1.573		-0.043	-0.302		0.045	0.508		0.02
CZK	0.006	1.719	*	0.745	1.264		0.280	0.227		1.526	2.008	**	0.10
DKK	0.003	1.150		0.898	1.809	*	-1.367	-1.317		0.392	0.612		0.08
EUR	0.003	1.096		0.908	1.830	*	-1.412	-1.362		0.377	0.590		0.08
GBP	0.001	0.422		1.683	4.229	**	0.371	0.446		-0.726	-1.415		0.14
HKD	0.000	-2.891	√√	0.016	0.616		0.031	0.561		-0.013	-0.383		0.01
HUF	0.009	2.606	**	1.711	2.752	**	-0.446	-0.343		2.031	2.534	**	0.22
IDR	0.003	0.924		-1.212	-1.878	√	-3.512	-2.604	√√	4.864	5.846	**	0.26
JPY	0.002	1.048		-1.735	-4.520	√√	-3.686	-4.594	√√	-0.162	-0.327		0.30
KRW	0.002	0.726		0.313	0.688		-4.744	-4.993	√√	3.506	5.982	**	0.42
MXN	0.002	1.444		1.977	7.014	**	-1.476	-2.504	√√	1.294	3.561	**	0.56
NOK	0.004	1.509		1.279	2.485	**	0.232	0.216		1.033	1.557		0.15
PHP	0.007	4.518	**	0.028	0.109		-0.135	-0.250		1.461	4.364	**	0.20
PLN	0.006	1.886	*	1.686	3.065	**	-1.037	-0.902		2.721	3.838	**	0.33
SEK	0.003	0.947		0.856	1.511		-1.283	-1.085		1.175	1.610		0.10
SGD	0.002	1.538		-0.104	-0.459		-1.837	-3.895	√√	1.161	3.990	**	0.22

Table 5. Prices of Investment Style Factors

Each column shows the result of a particular regression. Significance at 5% is indicated with ** (positive) and √√ (negative). Significance at 10% is indicated with * (positive) and √ (negative).

All Currencies

	(1)	(2)	(3)
Carry	0.0050	0.0049	0.0058
	[1.0462]	[1.1256]	[1.4274]
Momentum	-0.0167	-0.0083	
	[-2.6998]	[-1.3587]	
	√√		
PPP	-0.0005		-0.0004
	[-0.1483]		[-0.1073]
Volatility		-0.0204	-0.0211
		[-1.0578]	[-1.0746]
# curncies	19	19	19
# months	120	112	112
J stat	39.11	40.31	37.65
P value	0.0010	0.0007	0.0017

DM Currencies

	(1)	(2)	(3)
Carry	0.0016	0.0023	0.0031
	[0.2965]	[0.4100]	[0.7014]
Momentum	-0.0190	-0.0186	
	[-2.2278]	[-2.1297]	
	√√	√√	
PPP	-0.0017		-0.0019
	[-0.4396]		[-0.5018]
Volatility		-0.0257	-0.0243
		[-0.9611]	[-1.0275]
# curncies	11	11	11
# months	120	112	112
J stat	12.66	11.58	14.74
P value	0.1240	0.1708	0.0644

Table 5. Prices of Investment Style Factors [Continued]

EM Currencies

	(1)	(2)	(3)
Carry	0.0118	0.0163	-0.0036
	[1.0653]	[2.1240]	[-0.3713]
		**	
Momentum	0.0096	0.0175	
	[0.5492]	[1.6836]	
PPP	0.0019		-0.0165
	[0.1951]		[-1.8395]
Volatility		-0.0428	-0.0155
		[-1.4653]	[-0.5650]
# curncies	8	8	8
# months	120	112	112
J stat	9.95	5.97	15.02
P value	0.0767	0.3087	0.0103

Table 6. Betas of Investment Style Factors

The excess returns of each currency are regressed on factor returns. Listed in the first column are 3-digit currency codes. See footnote 7 for the currency names. Significance at 5% is indicated with ** (positive) and √√ (negative). Significance at 10% is indicated with * (positive) and √ (negative). See footnote 7 for the currency name associated with each currency code.

	Intercept			Carry			PPP			Volatility			R sq
	Est	T stat		Est	T stat		Est	T stat		Est	T stat		
AUD	0.010	3.882	**	1.104	9.765	**	-0.216	-2.183	√√	0.033	1.085		0.58
CAD	0.005	1.998	**	0.556	5.082	**	-0.123	-1.283		0.011	0.369		0.28
CHF	0.005	1.920	*	0.522	4.610	**	-0.645	-6.517	√√	0.133	4.418	**	0.36
CNY	0.000	0.303		-0.011	-0.594		-0.020	-1.192		0.000	0.090		0.02
CZK	0.007	2.585	**	0.995	7.721	**	-0.654	-5.806	√√	0.164	4.773	**	0.44
DKK	0.004	1.978	**	0.779	7.494	**	-0.585	-6.441	√√	0.113	4.066	**	0.45
EUR	0.004	1.927	*	0.777	7.487	**	-0.583	-6.429	√√	0.110	3.995	**	0.45
GBP	0.002	1.119		0.578	5.949	**	-0.388	-4.570	√√	0.057	2.221	**	0.34
HKD	0.000	-2.815	√√	0.015	2.047	**	-0.007	-1.132		0.005	2.876	**	0.08
HUF	0.011	3.310	**	1.093	7.351	**	-0.674	-5.188	√√	0.116	2.923	**	0.43
IDR	0.007	2.037	**	0.469	3.064	**	-0.334	-2.497	√√	0.008	0.187		0.16
JPY	0.002	0.798		-0.130	-1.267		-0.229	-2.548	√√	0.096	3.493	**	0.28
KRW	0.003	1.015		0.774	5.901	**	-0.454	-3.961	√√	0.037	1.052		0.36
MXN	0.002	1.275		0.507	5.773	**	-0.103	-1.337		-0.035	-1.493		0.44
NOK	0.006	3.113	**	0.831	9.659	**	-0.938	-12.479	√√	0.081	3.544	**	0.69
PHP	0.007	4.859	**	0.212	3.239	**	-0.149	-2.603	√√	-0.008	-0.452		0.20
PLN	0.007	2.347	**	0.957	6.791	**	-0.683	-5.544	√√	0.067	1.792	*	0.43
SEK	0.005	2.063	**	0.933	8.305	**	-0.736	-7.497	√√	0.109	3.635	**	0.53
SGD	0.002	1.860	*	0.320	5.682	**	-0.239	-4.850	√√	0.043	2.878	**	0.32

Figure 1. Returns of Fundamental Factors

FD is the forward discount, DD is the distance-to-default, SB is the stock beta, CC is the index of capital control, ER is the index of exchange regime, DC is the size of domestic credit, and PI is the per-capita income.

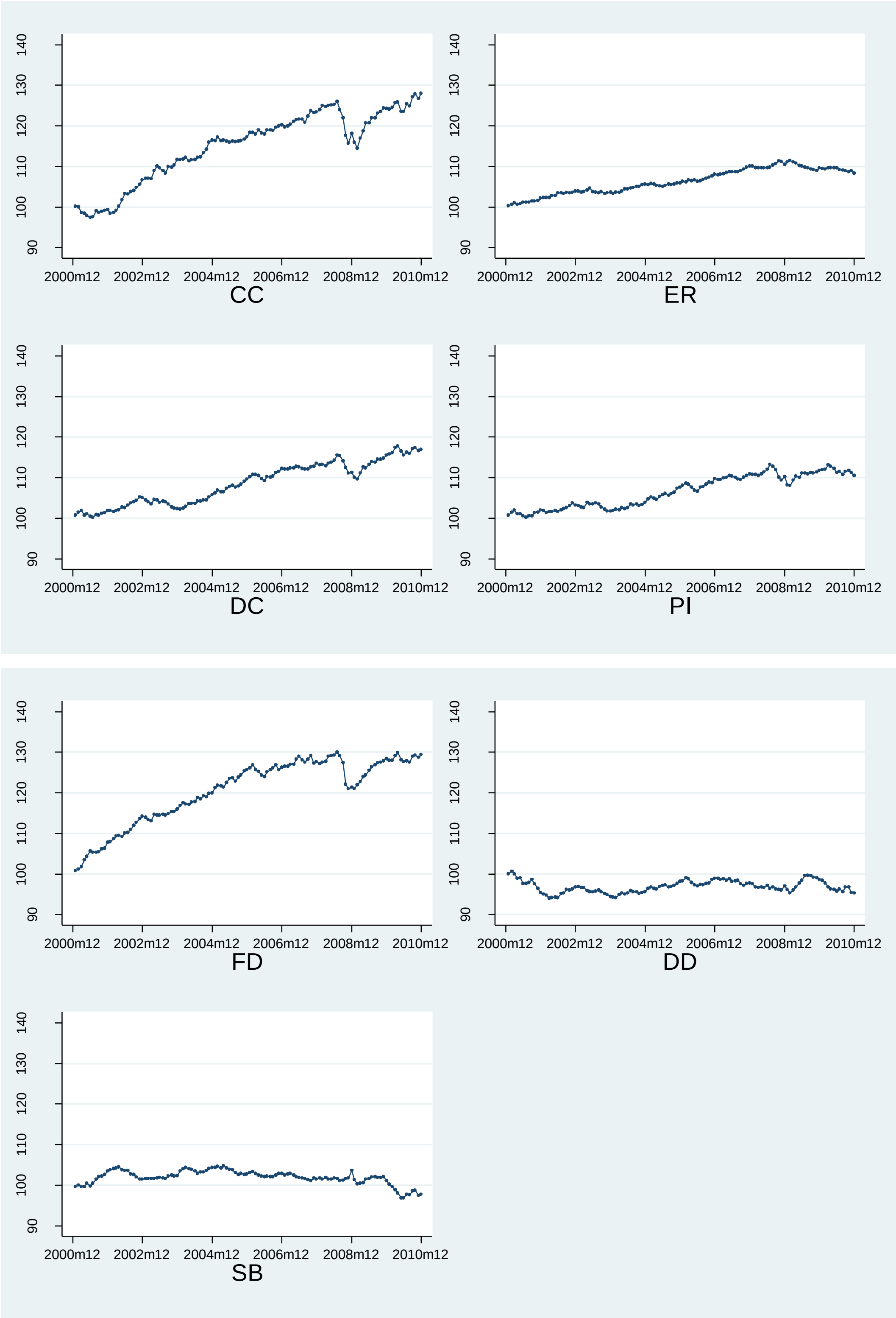

Figure 2. Returns of Investment Style Factors