Country Fundamentals and Cross-Section of Currency Excess Returns

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Abstract

We examine whether country fundamentals help explain the cross-section of currency excess returns. We consider fundamental variables such as default risk, foreign exchange policy orientation as well as interest rate in the multi-factor model framework. We find that fundamental factors explain a large part of the cross-section of currency excess returns. The zero-intercept restriction of the factor model is not rejected for most currencies. A factor model only with investment-style factors performs poorly in this respect. Our main empirical results are based on 2001-2010 balanced panel data of 19 major currencies.

Keywords

Country fundamentals, cross-section of currency excess returns, factor model, fundamental factors, investment-style factors

JEL Classification

F31, G12, G15

1. Introduction

The goal of this paper is to show that country fundamentals matter for the cross-section of currency excess returns. We include the variables reflecting macroeconomic fundamentals, such as interest rate, default risk, and foreign exchange policy orientation. We also include the variables reflecting the degree of capital control and the size of capital market. Our analysis shows that these variables do have explanatory power for the cross-section of currency excess returns.

Our research is partly motivated by a recent paper by Lustig, Roussanov, and Verdelhan (2008), and also a paper by Lustig and Verdelhan (2007). They explain the cross-section of currency returns with a single 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 adopt the factor model framework of these authors, but we include new factors that are based on country fundamentals.[1]

In a series of highly original papers, Pojarliev and Levich (2008, 2010, 2011) build a multi-factor currency returns model from the popular currency strategies such as carry, value, trend following, and volatility. Pojarliev and Levich used the factor model to explain the performance of currency fund managers. We modify the work of Pojarliev and Levich in two directions. First, we construct factors from *country fundamentals* rather than from *investment-style returns*. Second, we use the factor model to explain the performance of *currencies*, rather than *currency fund managers*.

Our main empirical results are based on monthly currency excess returns of 19 major currencies for the 10-year period between January 2001 and December 2010. The 19 currencies have been selected after dropping those currencies with inadequate fundamental data. Our main findings can be

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[1] Other authors have also examined the cross-section of currency returns. For example, Frankel and Poonawala (2010) presented a pooled cross-sectional time-series regression, which includes forward premium as an explanatory variable. Ito and Chinn (2007) also carried out panel regression, and their list of explanatory variables includes many of the fundamental variables that we use in this paper. Our approach, however, is clearly different from the approach of these authors. We use a factor model where each factor is a proxy for some underlying risk factor. The panel regressions of Frankel and Poonawala (2010) and Ito and Chinn (2007) are not compatible with a risk model. In our case, the explanatory power comes from the currencies' exposure to risk factors; in the case of panel regressions, the explanatory power comes from the characteristics of the currencies. To put it another way, our approach is comparable to the factor model of Fama and French (1993), while the panel regressions are comparable to the characteristics model of Daniel and Titmann (1997).

summarized as follows:

First, when the currencies are sorted on the basis of forward premium, exchange regime, the degree of capital control, and the size of capital markets, there are persistent return differences between high-ranked and low-ranked currencies. When the currencies are sorted by default risk, the return differences between high-ranked and low-ranked currencies are not persistent. As far as forward premium is concerned, the pattern has been discussed extensively in the previous literature. The results regarding the other fundamental variables are original in this paper.

Second, a parsimonious model with 3 factors--forward premium, default risk, and exchange regime—explains a large part of the cross-section of currency excess returns. Also the zero-intercept restriction of the factor model is *not* rejected for 13 out of 19 currencies. In comparison, a factor model with 3 investment-style factors is rejected for 13 out of 19 currencies.

In recent years, the persistent profits of so-called carry trades have drawn many authors' attention.[2] Carry traders buy a high-yield currency and sell a low-yield currency, or, equivalently, take a long forward position in a high-yield currency against a low-yield currency. Such trades exploit the failure of the uncovered interest parity (UIP). If the UIP holds, the excess returns cannot be predicted by interest rate or forward premium. In reality, a negative forward premium (i.e. the forward value of the currency being lower than the spot value) tends to be followed by a positive excess return, generating profits to carry traders.[3] We do not focus on carry profits in this study; however, many aspects of our discussion of currency excess returns are applicable to carry profits as well.

The rest of the paper is organized as follows. Section 2 reviews basic theories regarding currency excess returns. Section 3 describes the data. Our main empirical results are presented in Section 4. Section 5 concludes the paper. Appendix includes details on data sources and variable construction.

2. Currency Excess Returns: Measurement and Properties

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[2] For example, see Brunnermeiser, Nagel, and Pedersen (2008) and Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011).

[3] Profits to carry trades became unstable since the onset of the financial crisis. At a longer horizon, however, carry trades still have positive profits.

We define the excess return of currency i as the return to the investor who takes a long forward position in currency i against the base currency, i.e. the US dollar. Let $S_{i,t}$ be the time- t exchange rate between currency i and the base currency, expressed as the amount of base currency equivalent to one unit of currency i. Let $F_{i,t}$ be the time- t forward rate defined in a similar way. Then, the excess return of currency i is calculated as $(S_{i,t+1} - F_{i,t})/S_{i,t}$. This is called the "excess" return, as its "ordinary" value under the uncovered interest parity (UIP) and the covered interest parity (CIP) is zero on average.

Recall that the UIP states that the expected change in the spot exchange rate equals the interest differential:

$$\frac{1+r}{1+r^*} = \mathrm{E}_t\left(\frac{S_{t+1}}{S_t}\right). \qquad (1)$$

where r is the dollar deposit rate and r^* is the deposit rate of the non-USD currency[4]. When the CIP holds, we may substitute "forward premium" F_t/S_t for $(1+r)/(1+r^*)$ in the above formula and obtain another expression for the UIP:

$$\frac{F_t}{S_t} = \mathrm{E}_t\left(\frac{S_{t+1}}{S_t}\right). \qquad (2)$$

The formula above states that a forward exchange rate is an unbiased predictor of a spot exchange rate[5]. Another obvious implication is that the excess return has zero expected value.

Existing studies generally agree that the UIP does not hold, and that the excess return has non-zero expected value.[6] The empirical failure of the UIP has been reported as soon as enough data on the

[4] UIP is based on a no-arbitrage-like argument : a deposit of $1 in a US bank would give you on average the same return as exchanging $1 into a foreign currency, say, euro, and keeping the proceeds in a euro deposit. The return from the former is (1 + r) while the return from the latter, in dollar terms, is $(1 + \mathrm{r}^*)\mathrm{S}_{\mathrm{t}+1}/\mathrm{S}_{\mathrm{t}}$. The equivalence between these two returns gives us the UIP condition. Note that this is not a true arbitrage argument as the profit involved is not truly riskless.

[5] The failure of (2) is often called the forward premium puzzle. Recently, authors tend to discuss the forward premium puzzle and the violation of the UIP as a single phenomenon, as we do in this paper. See, for example, Brunnermeier, Nagel, and Pedersen (2008), Frankel and Poonawala (2010), Burnside, Eichenbaum, and Kleshchelski (2011), and Gilmore and Hayashi (2011).

[6] Some evidence indicates toward the opposite, though. The unconditional version of (1) is not rejected for developed market currencies. Also, some authors believe that the conditional version of (2)—with some

floating exchange rate regime has accumulated. Hansen and Hodrick (1980) report the rejection of the UIP using the exchange rates of the major currencies from the 1970s. They obtain the same result again using the data from the 1920s, which are more limited in currency inclusion. Fama's (1984) study is based on similar periods and currencies, and the failure of the UIP is confirmed once again. More recent studies include EM currencies in the analysis. Bansal and Dahlquist (2000) report that the violation of UIP is not very significant in the EM data, which is also confirmed by Frankel and Poonawala (2010). On the contrary, Flood and Rose (2002) and Burnside, Eichenbaum, and Rebelo (2007) report strong violation of UIP in the EM data. Gilmore and Hayashi (2011) resolve these contradictory findings. If one examines the country-by-country average, one gets the former result—that is, no significant violation of UIP. If one examines a portfolio of the high-yielding countries, one gets the latter result—that is, significant violation of UIP,—indicating a large variation among the EM currencies.

What is the nature of non-zero expected excess returns? As usual, there are two types of responses to this question: one emphasizing the behavioral bias and the other emphasizing the risk premium. A popular behavioral-bias explanation goes as follows: investors systematically underestimate the future spot exchange rate of a high-yield currency, and as a result, the forward exchange rate has a persistent forecast bias. On the other hand, in the risk-premium explanations, no behavioral bias is assumed. Instead, expected excess return is interpreted as the reward for bearing risk. For example, in the theory of Brunnermeiser, Nagel, and Pedersen (2008), expected excess return is the reward for bearing the risk of currency crashes.

The factor model approach to excess returns is a natural consequence of the risk-premium interpretation. If excess return is indeed the reward for bearing risk, then we should be able to identify the common factor, the exposure to which indicates the level of risk. According to Lustig, Roussanov, and Verdelhan (2008), global carry returns is a good proxy for the common factor. They have shown that a single-factor model with global carry returns does a good job explaining the cross-section of currency excess returns. Lustig and Verdelhan (2007) consider a consumption-CAPM type model, instead. It is shown that the global consumption growth also explains the cross-section of currency excess returns[7].

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conditioning variables—may hold for emerging market currencies. See Gilmore and Hayashi (2011).

[7] Though Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011) argue that factor models do not explain currency returns, their main interest is in explaining time-variation rather than cross-sectional variation. Also, what they test is whether currency portfolio returns fit within the system of equity returns. Their analysis leaves

3. A First Look at Data

We have collected data on exchange rates and country fundamentals from various sources[8]. Initially we have collected data for every country that is a member of the MSCI All Country Index, which includes all the major capital markets in the world open to foreign investment. We convert the country data into currency data wherever necessary. That is, when multiple countries share a single currency, we aggregate the data across the countries sharing the single currency. From the currency data, we create currency-pair data. All the variables in our analysis are defined for a currency pair. We use the US dollar as the base currency, and consider only those pairs between the US dollar and a non-US dollar currency. That is, we do not consider "crosses" between two non-US dollar currencies. Given the dominant role of the US dollar in the foreign exchange market, this does not seem problematic. Insufficient data availability has forced us to exclude certain currencies from our analysis. Our main results are based on 2001-2010 balanced panel data of 19 major currencies. These currencies are listed in Table 1.

For a robustness check, we have repeated all of our analyses using Gilmore and Hayashi's (2011) exchange rate data, which allow more accurate calculations than the public exchange rate data.[9] In particular, Gilmore and Hayashi's data set adjusts for the lag between the date of observing the spot rate and the delivery date, which is typically 2 days. Thus, in this data set, a forward contract is matched to the spot rate 2 days prior to the contract expiration date. The data set includes 29 currencies for the period between 1996 and 2010. Only 16 of these 29 currencies could be used in our analysis owing to the lack of stock market and macroeconomic data. The results, not reported here for space consideration, are mostly comparable to those based on our exchange rate data.

Table 1 reports summary statistics of excess returns for each currency in our sample. The mean excess return is positive for most currencies. Recall that the exchange rate is quoted as the US dollar price of a non-US dollar currency. Thus, a positive excess return means that the non-US dollar currency appreciate more than predicted by the forward rate. The t statistic is for the null hypothesis that excess

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room for a currency factor model not based on equity factors.

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

[9] The data set is available on the web site http://www.aeaweb.org.

return has zero mean, the implication of the UIP. For four currencies (Hungarian forint, Mexican peso, Philippine peso, and Polish zloty), this implication is rejected.

[Table 1 about here.]

Given the fact that the US dollar interest rate is lower than the interest rate of most other currencies in our sample, positive excess returns correspond to positive carry profits. When the US dollar interest rate is lower, the forward exchange rate of a non-US dollar currency is lower than the spot rate. That is, the spot rate is expected to depreciate. However, the spot rate in the next period turns out to be not as low as expected, creating positive carry profits. A buy-and-hold carry trader takes a long forward position in non-US dollar currencies against the US dollar when the non-US dollar currencies have higher interest rates than the US dollar. The excess return in Table 1 can be interpreted as the profit to this buy-and-hold carry trader. Most likely, however, the 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.

In Table 2, we look at the relationship between excess returns and forward premiums. We estimate the following regression equation:

$$\frac{S_{i,t+1} - F_{i,t}}{S_{i,t}} = \alpha_i + \beta_i \left(\frac{F_{i,t}}{S_{i,t}} - 1 \right) + \varepsilon_{i,t+1}. \qquad (3)$$

When $\beta_i = 0$, the above equation shows that mean excess returns *conditional on* forward premium do not depend on forward premium. Thus, this estimation is often called the “conditional test of UIP.” As can be seen from the t statistics for the slope (β_i) estimates, this “conditional UIP” is rejected for 10 out of 19 currencies. The slope estimates are mostly negative. This means that, when the forward premium is small (i.e., the interest rate of the non-US dollar currency is large), currency excess return is large.

[Table 2 about here.]

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, the position size is inversely proportional to the forward premium size. Whether a portfolio of such position performs better than the portfolio of unadjusted positions depends on the cross-sectional correlations among those positions.

This is another motivation for the factor model we develop in this paper. Once we have a factor model that explains the cross-section of currency excess returns, we might use this model to analyze the optimal weighting problem of carry positions.

Tables 1 and 2 show that there is substantial variation in returns across currencies. The annualized currency excess returns vary from -1% for the Japanese yen to +9% for the Hungarian forint. In the conditional UIP test, the slope coefficients vary from -4.6 for the Danish krone to 0.6 for the Czech krona. That is, a 1% drop in the forward premium is expected to increase currency returns by as much as 4.6%, or decrease currency returns by up to 0.6%. Such significant variations across currencies are the subject of our analysis in the remainder of this paper.

4. Fundamental Factors

We show the relevance of fundamentals by, first, constructing ‘factor returns’ out of fundamental variables and, second, explaining the cross-section of excess returns by these factors. Before we estimate the multi-factor model for each currency, we estimate the ‘factor price’ from moment condition using Hansens’s (1982) generalized method of moment (GMM). Below we describe each of these steps, in detail.

Construction of Factor Returns

Our analysis includes the variables to capture four aspects of country fundamentals—interest rate, default risk, foreign exchange policy, and size of the capital market. Previous studies have pointed out the importance of interest rates. As mentioned earlier, Lustig, Roussanov, and Verdelhan (2008) use, as a common factor, global carry profits which are calculated from interest rate-sorted portfolios. Also, the conditional UIP tests, including Fama (1984), suggest that the interest rate differential is an important explanatory variable. Specifically, a higher interest rate is associated with a higher currency return. So, it is natural to include interest rates in our analysis.

Instead of using the interest rate itself, however, we use the forward premium, $F_{i,t}/S_{i,t} - 1$. Recall that, under the CIP, the forward premium is identical to the interest rate differential $i - i^{*}$. We use the forward premium as the data on forward rates seem to be more reliable than the data on interest rates.[10] Previous studies, especially on carry profits, suggest that the forward premium has a negative effect on excess returns. That is, when the forward premium is high (i.e., when the interest rate on currency i is low), currency i tends to have negative returns. For the ease of interpretation, we multiply the forward premium by -1 so that the factor based on forward premium is expected to have a positive coefficient.

The second element of country fundamentals that we consider is the default risk of the banking system. Previous studies have examined the role of the default risk in CIP violation. Coffey, Hrung, and Sarkar (2009) attribute the failure of CIP during the financial crisis to the increased counter-party risk and lack of funding. Fong, Valente, and Fung (2010) confirm that the breakdown of the CIP is mainly due to the credit risk and liquidity problems. While the focus of this study is the deviation from UIP, and not from CIP, we still believe that the default risk of the banking system is relevant. When the banking system is in crisis, it inevitably affects the currency risk and thus the currency returns. To the extent that excess returns reflect the magnitude of risk, a higher default risk leads to a higher excess return. With a similar idea, Melvyn and Taylor (2009) relate the financial market stability to currency returns, especially the profits of carry trades.

As a proxy variable for default risk, we calculate the average distance-to-default; that is, the average of individual banks' distance-to-default. Distance-to-default is calculated from the implied market values of the total asset and the debt. Gropp, Vesala, and Vulpes (2006) and, especially, Chan-Lau, Jobert, and Kong (2004), show that the distance-to-default 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 has been first suggested by Black and Scholes (1973) and Merton (1974). The distance-to-default measure has been initially developed for KMV, a company later absorbed by Moody's. Crosbie and Bohn (2003) describe the implementation of the distance-to-default by Moody's KMV. A higher value of distance-to-default indicates a "longer distance to default," that is, a lower likelihood of default. Thus, a higher value of distance-to-default is expected to have a negative effect on excess returns. For ease of interpretation, we multiply the distance-to-default variable by -1, so that the factor based on the distance to default is expected to have a positive coefficient.

As an alternative measure of default risk, we calculate the average stock beta, that is, the average of

[10] We have repeated the part of the analysis using the interest rate data, and have obtained comparable results.

individual banks' stock beta. The beta of an individual bank is calculated from a traditional CAPM, with the local stock market index as the proxy for the market portfolio. The beta exhibits the exposure to systematic risk, and so it is only an indirect indicator of default risk. A higher beta value indicates more exposure to systematic risk. Thus, it is likely to have a positive effect on excess returns.[11]

The third element of country fundamentals that we consider is foreign exchange policy. The motivation for considering this is the observation that countries adopt different exchange rate regimes and many countries impose varying degrees of capital control as well. If capital control is of the most extreme form and the currency is completely pegged to the US dollar, then currency risk may be limited. However, if there is a high likelihood of capital control being imposed or lifted, then currency risk may increase substantially. Flood and Rose (2002) consider the effect of exchange regime on carry profits in DM and EM currencies. Notably, Ito and Chinn (2007) show that foreign exchange policy is relevant for currency returns. Their de jure capital account openness index has been shown to be negatively correlated with excess returns; that is, more openness (a higher value of the index) is associated with a smaller excess return. Also, indicators for a fixed exchange regime are positively correlated with excess returns, although the relationship is not significant.

To capture foreign exchange policy, we take two variables, capital control and exchange regime. The capital control variable is from Ito and Chinn (2007) with some modifications, and the exchange regime variable is from Reinart and Rogoff (2004) and Ilzetzki, Reinart, and Rogoff (2008).[12] Both of these variables are defined such that a higher value is assigned to a country with a less restrictive policy (i.e., more open and closer to floating). Thus, these variables are expected to have negative effects on excess returns. For the ease of interpretation, we multiply these variables by -1, and the factors based on these variables are expected to have positive coefficients.

We include the variables to capture the size of the capital markets as well. The size effect is known to matter for equity returns. We hypothesize that the size effect may matter for currency returns as well. Investing in a country with small capital markets may seem riskier 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 the market prices are affected by trading volume. In this line of thought, a smaller size is

[11] One may think of using CDS premium as a measure of default risk. However, CDS data on emerging market banks are not extensive. The use of CDS data will significantly reduce the number of currencies and the time period included in this analysis.

[12] See the appendix for the details.

associated with higher excess returns. We use domestic credit and per-capita income as proxies for the size of capital markets. We expect smaller domestic credit and per-capita income values to lead to higher excess returns. Again, we multiply these variables by -1, and the factors based on these variables are expected to have positive coefficients.

In sum, we collect 7 variables—forward premium, distance to default, stock beta, capital control, exchange regime, domestic credit, and per-capita income—for each of the 19 currencies in our balanced panel. Then, we subtract the corresponding value for the US dollar from each of these variables. Note that three of these variables (forward premium, distance to default, and stock beta) are monthly, while the rest are annual. For the annual variables, we assigned the same value for all the months in a year. As mentioned earlier, all variables except for stock beta are pre-multiplied by -1 so that all the factors are expected to have positive coefficients.

We construct factor returns f_{t+1} in the conventional manner, i.e., as in the three-factor model of Fama and French (1993). At the end of each month of the sample period (December 2000 to November 2010), we sort all the currencies by each of the 7 variables and create two portfolios for each sort (7 x 2 = 14 portfolios in total). A high portfolio includes all the currencies with above-median value and a low portfolio includes all the currencies with below-median value of the sorting variable. Finally, a long-short portfolio is created by taking a long position in the high portfolio and a short position in the low portfolio. We have 7 long-short portfolios, one for each of the 7 variables. For each long-short portfolio, we calculate the long-short return—the equal-weighted long portfolio return minus the equal-weighted short portfolio return. This long-short return is called the “factor return.”

Table 3 shows summary statistics of these factor returns. 4 out of the 7 factors—forward premium, capital control, exchange regime, and domestic credit—have significantly positive average returns. Per-capita income factor has marginally significant positive return. Distance-to-default and stock beta factors have somewhat negative average returns. Note that each factor return is the profit of a long-short investment strategy. Thus, a significantly positive average return indicates that the associated investment strategy is significantly profitable. While the profitability of forward premium-based investment strategy is well known, the profitability of other fundamental-based strategies is a new finding of this paper.

[Table 3 about here.]

Estimation of Factor Prices

Before we estimate the multi-factor model for each currency, we discuss 'factor price' estimates from the stochastic discount factor (SDF) framework. Factor price is the 'price' at which each unit of 'exposure' to the factor is translated into expected return. In the SDF framework, any excess return is orthogonal to an SDF, which is a linear function of factors. Let $R_{i,t+1}$ be the excess return of currency i; that is, $R_{i,t+1} = (S_{i,t+1} - F_{i,t})/S_{i,t}$. Also, let M_{t+1} be the stochastic discount factor, which is a linear function of factors f_{t+1}; that is,

$$M_{t+1} \equiv 1 - b'(f_{t+1} - \mu), \quad (4)$$

where μ is a vector of mean factor returns and b is a vector of "factor loadings." The orthogonality condition can be stated as

$$E[M_{t+1}R_{i,t+1}] = 0 \quad (5)$$

for all i. Factor price is defined as

$$\lambda = var(f_{t+1})\, b. \quad (6)$$

Factor price is estimated using Hansen's (1982) GMM.[13]

Table 4 reports the factor price estimates. Each column in the table represents a separate estimation. For example, the first column shows the estimates from the model with forward premium, distance to default, and capital control factors only, while the second column shows the estimates from the model with forward premium, distance to default, and exchange regime factors only. Given the relatively small sample size, we limit the number of factors in each estimation to three. To save space, we do not show the estimation results from all possible combinations. We observe that four factors—forward premium, capital control, domestic credit, and per-capita income—are persistently significant across the specifications. All of them are positive, as expected. The J statistics are for the hypothesis that all of the over-identifying restrictions in the GMM estimation are valid. A lower value of a J-statistic and a higher value of an associated p-value indicate that the model is well specified. Statistically, all the models are rejected at the conventional 5% significance level. This does not necessarily indicate that the factors are not useful. As we show below, it is possible to construct a factor model with these factors that have acceptable explanatory power.

[Table 4 about here.]

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

Estimation of Factor Model

We now discuss the estimation of factor model a la Fama and French (1993). For each currency i, we estimate the following equation from OLS[14]:

$$R_{i,t+1} = \alpha_i + \beta_i{}' f_t + \varepsilon_i \quad (7)$$

Here β_i is called factor exposure, or simply beta[15]. The intercept term α_i is an indicator of the validity of this factor model. The arbitrage pricing theory requires that the intercept term α_i to be zero. A significant intercept indicates that the model fails to be a proper risk model: if the model is a proper risk model, any excess return not correlated with risk factors should average out to be zero.

In Table 5, we report the estimation result for the model with 3 factors—forward premium, default risk, and exchange regime factors. Forward premium beta is significant for most of the currencies, and distance-to-default beta is significant for about half of the currencies. Exchange regime beta is less significant. Of more interest to us than the significance of betas is the significance of the intercept term. The intercept is significant for 4 currencies and marginally significant for 2 currencies. Formally speaking, the model is still rejected. Nonetheless, this is a fairly encouraging result, especially in comparison to the performance of other models.

We have estimated the factor model with other combinations of factors that are listed in Table 4, and have obtained mostly comparable results. In particular, when we replace the exchange regime factor with the domestic credit factor, we get very similar results. To save space, we do not report these results here. Instead, we present the estimates of the model with investment-style factors, to highlight the relative strength of fundamental factors.

[Table 5 about here.]

Comparison to Investment-Style Factors

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[14] β_i in this equation has nothing to do with the β_i from the conditional UIP test in (3). Given the limited possibility of confusion and in order not to deviate from convention, we do not introduce separate symbols.

[15] Beta is of course related to factor price. Given that $\beta_i = \text{cov}(R_{i,t} f_t')[\text{var}(f_{t+1})]^{-1}$, it is easy to verify that the orthogonality condition of (5) is equivalent to $\text{E}(R_{i,t}) = \beta_i \lambda$. In fact, the SDF model of (5) is essentially equivalent to the factor model (7). However, the small-sample properties of the estimates of these two models are very different, and one does not necessarily get the identical results from the two models.

For the lack of a conventional benchmark, we use the factor model with the investment-style factors of Pojarliev and Levich (2008, 2010, 2011). Pojarliev and Levich have proposed four style factors—the carry factor, the momentum factor, the PPP factor, and the volatility factor.[16] We note that Pojarliev and Levich have proposed these factors for the evaluation of currency fund managers, and using these factors in the model for currency excess returns is not what these factors are intended for.

Table 6 reports the summary statistics of these investment-style factors[17]. Not surprisingly, the carry factor shows a pattern similar to that of our forward premium factor. These two factors are calculated in similar ways. The carry factor is based on 9 major currencies and three sorted portfolios, while our forward premium factor is based on 19 currencies and two sorted portfolios. All the factors in Table 6 have positive average returns even though none is statistically significant. Table 7 shows the estimates of factor prices. The momentum factor is significant in some instances; the other factors are not significant regardless of the specifications. The J-statistics and the associated p-values also show low fits of the models.

[Table 6 about here.]

[Table 7 about here.]

Table 8 shows the estimates of the betas and the intercept. Betas are mostly significant, indicating the relevance of the factors. However, the intercept is significant as well, for 14 out of the 19 currencies. That is, the model is acceptable only for 5 out of 19 currencies. Recall that, with the fundamental factors, the model is acceptable for 13 out of 19 currencies. While both types of factors appear to capture the major market movements well, the fundamental factors do a better job in explaining currency excess returns.[18]

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[16] 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.

[17] All of these factor returns are from Deutsche Bank. Pojarliev and Levich used an alternative source for the momentum factor; this alternative series is not updated anymore, making it unsuitable to our study.

[18] We also estimated the models with mixtures of fundamental and style factors. Some of them appear as significant as the fundamental factor models. As our main goal is not suggesting the optimal combination of factors, we do not report the results here.

[Table 8 about here.]

5. Conclusion

We estimate the "fundamental factor model" of currency excess returns using the variables characterizing each country's default risk and exchange rate policy as well as interest rate. We show that the models have some explanatory power and a low rejection rate. As a way of comparison, we estimate the "style factor models" using the factors of Pojarliev and Levich (2008, 2010, 2011). While the style factors explain the currency fund managers' performance very well, they do not explain the currency excess returns as much as fundamental factors do. The results show the relevance of country fundamentals in determining and explaining currency returns.

Our analysis supports the idea that currency returns can be modeled in terms of exposure to a small number of common factors. One contribution of our paper is to show that useful proxies for common factors can be constructed out of country fundamentals. For practitioners, our analysis suggests the possibility of fundamental/macro currency strategies and, especially, a way to control the risk of those strategies.

Appendix: Data Sources and Variable Construction Details

For the calculation of excess returns, we collect the spot and forward rates data from Bloomberg, and supplement these with data from Reuters. For the variables measuring country fundamentals, we collect the deposit rates from Reuters, stock market data from MSCI, and other macroeconomic variables from the World Banks' *World Development Indicators*, Chinn and Ito (2008), and Ilzetzki, Reinhart, and Rogoff (2008). We also collect the firm-level stock prices and accounting data from the IDC and Worldscope.

We measure the default risk of a bank with the distance-to-default of Gropp, Vesala, and Vulpes (2006). We then average the distance-to-default across the 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

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

where V is the market value of all the assets, σ_V the standard deviation of V, D the book value of the debt, and r 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 represent 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 the standard deviation of the stock return, and Φ the cumulative distribution function for the standard normal distribution. Note that it would be better to use the face value rather than the book value of the debt, as the face value corresponds to the "strike price" of the option. This modification is justified, considering that a firm may avoid default even if the market value of the firm is slightly lower than the face value of the debt. This can be solved through numerical methods.

The distance-to-default measure has been initially developed for KMV, a company later absorbed by Moody's. Crosbie and Bohn (2003) describe KMV's implementation of the distance-to-default, which involves an estimation of the growth rate of asset value. Following Gropp, Vesala, and Vulpes (2006) and Chan-Lau, Jobert, and Kong (2004), we 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 with the financial openness index developed by Chinn and Ito (2008). Applying the method of principal components to the binary variables codifying the restrictions on the capital account transactions reported in the IMF's Annual Report on 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 that the degree of the sample countries' capital control in 2010 is the same as in 2009.

Reinart and Rogoff (2004) have developed a new system of classifying the de facto exchange rate system, and have constructed the regime index for 153 countries from 1946 to 2001. Ilzetzki, Reinhart, and Rogoff (2008) have updated this index up to 2007. Their classification differs from others mainly in that it focuses more 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. We categorize the regimes into four groups: peg, crawling peg or band, managed float, and the free floating exchange rate system. We extend Reinhart and Rogoff's index to 2010 using the information on the exchange rate arrangements reported in IMF's AREAR. IMF has adopted a revised system for the classification of exchange rate arrangements and has reported the countries' de facto exchange rate regime since 2008 (Habermeier, Kokenyne, Veyrune, and Anderson, 2009). Reinart and Rogoff's index can be downloaded from Reinhart's Internet homepage, http://www.carmenreinhart.com/research/.

The carry, momentum, PPP, and volatility factors are from Deutsche Bank. They are "G10 Currency Harvest USD," "FX Momentum USD," "FX PPP USD," and "FX Volatility Index," respectively, and can be downloaded from http://index.db.com.

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Table 1. Excess Returns

Excess return is the return to a long forward position in a currency against the US dollar. Let $S_{i,t}$ and $F_{i,t}$ be the spot and forward rates of currency i at the end of month t, expressed as the amount of the US dollar equivalent to one unit of currency i. Then the excess return for month $t+1$ is calculated as $(S_{i,t+1} - F_{i,t})/S_{i,t}$. Both the mean and SD are annualized. (They are not in the percentage term.) T value is for the hypothesis that the mean excess return is zero. Significance at 5% and 10% is indicated by ** and *, respectively.

	Start	End	Obs	Excess Return			
	Date	Date		Mean	SD	T value	
Australian dollar (AUD)	Feb-96	Dec-10	179	0.047	0.128	1.432	
Canadian dollar (CAD)	Feb-96	Dec-10	179	0.023	0.086	1.033	
Swiss franc (CHF)	Feb-96	Dec-10	179	0.001	0.109	0.029	
Chinese yuan (CNY)	Jan-99	Dec-10	144	0.006	0.014	1.595	
Czech krona (CZK)	Jan-97	Dec-10	168	0.032	0.132	0.901	
Danish krone (DKK)	Feb-96	Dec-10	179	0.003	0.106	0.109	
Euro (EUR)	Feb-99	Dec-10	143	0.016	0.110	0.501	
British pound (GBP)	Feb-96	Dec-10	179	0.016	0.086	0.729	
Hong Kong dollar (HKD)	Feb-96	Dec-10	179	-0.001	0.006	-0.535	
Hungarian forint (HUF)	Nov-97	Dec-10	158	0.091	0.139	2.361	**
Indonesian rupiah (IDR)	Jan-97	Dec-10	168	0.033	0.293	0.421	
Japanese yen (JPY)	Feb-96	Dec-10	179	-0.010	0.114	-0.344	
Korean won (KRW)	Jan-99	Dec-10	144	0.017	0.122	0.473	
Mexican peso (MXN)	Jan-97	Dec-10	168	0.067	0.096	2.605	**
Norwegian krone (NOK)	Feb-96	Dec-10	179	0.021	0.111	0.743	
Philippine peso (PHP)	Jan-97	Dec-10	168	0.048	0.093	1.944	**
Polish zloty (PLN)	Sep-96	Dec-10	172	0.070	0.132	1.999	**
Swedish krona (SEK)	Feb-96	Dec-10	179	0.004	0.116	0.139	
Singapore dollar (SGD)	Feb-96	Dec-10	179	-0.004	0.060	-0.239	

Table 2. Excess Returns vs. Forward Premium

Monthly excess returns are regressed on forward premiums for each currency. Let $S_{i,t}$ and $F_{i,t}$ be the spot and forward rates of currency i at the end of month t, expressed as the amount of the US dollar equivalent to one unit of currency i. Then the regression equation that we estimate is:

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

See Table 1 for the estimation period and full currency names. Significance at 5% and 10% is indicated by ** and *, respectively.

	Intercept				Slope				R sq
	Est	SE	T value		Est	SE	T value		
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
CNY	0.001	0.000	3.600	**	-0.559	0.089	-6.248	**	0.216
CZK	0.002	0.003	0.829		0.562	1.216	0.462		0.001
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
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
JPY	0.006	0.005	1.213		-2.269	1.400	-1.621		0.015
KRW	0.001	0.003	0.366		-1.057	0.543	-1.948	*	0.026
MXN	-0.002	0.003	-0.631		-0.962	0.307	-3.138	**	0.056
NOK	0.001	0.003	0.485		-0.885	1.207	-0.733		0.003
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
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

Table 3. Fundamental Factors

At the end of each month between December 2000 and November 2010, we sort the currencies in our sample (see Table 1) by the given fundamental variable. Those currencies that are ranked higher than the median are put into the ‘high portfolio,’ and the remaining currencies are put into the ‘low portfolio.’ We calculate the equal-weighted portfolio return for each portfolio. The factor return is the high portfolio return minus the low portfolio return. Both the mean and SD are annualized. (They are not in the percentage term.) T value is for the hypothesis that the mean excess return is zero. Significance at 5% and 10% is indicated by ** and *, respectively.

	Obs	Mean	SD	T stat	
Forward Premium	120	0.026	0.085	3.379	**
Distance-to-Default	120	-0.005	0.066	-0.781	
Stock Beta	120	-0.002	0.063	-0.381	
Capital Control	120	0.025	0.104	2.647	**
Exchange Regime	120	0.008	0.033	2.650	**
Domestic Credit	120	0.016	0.066	2.645	**
Per-capita Income	120	0.010	0.063	1.763	*

Table 4. Prices of Fundamental Factors

We obtain the factor prices from the following 'moment condition':

$$\mathrm{E}\left[\left(1-b'(f_{t+1}-\mu)\right)R_{i,t+1}\right]=0$$

In the formula above, b is 'factor loading,' f_{t+1} is month $t+1$ factor returns, μ is mean factor return, and $R_{i,t+1}$ is month $t+1$ excess return of currency i. See the notes for Tables 1 and 3 for the definition of currency excess return and factor return. Factor price is defined as $\mathrm{var}(f_{t+1})b$. The moment condition is estimated by GMM from the Jan 2001-Dec 2010 balanced panel data of 19 major currencies that are listed in Table 1. In the table below, each column shows the result of a particular regression with a particular combination of factors. Figures inside the square brackets are t statistics. Significance at 5% and 10% are indicated by ** and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Forward premium	0.0019	0.0020	0.0019	0.0018	0.0018	0.0018
	[1.7268]	[1.8956]	[1.8605]	[1.5364]	[1.6852]	[1.6643]
	*	*	*		*	*
Distance to default	-0.0003	-0.0002				
	[-0.5111]	[-0.2906]				
Stock beta			0.0007			
			[1.0422]			
Capital control	0.0022			0.0020		
	[2.0499]			[1.9047]		
	**			*		
Exchange regime		0.0003	0.0003		0.0003	0.0003
		[1.1245]	[0.9424]		[1.1047]	[1.1377]
Domestic credit				0.0011	0.0011	
				[1.8997]	[1.9786]	
				*	**	
Per-capita income						0.0010
						[1.9402]
						*
# currencies	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 5. Factor Model with Forward Premium, Distance to Default, and Exchange Regime Factors

The monthly excess returns are regressed on monthly factor returns for each currency. See the notes for Tables 1 and 3 for the definition of currency excess return and factor return. The notes for Table 1 also include full currency names. The sample is the 10-year period from Jan 2001 to Dec 2010. Significance at 5% and 10% is indicated by ** and *, respectively.

	Intercept			Forward premium			Distance to default			Exchange regime			R sq
	Est	T value		Est	T value		Est	T value		Est	T value		
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 6. Investment Style Factors

Index values for the investment-style factors are available at the web site of Deutsche Bank. We calculate monthly returns out of index values for the 10-year period, Jan 2001-Dec 2010. (For volatility, our return series start from Sep 2001.) Both the mean and SD are annualized. (They are not in the percentage term.) T value is for the hypothesis that the mean excess return is zero. Significance at 5% and 10% is indicated by ** and *, respectively.

	Obs	Mean	SD	T stat
Carry	120	0.042	0.337	1.365
Momentum	120	0.033	0.314	1.159
PPP	120	0.044	0.295	1.625
Volatility	112	0.087	1.305	0.704

Table 7. Prices of Investment Style Factors

We obtain the factor prices from the following 'moment condition':

$$E[(1 - b'(f_{t+1} - \mu))R_{i,t+1}] = 0$$

In the formula above, b is 'factor loading,' f_{t+1} is month $t+1$ factor returns, μ is mean factor return, and $R_{i,t+1}$ is month $t+1$ excess return of currency i. See the notes for Tables 1 and 6 for the definition of currency excess return and factor return. Factor price is defined as $\mathrm{var}(f_{t+1})b$. The moment condition is estimated by GMM from the Sep 2001-Dec 2010 balanced panel data of 19 major currencies that are listed in Table 1. In the table below, each column shows the result of a particular regression with a particular combination of factors. Figures inside the square brackets are t statistics. Significance at 5% and 10% are indicated by ** and *, respectively.

	(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]
# currencies	19	19	19
# months	120	112	112
J stat	39.11	40.31	37.65
P value	0.0010	0.0007	0.0017

Table 8. Factor Model with Carry, PPP, and Volatility Factors

The monthly excess returns are regressed on monthly factor returns for each currency. See the notes for Tables 1 and 6 for the definition of currency excess return and factor return. The notes for Table 1 also include full currency names. The sample period is from Sep 2001 to Dec 2010. Significance at 5% and 10% is indicated by ** and *, respectively.

	Intercept			Carry			PPP			Volatility			R sq
	Est	T value		Est	T value		Est	T value		Est	T value		
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