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Country Fundamentals and Currency Excess Returns[*]

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We examine whether country fundamentals help explain the cross-section of currency excess returns. For this purpose, we consider fundamental variables such as default risk, foreign exchange rate regime, capital control as well as interest rate in the multi-factor model framework. Our empirical results show 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. They also reveal that our factor model with country fundamentals performs better than a factor model with usual investment-style factors. Our main empirical results are based on 2001-2010 balanced panel data of 19 major currencies. This paper may fill the gap between country fundamentals and practitioners' strategies on currency investment.

Keywords: Currency Excess Returns, Country Fundamentals, Factor Model, Fundamental Factors, Investment-style Factors
JEL Classification: F31, G12, G15

I. Introduction

The purpose 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 rate regime. We also include the variables reflecting the degree of capital control and the size of capital market. We speculate that variations of country fundamentals may significantly affect the currency returns through increasing or

decreasing the currency risks. For example, the adoption of more flexible exchange rate regime may increase the currency risks substantially. Our analysis shows that these variables do have explanatory power for the cross-section of currency excess returns.

Some previous works also considered the country fundamentals as important determinants of currency returns. For example, Jordà and Taylor (2012) and Coudert and Mignon (2013) emphasize the relation of the real exchange rate and default risk with the currency returns, respectively. However, we consider a more extensive set of country fundamentals in this paper and adopt an empirical method basically different from the previous studies.

This paper's empirical methodology is partly motivated both by Lustig et al. (2011), and Lustig and Verdelhan (2007). They explain the cross-section of currency returns with a single factor—the global carry profits in case of Lustig et al. (2011) 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 their 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

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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. Jordà and Taylor (2012) and Ito and Chinn (2007) also carried out panel regression. In particular, Ito and Chinn (2007) include some of the fundamental variables that we use in this paper. Our approach, however, is clearly different from that 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).

fundamental data. Our main findings can be summarized as follows:

First, when the currencies are sorted on the basis of forward premium, exchange rate 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 three factors—forward premium, default risk, and foreign exchange rate 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 three investment-style factors is rejected for 14 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, and section 3 describes the data. Our main empirical results are presented in Section 4. Section 5 concludes the paper.

II. Currency Excess Returns: Measurement and Properties

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 spot exchange rate at time t between currency i and the

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[2] For example, see Brunnermeier et al. (2008) and Burnside et al. (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.

base currency, expressed as the amount of base currency equivalent to one unit of currency i. Let $F_{i,t}$ be the forward rate at time t 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:

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

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 (1) and obtain another expression for the UIP:

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

This 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 sufficient data on the 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

[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 $(1+r^*)S_{t+1}/S_t$. 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. As for the recent discussion on the forward premium puzzle and the violation of the UIP, see, for example, Brunnermeier et al. (2008), Frankel and Poonawala (2010), Burnside et al. (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 conditioning variables—may hold for emerging market currencies. See Gilmore and Hayashi (2011).

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 emerging market (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 et al. (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 Brunnermeier et al. (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 which indicates the exposure to the level of risk. According to Lustig et al. (2011), global carry return is a good proxy for the common factor. They have shown that a single-factor model with global carry returns does a good job in 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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[7] Though Burnside et al. (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 room for a currency factor model not based on equity factors.

III. A First Look at Currency Excess Returns

We have collected data on exchange rate 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.[8] 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. The currency list is presented 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 two days. Thus, in this data set, a forward contract is matched to the spot rate two days prior to the contract expiration date. The data set includes 29 currencies, but 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. The table uses all the available data on the spot and the forward exchange rates, and the sample period varies depending on the currencies. 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 appreciates more than predicted by the forward rate. The t-statistics are for testing the null hypothesis that excess 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.

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[8] See the Appendix II for the details on data sources.

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

Table 1. Currency Excess Returns

Currencies	Start Date	End Date	Obs.	Mean	Standard deviation	t-statistics
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

Note: t-statistics are for testing the hypothesis that the mean excess return is zero. Significance at 1%, 5% and 10% is indicated by ***, ** and *, respectively.

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:

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

When $\beta_i = 0$, the equation implies 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.[10]

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[10] Equation (3) corresponds to the "log excess return" equation of Fama (1984). He has suggested a decomposition of the log forward premium ($\log (F_t/S_t)$) through the following two equations:

$$\log \frac{F_t}{S_{t+1}} = \alpha_1 + \beta_1 \log \frac{F_t}{S_t} + \varepsilon_{1,t+1}$$

$$\log \frac{S_{t+1}}{S_t} = \alpha_2 + \beta_2 \log \frac{F_t}{S_t} + \varepsilon_{2,t+1}$$

$\log F_t/S_{t+1}$ is the minus of log excess return; so the first equation may be called the log excess return equation. $\log (S_{t+1}/S_t)$ is the log spot return; so the second equation may be called the log spot return equation. (This second equation is often called the "Fama regression equation.") We have omitted the subscript i for brevity. As Fama (1984) emphasized, these two equations are linked through the identity, and estimating one of the two is equivalent to estimating the other. Multiplying the both sides of the log excess return equation by -1 and then applying the approximation, $\log(1+x) \approx x$, we obtain:

$$\frac{S_{t+1} - F_t}{F_t} = -\alpha_1 - \beta_1 \left(\frac{F_t}{S_t} - 1 \right) + \varepsilon_{1,t+1}$$

The only difference from (3) is how the excess return is defined. The excess return in (3) is based on the assumption that the investor is keeping the spot price in the margin account; the excess return above is based on the assumption that the investor is keeping the forward price in the margin account. Both are equally valid assumptions.

Table 2. Currency Excess Returns vs. Forward Premium

Currencies	Intercept (α_i)		Slope (β_i)		R^2
	Estimates	t-statistics	Estimates	t-statistics	
AUD	-0.003	-0.648	-4.284	-2.332**	0.030
CAD	0.002	1.297	-3.082	-1.534	0.013
CHF	0.008	2.080**	-4.255	-2.584**	0.036
CNY	0.001	3.600***	-0.559	-6.248***	0.216
CZK	0.002	0.829	0.562	0.462	0.001
DKK	0.002	0.881	-4.589	-2.611***	0.037
EUR	0.003	1.005	-4.466	-2.130**	0.031
GBP	-0.001	-0.312	-2.429	-1.297	0.009
HKD	0.000	-0.326	-1.000	-12.738***	0.478
HUF	0.003	0.416	-0.700	-0.956	0.006
IDR	-0.003	-0.508	-0.823	-4.617***	0.114
JPY	0.006	1.213	-2.269	-1.621	0.015
KRW	0.001	0.366	-1.057	-1.948*	0.026
MXN	-0.002	-0.631	-0.962	-3.138***	0.056
NOK	0.001	0.485	-0.885	-0.733	0.003
PHP	0.006	1.499	0.235	0.505	0.002
PLN	0.005	1.194	-0.099	-0.166	0.000
SEK	0.001	0.216	-0.520	-0.339	0.001
SGD	0.001	0.825	-1.604	-1.793*	0.018

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

   This pattern has been known to practitioners for some time, and has been used as a justification for the "conditional carry strategy." In this 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 are substantial variations in returns across the 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.

IV. 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 Hansen's (1982) generalized method of moment (GMM). Below we describe each of these steps, in detail.

1. Construction of Factor Returns

Our analysis includes the variables to capture four aspects of country fundamentals ―interest rate, default risk, foreign exchange rate policy and financial opening, and size of the capital market. Previous studies have pointed out the importance of interest rates. As mentioned earlier, Lustig, et al. (2011) 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, $F_{i,t}/S_{i,t}-1$. This is because the data on forward rates seems to be more reliable than the data on interest rates. As is well known, it is difficult to obtain data on interest rates consistent throughout the countries and the time. Recalling the construction procedure of CIP, we can see that the forward premium and the interest rate differential, $i-i^*$ are closely and positively related.[11] 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

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

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 et al. (2009) attribute the failure of CIP during the financial crisis to the increased counter-party risk and lack of funding. Fong et al. (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. The relationship between the default risk and the excess return is highly probable, given that the investors will demand a higher risk premium when they perceive a higher default risk. Della Corte et al. (2014) elaborate on this point, and provide empirical evidence supporting it. With a similar idea, Melvin 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.[12] Gropp et al. (2006) and Chan-Lau et al. (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.[13]

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[12] See the Appendix II for the details on data sources and variable construction.

[13] To check whether the distance-to-default is correlated with the market assessment of default likelihood, we estimated the following equation through the Fama-Macbeth (1973) procedure:

$$CDS_{i,t} = a + b \cdot DD_{i,t} + \varepsilon_{i,t}$$

$CDS_{i,t}$ refers to the CDS premium of currency i at time t; $DD_{i,t}$ is the distance-to-default of currency i at time t. We have collected the CDS premium for 17 currencies for the period between

As an alternative measure of default risk, we calculate the average stock beta, that is, the average of individual bank's 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.[14]

The third element of country fundamentals that we consider includes policies on foreign exchange rate system and financial opening. The standard asset pricing models, starting from CAPM, states that the expected return is proportional to the exposure to the common risk. There is no room for non-risk characteristics ("fundamentals") to affect the expected return. However, stock market research has shown that this is not the case: fundamentals appear to matter. We take the issue to the foreign exchange market, i.e. we ask whether country fundamentals matter for currency returns.

Countries adopt different foreign 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 rate regime on carry profits both in developed and emerging market currencies. Notably, Ito and Chinn (2007) show that this kind of policy variables 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 more rigid exchange rate regime are positively correlated with excess returns, although the relationship is not significant.

In this paper, we use data on capital control and foreign exchange rate regimes

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2003 and 2010. (We could not obtain the CDS premium for some currencies in our sample. Also our CDS data set is not balanced.) As explained in the text, $DD_{i,t}$ is constructed so that a higher value indicates a higher likelihood of default. Recall that the Fama-Macbeth estimate is obtained in two steps: In the first step, the equation is estimated for each cross-section, and then, in the second step, we take the average of the estimates. We adopted the Fama-Macbeth procedure because we are more interested in the cross-sectional relationship between the variables. We found that the estimate of b is highly significant; the t-statistics is 8.67 (The point estimate of b is 13.43.) This suggests that the distance-to-default reflects the market assessment of default likelihood fairly well.

[14] 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.

which has been often used in the previous studies. The capital control variable is from Chinn and Ito (2008), and the exchange rate regime variable is from Reinhart and Rogoff (2004) and Ilzetzki et al. (2008).[15] 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 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 seven variables—forward premium, distance to default, stock beta, capital control, exchange rate 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 four of these variables (forward premium, distance to default, exchange rate regime 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.[16] 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. Limited data availability on some of our country fundamentals only allows the sample period of our balanced panel to start from January 2001. So, our main empirical findings are based on 2001-2010 balanced panel data of 19 countries.[17]

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[15] See the Appendix II for the details.

[16] Our factors are calculated as the returns to the fundamental-sorted long-short portfolios. When the fundamentals are annual variables, the components of the portfolios do not change for a year (while the weights are adjusted every month). This is not necessarily bad. In fact, many authors of equity market research (e.g. Fama and French (1993)) prefer to rebalance the portfolios only once a year. Whether frequent rebalancing and frequent adjustment of components leads to better construction is debatable.

[17] Summary statistics of selected fundamentals are presented in Appendix I.

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 seven 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 seven long-short portfolios, one for each of the seven 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. Four out of the seven factors─forward premium, capital control, exchange rate 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. For references we plot returns of fundamental factors over time in Figure 1 and excess returns against fundamentals in Figure 2.

Table 3. Fundamental Factors

| Variables	Observations	Mean	Standard deviation	t-statistics
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 Rate 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*

Note: Figures are not in the percentage term. Both the mean and standard deviation are annualized. t-statistics are for testing the hypothesis that the mean excess return is zero. Sample period is from January 2001 to December 2010. Significance at 1%, 5% and 10% is indicated by ***, ** and *, respectively.

Figure 1. Returns of Fundamental Factors over Time
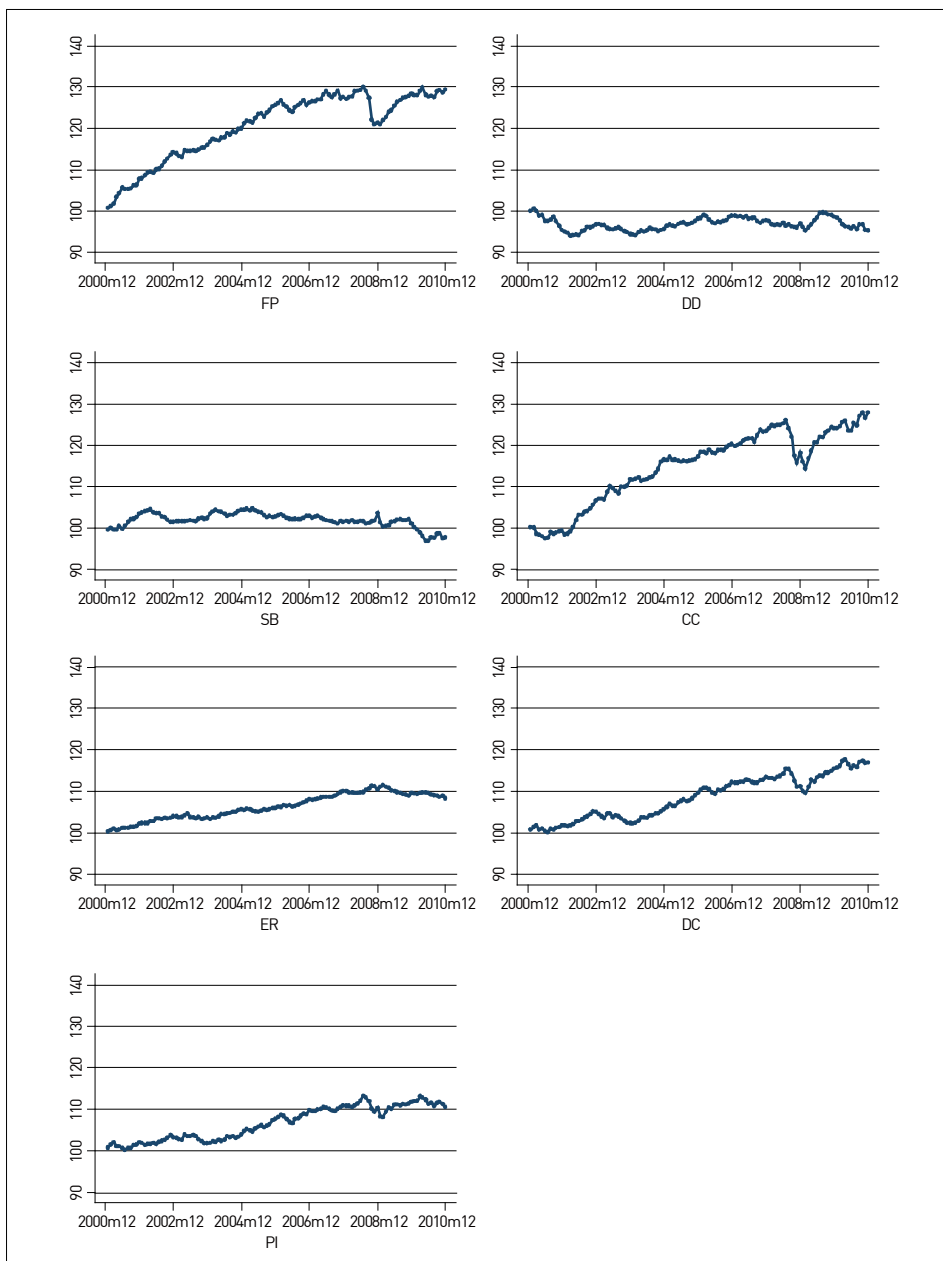
Note: FP = forward premium, DD = distance-to-default, SB = stock beta, CC = index of capital control, ER = index of exchange rate regime, DC = size of domestic credit, PI = per-capita income.

Figure 2. Excess Returns vs. Fundamentals
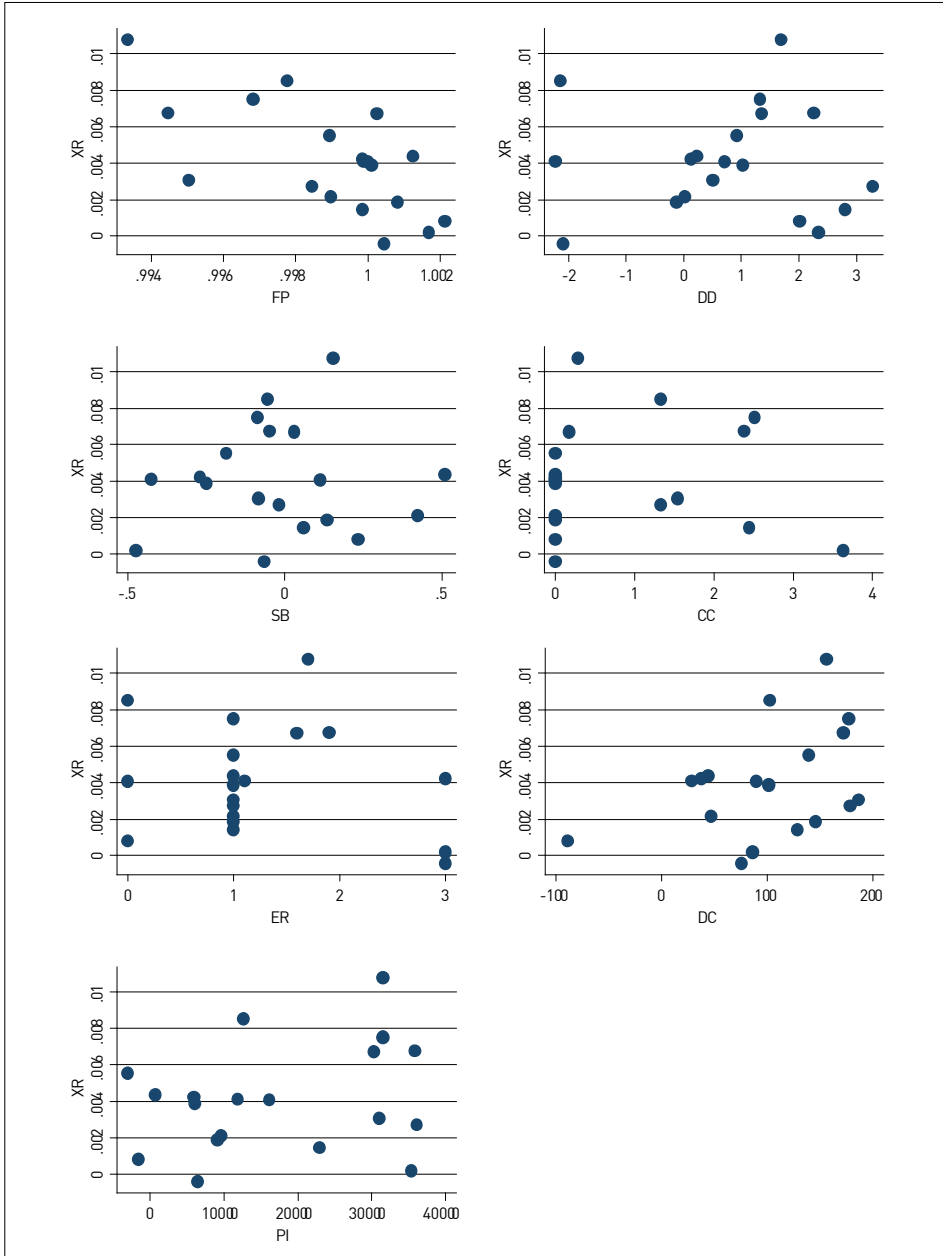
Note: The average excess return (y axis) is plotted against the average fundamental (x axis). FP = forward premium, DD = distance-to-default, SB = stock beta, CC = index of capital control, ER = index of exchange rate regime, DC = size of domestic credit, PI = per-capita income.

2. 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,

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

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

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

for all i. Factor price is defined as

$$\lambda = var(f_{t+1})b \qquad (6)$$

Factor price is estimated using Hansen's (1982) GMM.[18] 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 rate 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 testing 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.

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

As we show below, it is possible to construct a factor model with these factors that have acceptable explanatory power.

Table 4. Prices of Fundamental Factors

Factors	(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 rate 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)
# of currencies	19	19	19	19	19	19
# of months	120	120	120	120	120	120
J-statistics	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

Note: Each column shows the result of a particular regression with a particular combination of factors. Figures inside the parentheses are t-statistics. Sample period spans from January 2001 to December 2010. Significance at 1%, 5% and 10% is indicated by ***, ** and *, respectively.

3. Estimation of Factor Model

We now discuss the estimation of factor model à la Fama and French (1993). For each currency i, we estimate the following equation from OLS:[19]

$$R_{i,t+1} = \alpha_i + \beta_i' f_{t+1} + \varepsilon_{i,t+1} \tag{7}$$

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[19] 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.

Here β_i is called factor exposure, or simply beta.[20] 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.[21]

In Table 5, we report the estimation result for the model with three factors—forward premium, default risk, and exchange rate 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 rate regime beta is less significant. Of more interest to us than the significance of betas is the significance of the intercept term.[22] The intercept is significant for four currencies and marginally significant for two other 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 rate 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.

[20] Beta is of course related to factor price. Given that $\beta_i = \mathrm{cov}(R_{i,t+1} f'_{t+1})[\mathrm{var}(f_{t+1})]^{-1}$, it is easy to verify that the orthogonality condition of (5) is equivalent to $\mathrm{E}(R_{i,t+1}) = \beta_i \lambda$. 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.

[21] It is true that the cross-sectional size of our sample (N) is very small compared to the equity market research such as Fama and French (1993). However, the factor models have been successfully applied to much smaller samples outside the equity market. For example, many studies of commodity futures apply the factor model to the sample where N is less than 20. See De Roon and Szymanowksa (2010), Yang (2013), Szymanowska et al. (2014), and Bakshi et al. (2014).

[22] We have selected three variables (forward premium, distance-to-default, and exchange rate regime) for Table 5 because this combination has the highest p-value in Table 4. In fact, we obtain essentially the same results from other three-variable combinations shown in Table 4. We do not report the results for all combinations for the space consideration.

Table 5. Factor Model with Forward Premium, Distance to Default, and Exchange Rate
Regime Factors

Currencies	Intercept		Forward premium		Distance to default		Exchange rate regime		R^2
	Estimates	t-stat	Estimates	t-stat	Estimates	t-stat	Estimates	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

Note: Sample period spans from January 2001 to December 2010. Significance at 1%, 5% and 10% is
indicated by ***, ** and *, respectively.

4. Comparison with Investment-Style Factors

For the lack of a conventional benchmark, we use the factor model with the
investment-style factors of Pojarliev and Levich (2008, 2010, 2011). They have
proposed four style factors—the carry factor, the momentum factor, the PPP factor,
and the volatility factor.[23] 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.[24] Not

[23] Pojarliev and Levich (2008, 2010, 2011) 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.

[24] All of these factor returns are from Deutsche Bank. Pojarliev and Levich (2008, 2010, 2011)

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 nine 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.[25] 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. Investment Style Factors

Factors	Mean	Observations	Standard deviation	t-statistics
Carry	0.042	120	0.337	1.365
Momentum	0.033	120	0.314	1.159
PPP	0.044	120	0.295	1.625
Volatility	0.087	112	1.305	0.704

Note: Both mean and standard deviation are annualized. They are not in the percentage term. t-statistics are for testing the hypothesis that the mean excess return is zero. Sample period spans from January 2001 to December 2010.

Table 7. Prices of Investment Style Factors

Factors	(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)
# of currencies	19	19	19
# of months	120	112	112
J-statistics	39.11	40.31	37.65
P-value	0.0010	0.0007	0.0017

Note: Each column shows the result of a particular regression with a particular combination of factors. Figures inside the parentheses are t statistics. Sample period spans from January 2001 to December 2010. Significance at 1% is indicated by ***.

used an alternative source for the momentum factor; this alternative series is not updated anymore, making it unsuitable to our study.

[25] From Table 6, we do not have definite evidence that the average factor return is positive.

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 five out of 19 currencies.[26] 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 perform better in explaining currency excess returns.[27]

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

Currencies	Intercept		Carry		PPP		Volatility		R^2
	Estimates	t-stat	Estimates	t-stat	Estimates	t-stat	Estimates	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

[26] R^2 in Table 8 (average: 0.36) are higher than those in Table 5 (average: 0.18). This might indicate the effectiveness of the investment style factors. We believe this is rather unlikely for the following reason: R^2 of a misspecified model does not show the explanatory power. The degree of the misspecification is indicated by the significance of the intercept terms. The fundamental factors have less misspecification. Also, as we vary the specifications, R^2 varies quite a bit, suggesting that assigning too much importance to R^2 values is probably not prudent.

[27] 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. In addition, we have tested the hypothesis that the intercept is jointly zero after the estimation reported in Tables 5 (fundamental factors) and 8 (investment style factor). The F statistics are 2.58 and 5.69, respectively. Unfortunately, the hypothesis is rejected in both cases at the conventional significance level (the p-value for Table 5 is 0.0002 and it is almost zero for Table 8). Given the two "incorrect" models, however, one may still prefer the model with less violation.

Table 8. Continued

Currencies	Intercept		Carry		PPP		Volatility		R^2
	Estimates	t-stat	Estimates	t-stat	Estimates	t-stat	Estimates	t-stat	
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

Note: Sample period spans from January 2001 to December 2010. Significance at 1%, 5% and 10% is indicated by ***, ** and *, respectively.

V. Conclusion

We estimate the "fundamental factor model" of currency excess returns using the variables characterizing each country's default risk and foreign 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.[28] The results show the relevance of country fundamentals in determining and explaining currency returns.

[28] The fact that Pojarliev and Levich (2008, 2010, 2011) did not use the investment style factors for individual currencies does not make our comparison of fundamentals vs. investment style not interesting. With due respects to the originality of their works, we may still say that the investment style factors are not the invention of these authors. These factors have been used extensively in the equity market literature since Fama and French (1993). The fact that Pojarliev and Levich's factors are compiled and posted by Deutsche Bank also shows how widespread the use of these factors is. In the equity market research, the same factor model is used to assess fund performance and individual asset performance. So the work by Pojarliev and Levich is just one *more* reason to consider the investment style factors for individual currencies, not the reason not to do so. The natural question is: if the idea is so obvious, why is it that no one used the investment style factors for individual currencies? Perhaps our analysis suggests one answer: While the idea is obvious, its empirical performance is rather disappointing.

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. This paper may fill the gap between the country fundamentals and practitioners' strategies on currency investment.

Appendix I: Summary Statistics of Selected Fundamentals

	Forward premium		Distance to default		Exchange rate regime	
Currency	Mean	SD	Mean	SD	Mean	SD
AUD	0.998	0.001	-2.150	1.403	0.000	0.000
CAD	1.000	0.001	-2.233	1.399	1.107	0.311
CHF	1.001	0.001	0.231	1.900	1.000	0.000
CNY	1.002	0.003	2.339	3.417	3.000	0.000
CZK	1.000	0.002	1.356	2.690	1.595	0.493
DKK	1.000	0.001	0.124	1.562	3.000	0.000
EUR	1.000	0.001	0.717	1.655	0.000	0.000
GBP	0.999	0.001	0.024	0.934	1.000	0.000
HKD	1.000	0.000	-2.091	2.724	3.000	0.000
HUF	0.993	0.004	1.688	2.600	1.702	0.459
IDR	0.998	0.037	3.284	3.128	1.000	0.000
JPY	1.002	0.002	2.012	2.908	0.000	0.000
KRW	1.000	0.006	2.810	2.854	1.000	0.000
MXN	0.995	0.005	0.512	2.957	1.000	0.000
NOK	0.999	0.002	0.926	1.922	1.000	0.000
PHP	0.994	0.003	2.254	3.295	1.901	0.300
PLN	0.997	0.003	1.326	2.745	1.000	0.000
SEK	1.000	0.002	1.029	1.727	1.000	0.000
SGD	1.001	0.001	-0.124	2.402	1.000	0.000

Appendix II. Data Sources and Variable Construction Details

Exchange Rates, Stock Market Indicators and Macroeconomic Variables

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*. We also collect the firm-level stock prices and accounting data from the IDC and Worldscope.

Distance-to-Default

We measure the default risk of a bank with the distance-to-default of Gropp et al. (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

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

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

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

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 omit subscripts for convenience.

While D and r are directly observable, V and σ_V 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:

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

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

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 et al. (2006) and Chan-Lau et al. (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.

Capital Control and Exchange Rate Regime

We measure the degree of capital control for each country with the financial openness index developed by Chinn and Ito (2008). They codify the restrictions on the capital account transactions which are reported in the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions*. Applying the method of principal components to those binary variables, they construct the annual index for 182 countries. The updated index is available at Chinn's internet homepage, http://web.pdx.edu/~ito/Chinn-Ito_website.htm.

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 et al. (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. In this paper, we 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. The updated index

can be downloaded from Reinhart's internet homepage, http://www.carmenreinhart.
com/research/.

Investment-Style Factors

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.
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