NBER WORKING PAPER SERIES

COUNTERCYCLICAL CURRENCY RISK PREMIA

Hanno Lustig
Nikolai Roussanov
Adrien Verdelhan

Working Paper 16427
http://www.nber.org/papers/w16427

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2010

The findings in this paper were first reported in 'Common Risk Factors in Currency Markets', by the same authors. The authors thank Andy Atkeson, Alessandro Beber, Frederico Belo, Michael Brennan, Alain Chaboud, John Cochrane, Pierre Collin-Dufresne, Magnus Dahlquist, Kent Daniel, Frans DeRoon, Darrell Duffie, Xavier Gabaix, John Heaton, Urban Jermann, Don Keim, Leonid Kogan, Olivier Jeanne, Karen Lewis, Fang Li, Francis Longstaff, Pascal Maenhout, Rob Martin, Anna Pavlova, Monika Piazzesi, Richard Roll, Geert Rouwenhorst, Clemens Sialm, Ken Singleton, Rob Stambaugh, Hongjun Yan, and seminar participants at many institutions and conferences for helpful comments. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Countercyclical Currency Risk Premia
Hanno Lustig, Nikolai Roussanov, and Adrien Verdelhan
NBER Working Paper No. 16427
September 2010
JEL No. F3,F31,G12

ABSTRACT

Currency excess returns are predictable, more than stock returns, and about as much as bond returns. The average forward discount of the dollar against developed market currencies is the best predictor of average foreign currency excess returns earned by U.S. investors on a long position in a large basket of foreign currencies and a short position in the dollar. The predicted excess returns on baskets of foreign currency are strongly counter-cyclical because they inherit the cyclical properties of the average forward discount. This counter-cyclical dollar risk premium compensates U.S. investors for taking on U.S.-specific risk in foreign exchange markets by shorting the dollar. Macroeconomic variables such as the rate of U.S. industrial production growth increase the predictability of average foreign currency excess returns even when controlling for the forward discount.

Hanno Lustig
UCLA Anderson School of Management
110 Westwood Plaza, Suite C413
Los Angeles, CA 90095-1481
and NBER
hlustig@anderson.ucla.edu

Adrien Verdelhan
MIT Sloan School of Management
100 Main Street, E62-621
Cambridge, MA 02142
and NBER
adrienv@mit.edu

Nikolai Roussanov
University of Pennsylvania
Wharton School
2424 Steinberg-Dietrich Hall
3620 Locust Walk
Philadelphia, PA 19104-6367
and NBER
nroussan@wharton.upenn.edu

An online appendix is available at:
http://www.nber.org/data-appendix/w16427

The excess returns on a long position in a basket of foreign currencies and a short position in the dollar are highly predictable, more than stock returns, and about as much as bond returns. The best predictor is the average dollar forward discount (henceforth AFD) or interest rate difference between the average interest rates of a basket of developed currencies and the US interest rate. AFD is the best predictor even when investing in a basket of emerging market currencies. As the U.S. economy enters a recession, U.S. investors who short the dollar earn a larger interest rate spread, the AFD, and they earn an additional 150 basis points per annum in currency appreciation per 100 basis point increase in the interest rate spread. The economic driving force is the counter-cyclical variation in the risk price required by U.S. investors for taking on U.S. risk in foreign exchange markets by shorting the dollar. We refer to this risk premium as the dollar risk premium.

Since the work by Meese and Rogoff (1983), the standard view in international economics is that individual exchange rates follow a random walk, with perhaps small departures from the random walk at high frequencies (Evans and Lyons (2005)). This view emerged from the failure of a large class of models to outperform the random walk in forecasting changes in exchange rates for individual currency pairs.[1] This standard view implies that currency investors simply expect to earn forward discounts or interest rate differences between countries. From an economic point of view, there is little reason to expect the currency risk premium to be exactly equal to the interest

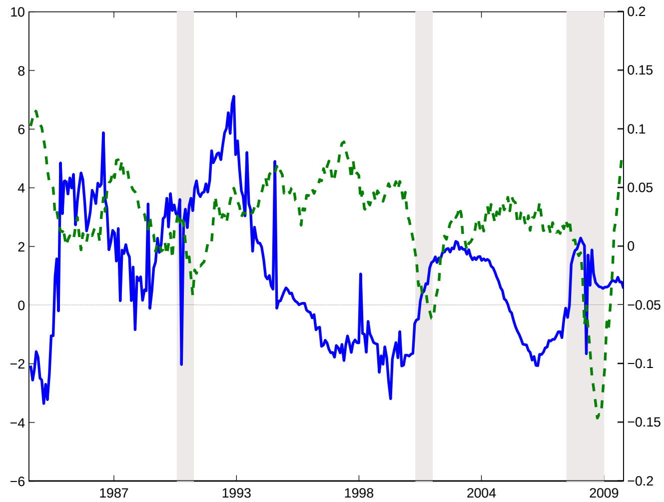
[1]Meese and Rogoff (1983) show that the out-of-sample predictions of exchange rates based on a drift-less random walk dominate those of all macro-founded models available for up to 12-month ahead forecasts. This result has been difficult to overturn. Engel and West (2005) show that exchange rates look like a random walk when fundamentals are I(1) and the discount factor is constant and near one. Note that in our approach the stochastic discount factor is not constant, and its time-variation is key to explain predictability in currency markets. Three challenges to the Meese and Rogoff (1983) result stand out. First, Mark (1995) shows that a model based on money demand beats the random walk if the horizon of the prediction increases from one to 16 quarters. Extending the sample period, however, Kilian (1999) does not confirm the result. Second, Evans and Lyons (2005) show that a model of exchange rates based on disaggregated order flow outperforms the random walk over horizons from one day to one month. Third, Gourinchas and Rey (2007), stressing the valuation effect of foreign assets on exchange rates, show that deviations from trend of the ratio of net exports to net foreign assets predict net foreign asset portfolio returns one quarter to two years ahead. We complement these three approaches with a risk-premium-based perspective. We focus on excess returns as well as spot rate changes and uncover new sources of predictability in exchange rates.

rate difference for that particular currency at all times, and, in fact, we find that it is not, because the forward discounts of other currencies and other macroeconomic variables also predict currency returns.

In any no-arbitrage model, the expected excess return on foreign currency investments has two components: a domestic and a global risk premium. The domestic or dollar risk premium compensates U.S. investors for bearing risk that is specific to the U.S., and the global risk premium compensates investors for bearing common risk. The excess returns on a long position in a broad basket of developed currencies and a short position in the dollar reflect mostly the dollar risk premium provided that the average country in the basket is equally exposed to common shocks as the U.S. A short position in the dollar is risky because the dollar appreciates in case of a negative U.S. shocks. In that case, common innovations to the domestic and foreign pricing kernels do not affect the dollar exchange rate against this basket of currencies, but U.S.-specific shocks do. Our findings support this view for the dollar. In related work, Lustig, Roussanov and Verdelhan (2009) argue that the carry trade risk premium, obtained by going long in high interest rate currencies and short in low interest rate currencies, is compensation for common risk.

The AFD for a broad basket of developed country currencies against the dollar measures the dollar risk premium, because it tracks the market price demanded by U.S. investors for bearing the U.S-specific risk priced in currency markets. Figure 1 plots the dollar AFD for a basket of developed currencies against the growth rate of U.S. industrial production. Clearly, it is highly countercyclical. In the model, as the AFD increases in U.S. recessions, the dollar risk price increases as well, and so do the expected excess returns on a basket of foreign currencies. In the data the AFD for a basket of developed currencies is a good predictor of average foreign currency excess returns earned by U.S. investors on baskets of foreign currencies. The one-month ahead AFD

Figure 1: 12-month AFD and U.S. Industrial Production Growth



The full line (axis on the left hand side) plots the 12-month AFD for the basket of developed currencies. The dotted line (axis on the right hand side) plots the 12-month seasonally adjusted rate of industrial production growth for the U.S. The shaded areas are NBER recessions.

explains 1 to 5 percent of the variation in the average foreign currency excess returns over the next month. When the horizon increases, R^2s increase too, because the AFD is persistent. At the 12-month horizon, the forward discount explains up to 15 percent of the variation in returns over the next year.

These effects are economically meaningful. An increase in the AFD of 100 basis points increases the expected excess return by 250 basis points per annum and it leads to an annualized depreciation of the dollar by 150 basis points. This is not so for the AFD computed on a basket of emerging market currencies. However, the AFD against a basket of developed currencies does forecast the returns on a basket of emerging market currencies, and the effect on returns is about 180 basis points per 100 basis point increase in the AFD. Moreover, we find that the AFD has forecasting power at the individual currency level above and beyond that of the currency-specific interest rate differential. These AFD slope coefficients are much larger than the average slope coefficients typically found for bilateral exchange rates, because the AFD averages out the effect of heterogeneity in exposure to common shocks on interest rates. These AFD slope coefficients are also more precisely estimated, because the AFD averages out idiosyncratic variation in currency-specific interest rate differences. The average slope coefficient in the predictability regression for bilateral exchange rates is only 44 basis points in our sample. There is a gap of more than 200 basis points between the AFD and the average individual forward discount slope coefficient. Even when forecasting individual currency returns, the AFD often outperforms the currency-specific forward discount. When we include both in the return predictability regressions at the 12-month horizon, we find an average slope coefficient of 1.95 for the AFD, compared to an average of -0.41 for the individual slope coefficients.

The predicted foreign currency excess returns on long position in foreign currency and a short position in the dollar are strongly counter-cyclical because they inherit the cyclical properties of U.S.-specific risk prices. We show that the U.S.-specific component of macroeconomic variables such as the rate of industrial production (henceforth IP) growth actually predict future excess returns even after controlling for the AFD. We investigate the one-month to one-year ahead predictability of the excess returns on baskets of foreign currency and we obtain R^2s of up to 25 percent when using the AFD and industrial production growth as predictors.[2]

These findings point towards a risk-based view of exchange rates: as their equity and bond counterparts, expected currency excess returns are predictable. They are high in bad times and low in good times. If the U.S. exposure to global shocks is close to that of the average currency

[2]We focus on the 12-month percentage change in U.S. industrial production index because it turns out to be the best forecaster. This variable is highly correlated with the output gap used by Cooper and Priestley (2009) to predict stock returns. Importantly, as documented in the term-structure literature (Duffee (2008), Ludvigson and Ng (2009), Joslin, Priebsch and Singleton (2010)), IP growth contains information about bond risk premia that is not captured by interest rates and, therefore, forward discounts.

in the basket, then our model implies that most of the predictability should come from U.S.-specific variables. IP, however, is correlated with foreign business cycles. We thus project IP on an average of foreign equivalents in order to remove the global component, and we use the residuals as predictors. Again, we obtain high R^2s, ranging from 17 up to almost 30 percent. These effects are large: a relatively small 100 basis point drop in year-over-year U.S. industrial output growth raises the expected excess return by 89 basis points per annum, after controlling for the AFD.

We develop a simple, multi-country model of exchange rates that encompasses both country-specific and common innovations. The model decomposes the expected foreign currency excess returns into a dollar risk premium, which compensates U.S. investors for exposure to U.S.-specific innovations, and a global risk premium, which compensates all investors for exposure to global innovations. Our model has three main implications for return predictability in currency markets. First, the AFD should be a good predictor of the average excess returns on foreign currency investments because it measures the prices of dollar risk; it should only predict carry trade returns if the exposure of the U.S. to global innovations is different from of the average country in the basket. Second, uncovered interest rate parity (UIP) should be more strongly rejected for baskets of currencies than for bilateral exchange rates. Slope coefficients in regressions of average changes in exchange rates on the AFD should be larger than those for regressions of bilateral exchange rates on bilateral forward discounts. Third, the dollar risk premium should be counter-cyclical with respect to the U.S.-specific component of the business cycle. As the price of this risk increases during U.S. recessions, the expected excess return on foreign currency increases. These predictions are borne out by the data. We develop a version of the model that is calibrated to match the key moments in the data. This model quantitatively reproduces our predictability findings provided that the maximum Sharpe ratio is high enough.

Related Literature A large literature already reports predictability on equity markets. We do not attempt to present it here, but refer the readers to Cochrane (2005) for a survey. Macroeconomic and financial variables predict stock market returns, particularly at long horizons. Other returns turn out to be predictable as well. In recent work, Duffee (2008), Ludvigson and Ng (2009), Joslin et al. (2010) report similar findings for the bond market using IP growth, and Piazzesi and Swanson (2008) document that payroll growth predicts excess returns on interest rate futures. Hong and Yogo (2009) show that common predictors of bond and stock returns, such as the short rate and the yield spread, also predict returns on commodity futures. But forecasting has been a longstanding challenge in international economics. A very large literature studies the link between exchange rates and interest rates. Twenty years ago, Froot and Thaler (1990) found already 75 papers on the topic. There has been no shortage since. In general, the reported R^2s are small and the slope coefficients borderline significant. The existing literature, however, focuses mainly on forecasting bilateral exchange rates (see Bekaert and Hodrick (1992) and Bekaert and Hodrick (1993) for prominent examples), not portfolios of currency excess returns. Within such settings detecting the effect of macroeconomic variables, such as IP growth, on currency risk premia requires imposing tight parametric structure on the stochastic discount factor (e.g. as in Dong (2006)).

Our model belongs to the essentially-affine class that is popular in the term structure literature. Special cases of this class of models applied to currency markets are proposed by Frachot (1996), Backus, Foresi and Telmer (2001) and Brennan and Xia (2006), as well as Lustig et al. (2009). We review here this last case and derive its implications for exchange rate predictability.

Section 2 presents the no-arbitrage model developed by Lustig et al. (2009). We use this model to derive currency return predictability implications. Section 3 describes the data, how we build currency portfolios and their main characteristics. Section 4 reports the time variation in excess returns that U.S investors demand on these foreign currency portfolios. Section 5 explores whether a model built to explain the cross-section of currency excess returns can quantitatively match the return predictability we find in the data. Section 6 shows that macro variables such as the rate of industrial production growth have incremental explanatory power for future currency basket returns. countries. Section 7 concludes. A separate appendix reports additional results. The portfolio data can be downloaded from our web sites and are regularly updated.

2 No-Arbitrage Model of Interest Rates and Exchange Rates

The literature has mostly focussed on the predictability of excess returns for individual foreign currency pairs. By shifting the focus to investments in baskets of foreign currencies, our paper shows that most of the predictability in currency markets actually reflects common variation in interest rates and exchange rates. We develop a standard affine model that reproduces the common variation in exchange rates and interest rates. The model has several implications for the predictability of returns on baskets of currencies. In the next section, we will test these predictions.

2.1 Setup

We assume that financial markets are complete, but that some frictions in the goods markets prevent perfect risk-sharing across countries. As a result, the change in the real exchange rate Δq^i between the home country and country i is $\Delta q^i_{t+1} = m_{t+1} - m^i_{t+1}$, where q^i is measured in country i goods per home country good and m denotes the log stochastic discount factor (SDF) or pricing kernel. An increase in q^i means a real appreciation of the home currency. For any variable that pertains to the home country (the U.S.), we drop the superscript. The real expected log currency excess return equals the interest rate difference plus the expected rate of appreciation. If pricing kernels are log-normal, the real expected log currency excess return is equal to:

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

We use the model developed by Lustig et al. (2009) to explain carry trade returns. In the model, there are two sources of priced risk: country-specific and world shocks.[3] Each type of risk has a different price. We assume that the risk prices of country-specific shocks depend only on the country-specific factors, and that the risk prices of world shocks can depend on world and country-specific factors.

We consider a world with N countries and currencies. We do not specify a full economy complete with preferences and technologies; instead we posit a law of motion for the SDFs directly. Following Backus et al. (2001), we assume that in each country i, the logarithm of the real SDF m^i follows a two-factor Cox, Ingersoll and Ross (1985)-type process:

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

To be parsimonious, we limit the heterogeneity in the SDF parameters to the different loadings, denoted δ^i, on the world shock; all the other parameters are identical for all countries. Lustig et al. (2009) show that cross-sectional variation in δ is key to understanding the carry trade.

[3]Bakshi, Carr and Wu (2008), Brandt, Cochrane and Santa-Clara (2006), Colacito (2008) and Colacito and Croce (2008) emphasize the importance of a large common component in SDFs to make sense of the high volatility of SDF and the relatively 'low' volatility of exchange rates. In addition, there is a lot evidence that much of the stock return predictability around the world is driven by variation in the global risk price, starting with the work of Harvey (1991) and Campbell and Hamao (1992). Lustig et al. (2009) show that, in order to reproduce cross-sectional evidence on currency excess returns, risk prices must load differently on this common component.

In this model, there is a common global factor z_t^w and a country-specific factor z_t^i. The currency-specific innovations u_{t+1}^i and global innovations u_{t+1}^w are $i.i.d$ gaussian, with zero mean and unit variance; u_{t+1}^w is a world shock, common across countries, while u_{t+1}^i is country-specific. The country-specific and world volatility components are governed by square root processes:

$$
\begin{aligned}
z_{t+1}^i &= (1-\phi)\theta + \phi z_t^i + \sigma\sqrt{z_t^i}v_{t+1}^i, \\
z_{t+1}^w &= (1-\phi)\theta + \phi z_t^w + \sigma\sqrt{z_t^w}v_{t+1}^w,
\end{aligned}
$$

where the innovations v_{t+1}^i, v_{t+1}^w are uncorrelated across countries, $i.i.d$ gaussian, with zero mean and unit variance. These processes ensure that log SDFs have positive variances.

As is common in the equity and bond asset pricing literature, we assume that the market price of U.S.-specific risk – and thus z^i – is counter-cyclical. This feature of asset markets is a key ingredient of leading dynamic asset pricing models (see Campbell and Cochrane (1999) and Bansal and Yaron (2004) for prominent examples).

In this model, the real interest rate investors earn on currency i is given by:

$$
r_t^i = \left(\chi - \frac{1}{2}(\gamma+\kappa)\right) z_t^i + \left(\chi - \frac{1}{2}\delta^i\right) z_t^w.
$$

We assume that the precautionary effect dominates on real interest rates, lowering rates when volatility increases: $\chi - \frac{1}{2}(\gamma+\kappa) < 0$ and $\chi - \frac{1}{2}\delta^i < 0$. High interest rate currencies tend to have low loadings δ^i on common innovations, while low interest rate currencies tend to have high loadings δ^i.

2.2 The Currency Risk Premium

The forward discount between currency i and the U.S. is thus equal to:

$$r_t^i - r_t = \left(\chi - \frac{1}{2}(\gamma + \kappa)\right)(z_t^i - z_t) - \frac{1}{2}\left(\delta^i - \delta\right) z_t^w. \tag{2.1}$$

We focus in our empirical work on the expected log currency excess return. In the model, the real log currency risk premium is given by:

$$E_t[rx_{t+1}^i] = \frac{1}{2}[(\gamma + \kappa)\left(z_t - z_t^i\right) + \left(\delta - \delta^i\right) z_t^w], \tag{2.2}$$

This log risk premium depends on the foreign factor, but the magnitude of this Jensen-inequality term is very small in the data. If $\chi = 0$, the log of real exchange rates follows a random walk, and the expected log excess return is simply proportional to the real interest rate difference.

2.3 Predictability of Currency Basket Returns

Consider a basket of currencies. We denote with a bar superscript ($\overline{x}$) the average of any variable or parameter x across all the countries in the basket. All of the parameters are symmetric across countries except for the loadings on the global shock, δ. Hence, the average real expected log excess return of the basket is:

$$E_t[\overline{rx}_{t+1}] = \frac{1}{2}(\gamma + \kappa)(z_t - \overline{z_t}) + \frac{1}{2}\left(\delta - \overline{\delta}\right) z_t^w. \tag{2.3}$$

We assume that the country-specific shocks average out within each portfolio. In this case, $\overline{z}$ is constant in the limit $N \to \infty$ by the law of large numbers. As a result, the real expected excess return on this basket consists of a dollar risk premium (the first term above, which depends only on z_t) and a global risk premium (the second term, which depends only on z_t^w).

The real expected excess return of this basket depends only on z and z^w. These are the same variables that drive the AFD:

$$\overline{r_t} - r_t = \left(\chi - \frac{1}{2}(\gamma + \kappa)\right)(\overline{z_t} - z_t) + \frac{1}{2}\left(\delta - \overline{\delta}\right) z_t^w.$$

Clearly, the AFD should have predictive power for average excess returns on a basket of currencies.

The Dollar Premium In the case of a basket consisting of a large number of developed currencies, it is natural to assume that that the average country's SDF has the same exposure to global innovations as the U.S.: $\overline{\delta} = \delta$. In this case, the log currency risk premium on the basket only depends on the U.S.-specific factor z_t:

$$E_t[\overline{rx}_{t+1}] = \frac{1}{2}(\gamma + \kappa)(z_t - \overline{z_t}). \tag{2.4}$$

Hence, the currency risk premium on this basket is the *dollar risk premium*, as it compensates U.S. investors proportionally to their exposures to the local (γ) and global (*kappa*) risks. In our model, the dollar risk premium is driven exclusively by U.S. variables (e.g. the state of the U.S. business cycle).

Similarly, the AFD only depends on the U.S. factor z_t as well:

$$\overline{r_t} - r_t = \left(\chi - \frac{1}{2}(\gamma + \kappa)\right)(\overline{z_t} - z_t). \tag{2.5}$$

By creating a basket in which the average country shares the U.S. exposure to global shocks, we have eliminated the effect of foreign idiosyncratic factors on currency risk premia *and* on interest rates. For this specific basket, the slope coefficient in a predictability regression of the average log returns in the basket on the AFD is $-\frac{1}{2}(\gamma+\kappa)/\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)$. Correspondingly, the UIP slope coefficient in regression of average real exchange rate changes for the basket on the real forward discount is $\chi/\left(\chi-\frac{1}{2}\gamma\right)$. On the one hand, if $\chi<\frac{1}{2}(\gamma+\kappa)$, a positive interest rate differential forecasts positive future returns. If $\chi=0$, then interest rate differences and currency risk premia are perfectly correlated. On the other hand, when $\gamma=0$ and $\chi>0$, then UIP holds.

Carry Trade By contrast, if we were to take a carry trade position and sort currencies by interest rates into portfolios, then, as shown by Lustig et al. (2009), investors would only be exposed to common innovations, not to U.S. innovations. Carry trades correspond to investments that are long high interest rate currencies and short low interest rate currencies. The return innovations on this high-minus-low (denoted *hml*) investment equals:

$$hml_{t+1}-E_t[hml_{t+1}] \quad = \quad \left(\frac{1}{N_L}\sum_{i\in L}\sqrt{\delta^i z_t^w+\kappa z_t^i}-\frac{1}{N_H}\sum_{i\in H}\sqrt{\delta^i z_t^w+\kappa z_t^i}\right)u_{t+1}^w.$$

The *hml* portfolio will have positive average returns if the pricing kernels of low interest rate currencies are more exposed to the global innovation. It is easy to show that the expected excess return on the carry trade portfolio do not depend on z_t, the U.S. specific factor, given our assumptions, and hence we do not expect the AFD to predict carry trade returns.

2.4 Predictability of Individual Currency Returns

Next, we consider the case of investing in individual currencies. When the U.S.' exposure differs from that of the foreign country, then the currency risk premium loads on the global factor, and so does the forward discount for that currency. Given all of the symmetry we have imposed on the model, this type of heterogeneity will invariably lower the UIP slope coefficient in a regression of exchange rate changes on the forward discount in absolute value relative to the case of a basket of currencies. The UIP slope coefficient for individual currencies using the forward discount for that currency is given by the expression on the left hand side:

$$\left|\frac{\chi\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)var(z_t^i-z_t)}{\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)^2 var(z_t^i-z_t)+\frac{1}{4}\left(\delta^i-\delta\right)^2 var(z_t^w)}\right|<\left|\frac{\chi}{\chi-\frac{1}{2}(\gamma+\kappa)}\right|.$$

It is lower than the right hand side simply because $\frac{1}{4}\left(\delta^i-\delta\right)^2 var(z_t^w)>0$. Intuitively, note that by considering only country-specific investments, the volatility of the forward discount has increased but the covariance between interest rate differences and exchanges rate changes has not, relative to the case of a basket of currencies. Hence, heterogeneity in exposure to the global innovations pushes the UIP slope coefficients towards zero, relative to the benchmark case with identical exposure. As a result, in the range of negative UIP slope coefficients, the slope coefficients in the predictability regressions will be smaller than $-\frac{1}{2}\gamma/\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)$, the coefficient that we obtained in the benchmark case with average exposures to global innovations equal to U.S exposure. Hence, we expect to see larger slope coefficients in absolute value for UIP regressions on baskets of currencies, because these baskets eliminate the heterogeneity in exposure to global innovations.

2.5 Inflation and Currency Return Return Predictability

The nominal pricing kernel is the real pricing kernel minus the rate of inflation: $m_{t+1}^{i,\$} = m_{t+1}^{i} - \pi_{t+1}^{i}$. If inflation innovations are not priced, the expected nominal excess returns in levels on the individual currencies and currency portfolios are identical to the expected real excess returns we have derived, but in logs they are slightly different, because of Jensen's inequality. However, these differences are of second order.

We simply assume that the same factors driving the real pricing kernel also drive expected inflation. In addition, we assume that inflation innovations are not priced. Thus, country i's inflation process is given by

$$\pi_{t+1}^{i} = \pi_0 + \eta z_t^i + \eta^w z_t^w + \sigma_\pi \epsilon_{t+1}^{i},$$

where the inflation innovations ϵ_{t+1}^{i} are i.i.d. gaussian. The nominal risk-free interest rate (in logarithms) is given by

$$r_t^{i,\$} = \pi_0 + \alpha + \left(\chi + \eta - \frac{1}{2}(\gamma + \kappa)\right) z_t^i + \left(\chi + \eta^w - \frac{1}{2}\delta^i\right) z_t^w - \frac{1}{2}\sigma_\pi^2.$$

Consider the simplest case in which the average country in the basket has the same exposure as the U.S. to global innovations (same δ and η^w). The nominal UIP slope coefficients in a regression of nominal exchange rate change for one currency on the nominal forward discount is given by $(\chi + \eta)/\left(\chi + \eta - \frac{1}{2}(\gamma + \kappa)\right)$. The slope coefficient in a predictability regression of the average log returns on the basket on the nominal dollar forward discount is

$$-\frac{1}{2}(\gamma + \kappa)/\left(\chi + \eta - \frac{1}{2}(\gamma + \kappa)\right). \tag{2.6}$$

Clearly, if $\eta = 0$ and expected inflation is driven by the global factors, then the forward discount and the risk premium are driven only by the common factor, and the UIP slope coefficients for currency baskets are unchanged from the 'real' slope coefficients that we have derived. The risk premium is still given by equation 2.4 and the AFD is still given by the expression in equation 2.5. However, if $\eta > 0$, the slope coefficients in predictability regressions for individual currency pairs tend to be smaller in absolute value as η increases. This is exactly what we find for baskets of emerging market currencies.

Summary This simple model offers two sets of predictions. First, average excess returns for baskets of currencies and average spot exchange rate changes should exhibit stronger predictability than can be obtained for individual currency pairs by eliminating the effect of foreign idiosyncratic and common shocks to interest rates and exchange rates. The return predictability on large baskets of developed currencies should largely reflect variation in the dollar risk premium. This variation is captured by the AFD. We expect the dollar risk premium to be counter-cyclical with respect to the U.S.-specific component of the business cycle. Second, we expect to see larger UIP slope coefficients in absolute value for baskets of currencies because these baskets largely eliminate the effect of heterogeneity in exposure to global innovations on interest rates and the AFD.

3 Forward and Spot Prices in Currency Markets

We now turn to the data to test the predictability of currency excess returns and exchange rates. We start by setting up some notation and describing the data, and give a brief summary of the currency returns at the level of currency baskets. We use the quoted prices of traded forward contracts of different maturities to study return predictability. Hence, there is no interest rate risk in the investment strategies that we consider. Moreover, these trades can be implemented at fairly low costs.

Currency Excess Returns using Forward Contracts We use s to denote the log of the nominal spot exchange rate in units of foreign currency per U.S. dollar, and f for the log of the forward exchange rate, also in units of foreign currency per U.S. dollar. An increase in s means an appreciation of the home currency. The log excess return rx on buying a foreign currency in the forward market and then selling it in the spot market after one month is simply $rx_{t+1} = f_t - s_{t+1}$. This excess return can also be stated as the log forward discount minus the change in the spot rate: $rx_{t+1} = f_t - s_t - \Delta s_{t+1}$. In normal conditions, forward rates satisfy the covered interest rate parity condition; the forward discount is equal to the interest rate differential: $f_t - s_t \approx i_t^\star - i_t$, where $i^\star$ and i denote the foreign and domestic nominal risk-free rates over the maturity of the contract. Akram, Rime and Sarno (2008) study high frequency deviations from covered interest rate parity (CIP). They conclude that CIP holds at daily and lower frequencies.[4] Hence, the log currency excess return equals the interest rate differential less the rate of depreciation: $rx_{t+1} = i_t^\star - i_t - \Delta s_{t+1}$.

Horizons Forward contracts are available at different maturities. We use k-month maturity forward contracts to compute k-month horizon returns (where $k = 1,\ 2,\ 3,\ 6$, and 12). The log excess return on the k-month contract for currency i is $rx^i_{t+k} = -\Delta s^i_{t\rightarrow t+k} + f^i_{t\rightarrow t+k} - s^i_t$, where $f^i_{t\rightarrow t+k}$ is the k-month forward exchange rate, and the k-month change in the log exchange rate is $\Delta s^i_{t\rightarrow t+k} = s^i_{t+k} - s^i_t$. For horizons above one month our series consists of overlapping k-month returns computed at monthly frequency.

[4]While this relation was violated during the extreme episodes of the financial crisis in the fall of 2008, including or excluding those observations does not have a major effect on our results.

Data We start from daily spot and forward exchange rates in U.S. dollars. We build end-of-month series from November 1983 to June 2010. These data are collected by Barclays and Reuters and available on Datastream. Our main data set contains at most 35 different currencies: Australia, Austria, Belgium, Canada, Hong Kong, Czech Republic, Denmark, Euro area, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Kuwait, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, United Kingdom. Some of these currencies have pegged their exchange rate partly or completely to the US dollar over the course of the sample. We keep them in our sample because forward contracts were easily accessible to investors. The euro series start in January 1999. We exclude the euro area countries after this data and only keep the euro series. Based on large failures of covered interest rate parity, we chose to delete the following observations from our sample: South Africa from the end of July 1985 to the end of August 1985; Malaysia from the end of August 1998 to the end of June 2005; Indonesia from the end of December 2000 to the end of May 2007; Turkey from the end of October 2000 to the end of November 2001; United Arab Emirates from the end of June 2006 to the end of November 2006.

Baskets of Currencies We construct three currency baskets. The first basket is composed of the currencies of the 15 developed countries: Australia, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland and United Kingdom, and the Euro. The second basket groups all of the remaining currencies, which correspond to the emerging countries in our sample. The third basket consists of all of the currencies in our sample. All of the average log excess returns and average log exchange rate changes are equally weighted within each basket.

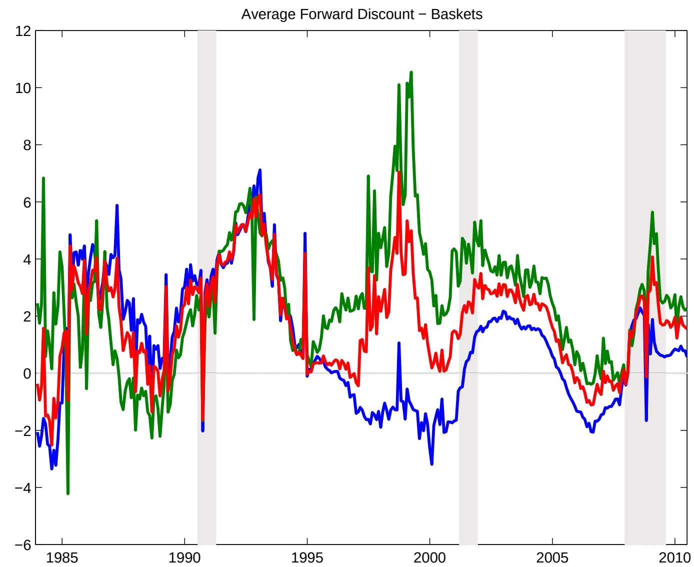
The average log excess return on currencies in basket j over horizon k is $\overline{rx}^j_{t\to t+k} = \frac{1}{N_t^j}\sum_{i=1}^{N_t^j} rx^i_{t+k}$, where N_t^j denotes the number of currencies in basket j at time t. Similarly, the average change in the log exchange rate is $\overline{\Delta s}^j_{t\to t+k} = \frac{1}{N_t^j}\sum_{i=1}^{N_t^j} \Delta s^i_{t\to t+k}$, and the AFD for maturity k is $\overline{f}^j_{t\to t+k} - \overline{s}^j_t = \frac{1}{N_t^j}\sum_{i=1}^{N_t^j} f^i_{t\to t+k} - s^i_t$.

Figure 2 displays the AFDs (Panel A) and cumulative average log excess returns (Panel B) on the three baskets. The shaded areas are NBER recessions determined by the U.S. The behavior of the returns is generally similar over the sample period (with some differences in the magnitude of variation), mostly reflecting the swings in the U.S. dollar. The AFDs computed on developed and emerging countries are virtually identical in the first half of the sample, but diverge dramatically during the period around the Asian financial crisis of 1997-1998, with emerging countries interest rates shooting up relative to both the U.S. and the developed countries averages. This disparity suggest that one should expect different patterns of predictability for the two baskets.

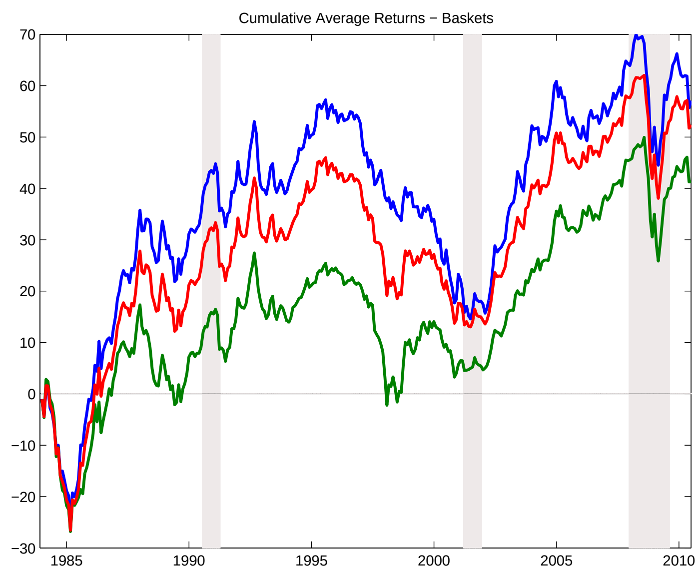
Table I presents the summary statistics of the three currency baskets, in particular annualized means and standard deviations of AFDs, average spot rate changes, and average log excess returns, as well as autocorrelations of the AFDs for all horizons. In the sample of developed countries, the unconditional average annualized dollar premium varies between 2.12 and 2.37% per annum depending on horizon. The AFDs are highly persistent, especially at longer horizons, with monthly autocorrelations between 0.83 and 0.98. Hence, the annualized autocorrelations vary between 0.11 and 0.78. Therefore, they are less persistent than the dividend yield on the U.S. stock market which has an annualized autocorrelation of 0.96.

Figure 2: Average 12-month Forward Discounts and Returns on 3 Currency Baskets

Panel A.



Panel B.



This figure presents the average 12-month forward discounts (top panel) and currency excess returns (bottom panel) on 3 currency baskets. In each panel, the top line is for developing countries. The middle line is for all countries. The bottom line is for developed countries. The shaded areas are NBER recessions. The sample period is 11/1983–6/2010.

4 Predictability in Currency Markets

In this section, we investigate the predictability of currency excess returns and changes in exchange rates. We show that the AFD forecasts basket-level exchange rate changes and returns, and does a good job of describing the time variation in expected currency excess returns even compared with the individual currency pairs' forward discounts. Further, we document that expected excess returns on currency baskets are counter-cyclical, and that they are driven by the domestic-country specific component of the business cycle, consistent with the no-arbitrage model.

4.1 The Average Dollar Forward Discount and the Dollar Risk Premium

We run the following regressions of basket-level average log excess returns on the AFD, and of average changes in spot exchange rates on the AFD:

$$\overline{rx}_{t\to t+k} = \psi_0 + \psi_{\mathbf{f}}(\overline{f}_{t\to t+k} - \overline{s}_t) + \eta_{t+k}, \tag{4.1}$$

$$-\overline{\Delta s}_{t\to t+k} = \zeta_0 + \zeta_{\mathbf{f}}(\overline{f}_{t\to t+k} - \overline{s}_t) + \epsilon_{t+k}. \tag{4.2}$$

We report several standard errors for the slope coefficients $\psi_{\mathbf{f}}$ and $\zeta_{\mathbf{f}}$. The AFD are strongly autocorrelated, albeit less so than individual countries' interest rates. This complicates statistical inference. To deal with this issue, we use two asymptotically-valid corrections. The Hansen-Hodrick standard errors (HH) are computed with one lag, plus the number of lags equal to horizon k for overlapping observation. The Newey-West standard errors (NW) are computed with the optimal number of lags following Andrews (1991). Both of these methods correct for error correlation and conditional heteroscedasticity. Bekaert, Hodrick and Marshall (1997) note that the small sample performance of these test statistics is also a source of concern. In particular, due to the persistence of the predictor variable, estimates of the slope coefficient can be biased (as pointed out by Stambaugh (1999)), as well as have wider dispersion than the asymptotic distribution. To address these problems, we computed bias-adjusted small sample t-statistics, generated by bootstrapping 10,000 samples of returns and forward discounts from a bivariate VAR.[5] We also report the Newey-West (bootstrap) t-statistics for the coefficients estimated using only non-overlapping observations.

The regression equations 4.2 test different hypotheses. In the regression for excess returns in equation (4.2), the null states that the log expected excess currency returns are constant. In the regression for log exchange rates changes, the null states that changes in the log spot rates are unpredictable, i.e., the expected excess returns are time varying and they equal to the interest rate differential (forward discount).

Developed Countries Table II reports the estimated slope coefficient with the corresponding t-statistics reported in brackets below each estimate, and the R^2 of each regression. There is strong evidence against UIP in the returns on the developed countries basket, at all horizons: the estimated slope coefficients $\kappa_{\mathbf{f}}$ in the predictability regressions are highly statistically significant, regardless of method used to compute the t-statistics, except for annual horizon non-overlapping returns; we have too few observations given the length of our sample. The R^2 increase from about 3.5% at the monthly horizon to up to 15% at one-year horizon. This increase in the R^2 as we increase the holding period is not surprising, given the persistence of the AFD.

Moreover, given that the coefficient is substantially greater than unity, the average exchange

[5]Our bootstrapping procedure follows Mark (1995) and Kilian (1999) and is similar to the one recently used by Goyal and Welch (2005) on U.S. stock excess returns. It preserves the autocorrelation structure of the predictors and the cross-correlation of the predictors' and returns' shocks.

rate changes are also predictable, more so than is typically detected using individual currency returns: the coefficient $\zeta_{\mathbf{f}}$ is statistically significant according to most methods at all horizons above one month. Since the log excess returns are the difference between changes in spot rates at $t+1$ and the AFD at t, these two regressions are equivalent and $\psi_{\mathbf{f}} = \zeta_{\mathbf{f}} + 1$. The R^2s for the the exchange rate regressions are lower, ranging from just over 1 percent for monthly to almost 15 percent for annual horizon.

These effects are large. At the one-month horizon, each 100 basis point increase in the forward discount implies a 250 basis points increase in the expected return, and it increases the expected appreciation of the foreign currency basket by 150 basis points. The estimates are very similar for all maturities, except the 12-month estimate, which is 34 basis points lower.

Emerging Markets The second column in table reports the results for the emerging markets basket. For the basket of emerging market currencies, the results are quite different if we the use the corresponding emerging market AFD. The expected excess returns are less predictable. The estimated slope coefficients are smaller and statistically indistinguishable from zero for all maturities under one year, and exchange rate changes having negative coefficients.

This is not surprising in light of the sharp divergence between emerging and developed countries' AFD's without a corresponding divergence in returns exhibited in Figure 2. It is also consistent with the findings of Bansal and Dahlquist (2000), who argue that the UIP has more predictive power for exchange rates of high-inflation countries, which are mostly emerging markets. As we showed earlier in equation 2.5, this is consistent with the model: larger loadings of expected inflation on the domestic factor reduce the slope coefficients in predictability regressions. This is what we find for baskets of emerging market currencies.

Finally, with all currencies in our sample in the same basket, the results are, not surprisingly, mixed. While the excess returns are predictable (albeit with marginal statistical significance), the exchange rate changes are not, since all of the slope coefficients are attenuated due to the opposing effects of developed and emerging countries. This result suggests that environments characterized by high (expected) inflation may make it harder to extract risk premia from exchange rate data. This is consistent with our model for nominal exchange rates in Section 2.

The affine model in Section 2 suggests that the AFD should reflect the time-varying risk premia driven by the domestic state variables, as well as global state variable that affect the domestic investors asymmetrically. As such, they should have forecasting power for excess returns and spot exchange rate changes of currencies other than the ones used to construct the differential. To test this use the AFD of the developed countries' basket to forecast the emerging markets basket as well as the basket containing all countries (using matched-horizon forward discounts and exchange rate changes). Table III presents the results: there is equally strong predictability for average log excess returns and average spot rate changes for the emerging markets basket, as well as for the basket of all countries. The results are consistent across different maturities: there is a 170 basis point increase in the annualized expected excess return in response to a 100 basis point increase in the AFD for developed currencies. The signs of all slope coefficients are positive in all cases, with magnitudes between 1 and 2 and large t-statistics using most methods. The R^2 are between 1.5 percent for monthly data and up to 14% for annual data. This is despite the fact that predictability is quite weak for these baskets using their own AFD's. This is consistent with the view that among emerging markets currencies forward discounts mostly reflect inflation expectations rather than risk premia, but the latter are nevertheless important for understanding currency fluctuations.

4.2 The Average Forward Discounts and Bilateral Exchange Rates

By capturing the Dollar risk premium, the average forward discount is able to forecast individual currency returns as well as their basket-level averages. In fact, it is often a better predictor than the individual forward discount specific to the given currency pair. One way to see this is via a pooled panel regression

$$\overline{rx}^i_{t\to t+k} = \kappa^i_0 + \tilde{\kappa}_{\mathbf{f}}(\overline{f}^j_{t\to t+k} - \overline{s}^j_t) + \tilde{\kappa}_f(f^i_t - s^i_t) + \eta^i_{t+k},$$

for excess returns as well as regressions on the average as well as the currency-specific forward discount, and a similar regression for spot exchange rate changes :

$$-\Delta s^i_{t\to t+k} = \zeta^i_0 + \tilde{\zeta}_{\mathbf{f}}(\overline{f}^j_{t\to t+k} - \overline{s}^j_t) + \tilde{\zeta}_f(f^i_t - s^i_t) + \tilde{\eta}^i_{t+k},$$

where κ^i_0 and ζ^i_0 are currency fixed effects, so that only the slope coefficients are constrained to be equal across currencies.

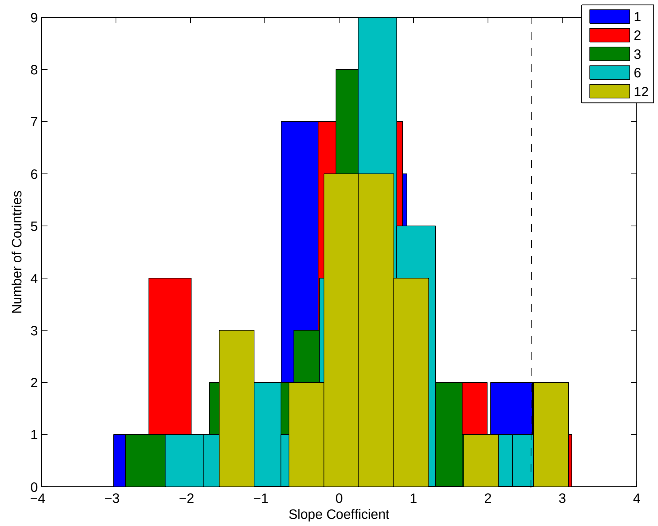
Table IV presents the results for the developed and emerging countries subsamples, as well as the full sample of all currencies that we use. The coefficients on the average forward discount are large, around 2 for developed countries for both excess returns and exchange rate changes (as we are controlling for individual forward discounts). They are robustly statistically significant for developed countries and somewhat weaker for emerging countries sample. In contrast, the coefficients on the individual forward discount are small for the developed markets sample, not statistically different from zero (and in fact negative for spot rate changes). For emerging countries, the individual forward discount is equally important as the AFD for predicting excess returns, but not for exchange rate changes.

The restriction on the slope coefficients, while allowing for precise estimation, is likely to be misspecified. As we show in section 2 using the framework of our model, heterogeneity in the exposures to the global shocks leads to differences in slope coefficients. However, a similar picture emerges from bivariate predictive regressions run separately for individual currencies. To save space, we summarize those briefly here, the full set of results can be found in the Supplementary Appendix.[6] Figure 3 shows the histogram of predictability regression slope coefficients estimated on bilateral exchange rates over the same sample. The means of the slope coefficients are 0.12, 0.16, 0.09, 0.35, 0.44, and 0.28 for k = 1, 2, 3, 6, and 12 respectively. On average, we find that a 100 basis points increase in the individual forward discount leads to an annualized appreciation of the dollar against this basket of than 44 basis points at the 12 month horizon. The red line is the estimate for the basket.

Finally, figure 3 shows the histogram of predictability regression slope coefficients estimated on bilateral exchange rates over the same sample obtained when we include both the AFD (histogram shown in the panel on the left) and the individual forward discount (histogram shown in the panel on the right). As the maturity increases, the AFD slope distribution shifts to the right, while the individual forward discount distribution shifts to zero (or below zero). At the 12-month horizon, the average slope coefficient for the AFD is 1.95, while the average individual slope coefficient is $-.41$. The implied UIP slope coefficient is now 1.41. After controlling for the AFD, the spot exchange rate depreciates more than 100 basis points in response to a 100 basis point increase in the individual forward discount. For example, in the case of France, the ADF slope coefficient is 2.03, while the individual forward discount coefficient is zero. In the case of Germany, the AFD

[6] Available on-line at `http://finance.wharton.upenn.edu/~nroussan/CCRP_Supplementary_Appendix`.

Figure 3: Histogram of Predictability Slope Coefficients for Individual Currencies



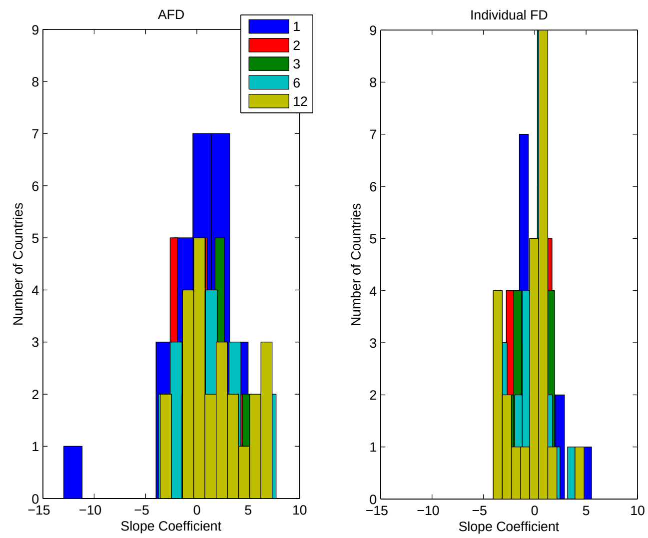
Histogram of annualized Predictability Regression Slope Coefficients for individual currencies at 1-month, 2-month, 3-month, 6-month and 12-month horizons. Sample: 1983.11-20010.6. Sample covers 37 currencies (including the Euro). The line is the estimate for the basket of developed currencies using the AFD. The means of the slope coefficients are 0.12, 0.16, 0.09, 0.35, and 0.44 for $k = 1$, 2, 3, 6, and 12 respectively.

slope coefficient is 3.94, while the individual discount coefficient is -1.26.

Summary We found that a single return forecasting variable describes time variation in currency excess returns and changes in exchange rates even better than the forward discount rates on the individual currency portfolios. This variable is the average of all the forward discounts across currencies in the developed countries basket. The results are consistent across different baskets and maturities: a 100 basis points increase in the AFD leads to an annualized depreciation of the dollar against this basket of more than 150 basis points. These are much larger (in absolute value) than the estimates obtained for individual exchange rates. The calibrated model will reproduce this finding.

We now turn to the business cycle properties of *expected* currency excess returns.

Figure 4: Histogram of Predictability Slope Coefficients for Individual Currencies



Histogram of annualized Predictability Regression Slope Coefficients for individual currencies at 1-month, 2-month, 3-month, 6-month and 12-month horizons. Sample: 1983.11-20010.6. Sample covers 37 currencies (including the Euro). The line is the estimate for the basket of developed currencies using the AFD. The means of the AFD slope coefficients are 0.09, 0.53, 0.82, 1.27, and 1.95 for $k = 1, 2, 3, 6$, and 12 respectively. The means of the individual slope coefficients are 0.22, 0.02, -0.15, -0.19, and -0.41.

4.3 Cyclical Properties of the Dollar Risk Premium

Our predictability results imply that expected excess returns on currency portfolios vary over time. We now show that this time variation has a large U.S. business cycle component: expected excess returns go up in U.S. recessions and go down in U.S. expansions, which is similar to the counter-cyclical behavior that has been documented for bond and stock excess returns.

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

$$\widehat{E}_t rx^j_{t+1} = \psi^j_0 + \psi^j_{\mathbf{f}}(\overline{f}^j_{t\to t+k} - \overline{s}^j_t).$$

Therefore, expected excess returns on currency baskets inherit the cyclical properties of the

AFDs. To assess the cyclicality of these forward discounts, we use three standard business cycle indicators and three financial variables: (i) the 12-month percentage change in U.S. industrial production index, (ii) the 12-month percentage change in total U.S. non-farm payroll index, (iii) the 12-month percentage change in the Help Wanted index, (iv) the term spread – the difference between the 20-year and the 1-year Treasury zero coupon yields, (v) the default spread – the difference between the BBB and AAA Bond Yield – and (vi) the CBOE VIX index of S&P 500 index-option implied volatility.[7] Macroeconomic variables are often revised. To check that our results are robust to real-time data, we use vintage series of the payroll and industrial production indices from the Federal Reserve Bank of Saint Louis. The results are very similar to the ones reported in this paper. Note that macroeconomic variables are also published with a lag. For example, the industrial production index is published around the 15th of each month, with a one-month lag (e.g. the value for May 2009 was released on June 16, 2009). In our tables, we do not take into account this publication lag of 15 days or so and assume that the index is known at the end of the month. We check our results by lagging the index an extra month. The publication lag sometimes matters for short-horizon predictability but does not change our results over longer horizons.

Table V reports the contemporaneous correlations of the AFDs (across horizons) with these macroeconomic and financial variables. Developed countries are in the first panel and emerging countries in the second. As expected, average forward discounts (and, therefore, forecasted excess returns) are counter-cyclical. There are some differences, however, between the two baskets.

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

On the one hand, both baskets' AFDs are negatively correlated with the real macroeconomic variables, indicating that AFDs rise in recessions. Similarly, for both baskets they are positively correlated with the slope of the U.S. term structure. On the other hand, monthly correlations of the AFD with the default spread are positive for the developed markets basket, but negative for the emerging markets basket. Figure 1 plots the AFD on the basket of developed currencies (blue line) against 12-month Industrial Production growth in the U.S (green line). The shaded areas are NBER recessions. We find roughly the same business cycle variation in AFD across horizons. At every maturity we consider, the AFD appears counter-cyclical. Since excess returns load positively on the AFD, they are also counter-cyclical.

In the model, the AFD captures the U.S.-specific variation in risk premia, if the average exposure to common shocks in the basket equals that of the U.S. To check that the U.S.-specific component of the AFD of developed countries matters most here, we run predictability tests using the residuals from the projection of the AFD on the average 12-month changes of foreign countries Industrial Production indices, which removes much of the covariation of the AFD with the global macroeconomic conditions:

$$
\begin{aligned}
(\overline{f}^{j}_{t\rightarrow t+k} - \overline{s}^{j}_{t}) &= \alpha + \beta \overline{\Delta \log IP_t} + AFD_{res,t}, \\
\overline{rx}^{i}_{t\rightarrow t+k} &= \kappa_0 + \psi^{j}_{\mathbf{f}} AFD_{res,t} + \eta^{i}_{t+1},
\end{aligned}
$$

where $\overline{\Delta \log IP_t}$ denotes the average of the 12-month changes in IP indices across 28 developed countries (excluding the U.S.). The results are reported in Table VI. The t-stats reported do not reflect the statistical uncertainty from the estimation in the first stage. These results can be compared to the first column in Table II and Table III. For the basket of developed currencies, the slope coefficients are about 20 basis points lower across different maturities. For the other baskets, the results are similar.

Conversely, the equity option-implied volatility index (VIX) is positively correlated with the emerging markets AFD but negatively correlated with that of the developed markets in our sample. The VIX seems like a good proxy for the global risk factor because it is highly correlated with similar volatility indices abroad.[8]

This heterogeneity in exposures to the VIX is therefore consistent with the predictions of the no-arbitrage model in (Lustig et al. 2009). The model predicts negative loadings on the common risk factor for the risk premia on low interest rate currencies and positive loadings for the risk premia on high interest rate currencies (which typically include more emerging than developed markets currencies). In times of global market uncertainty, there is a flight to quality: investors demand a much higher risk premium for investing in high interest rate currencies, and they accept lower (or more negative) risk premia on low interest rate currencies.

5 Calibrated Model

This section explores whether the model can quantitatively match the return predictability that we have described in the data. We calibrate a completely symmetric version of the full model in which all countries share the same δ. We first focus on real moments. There are 8 parameters in the real part of the model: 5 parameters govern the dynamics of the real stochastic discount factors (α, χ, γ, κ, and δ) and 3 parameters (ϕ, θ, and σ) describe the evolution of the country-specific and global factors (z and z^w). We choose these parameters to match the following 9 moments in

[8]The VIX starts in February 1990. The DAX equivalent starts in February 1992; the SMI in February 1999; the CAC, BEL and AEX indices start in January 2000. Using the longest sample available for each index, the correlation coefficients with the VIX are very high, 0.82 and 0.88 using monthly time-series.

the data: the mean, standard deviation and autocorrelation of the U.S. real short-term interest rates, the standard deviation of changes in real exchanges rates, the real UIP slope coefficients, the R^2 in the UIP regressions[9], the cross-country correlation of real interest rates, the conditional maximum Sharpe ratio (e.g the standard deviation of the log SDF) and a Feller parameter (equal to $2(1-\phi)\theta/\sigma^2$), which helps ensure that the z and z^w processes remain positive. These 9 moments as well as the targets in the data that we match are listed in Panel A of Table VII. The first column reports the moments ate monthly frequency. The second column reports the annualized version. The third column reports the actual moments (computed in closed form).

The data for this calibration exercise come from Barclays and Reuters (Datastream). Because of data availability constraints, we focus on the subset of developed countries. The sample runs from 11/1983 to 12/2009. However, for the U.S. real interest rates data, we use the real zero-coupon yield curve data for the U.S. provided by J. Huston McCulloch on his web site; the sample covers 1/1997–10/2009.

We obtain the 3 inflation parameters (η^w, σ^π,π_0) by targeting the mean, standard deviation as well as the fraction of inflation that is explained by the common component. We set $\eta = 0$, so expected inflation does not respond to the country-specific factor. As a result, there is no difference in UIP slope coefficients between the nominal and the real model. In Panel B of Table VII, we list the expression for the variance of inflation and the fraction explained by the common component. We target an annualized standard deviation for inflation of 1.09% and an average inflation rate of 2.90%. 28% of inflation is accounted by the common component. Finally, for completeness, Panel C also shows the implied moments of nominal interest rates and exchange rates in this symmetric

[9]The R^2 for the basket regression is the same: $\frac{\beta^2_{UIP}\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)^2 * var(z)}{\gamma\theta+2\chi^2 var(z^i)}$, because one divides the numerator and the denominator by 2.

version of the model. The implied correlation of nominal interest rates is much too low.

To obtain the 11 parameter values listed in Table VIII, we minimized the sum of squared errors for the 12 moments listed in Table VII. We target a UIP slope coefficient of -1.5, and an R^2 in the UIP regression of 3.40%, an average real interest rate of 1.72% per annum, an annualized standard deviation of the real interest rate of .57% per annum, and an autocorrelation (in monthly data) of 0.92. The annual standard deviation of real exchange rate changes is 10%. We target a maximum Sharpe ratio of 0.5. The average pairwise correlation of real interest rates is .3. The annual dollar risk premium is .5% per annum. A Feller coefficient of 20 guarantees that all of the state variables following square-root processes are positive (this is exact in the continuous-time approximation, and implies a negligible probability of crossing the zero bound in discrete time). We cannot match all of the moments. In particular, the model overstates the volatility of the risk-free rate. Moreover, the maximum Sharpe ratio is twice as high as our target of 50%. All of the other moments are matched almost exactly. In particular, the model reproduces the UIP real slope coefficient of -1.50 that we uncover in the data. The model-implied nominal slope coefficient is identical.

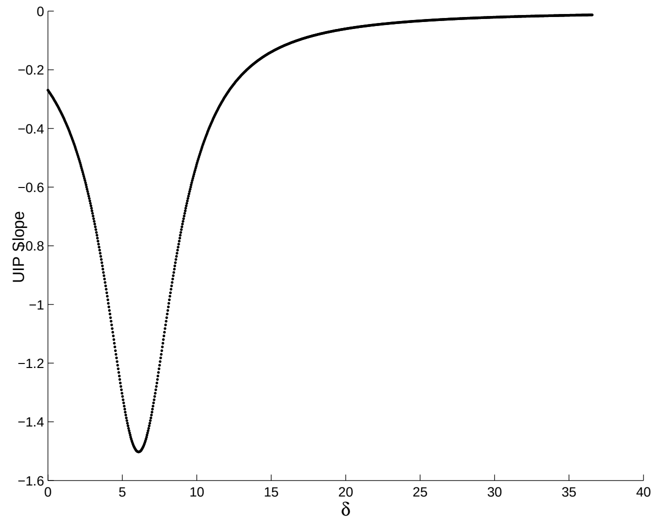
For this specific basket, the slope coefficient in a predictability regression of the average log returns on the basket on the real dollar forward discount is $-\frac{1}{2}(\gamma+\kappa)/\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)$, and, correspondingly, the UIP slope coefficient in regression of average real exchange rate changes for the basket on the real forward discount is $\chi/\left(\chi-\frac{1}{2}\gamma\right)$. If $\chi<\frac{1}{2}(\gamma+\kappa)$, a positive interest rate differential forecasts positive future returns. If $\chi=0$, then interest rate differences and currency risk premia move one-for-one. On the other hand, when $\gamma=0$ and $\chi>0$, then UIP holds. Next, we consider the case of investing in individual currencies. When the U.S.' exposure differs from that of the foreign country, then the currency risk premium loads on the global factor, and so does the forward discount for that currency. Given all of the symmetry we have imposed on the model, this type of heterogeneity will invariably lower the UIP slope coefficient in a regression of exchange rate changes on the forward discount in absolute value relative to the case of a basket of currencies. The UIP slope coefficient for individual currencies using the forward discount for that currency is given by the expression on the left hand side:

$$\left|\frac{\chi\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)var(z_t^i-z_t)}{\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)^2 var(z_t^i-z_t)+\frac{1}{4}\left(\delta^i-\delta\right)^2 var(z_t^w)}\right|<\left|\frac{\chi}{\chi-\frac{1}{2}(\gamma+\kappa)}\right|,$$

simply because $\frac{1}{4}\left(\delta^i-\delta\right)^2 var(z_t^w)>0$. To see why note that the volatility of the forward discount has increased but the covariance between interest rate differences and exchanges rate changes has not, relative to the case of a basket of currencies. Hence, heterogeneity in exposure to the global innovations pushes the UIP slope coefficients towards zero, relative to the benchmark case with identical exposure. As a result, in the range of negative UIP slope coefficients, the slope coefficients in the predictability regressions will be smaller than $-\frac{1}{2}\gamma/\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)$, the coefficient that we obtained in the benchmark case with average exposures to global innovations equal to U.S exposure. Hence, we expect to see larger slope coefficients in absolute value for UIP regressions on baskets of currencies, because these baskets eliminate the heterogeneity in exposure to global innovations. Figure 5 plots the implied UIP slope coefficients for individual currencies against δ. The UIP slope coefficients reaches a maximum in absolute value at the home country value of 6.89. As we increase/decrease δ, the slope coefficient declines to zero in absolute value.

Finally, table IX reports the regression results on simulated data for a basket of 30 currencies with δ's uniformly distributed between 65% and 135% of the home country (the U.S.). We used a sample of 336 months. These are one-month returns regressed the one-month AFD. We do not

Figure 5: UIP Slope for Individual Currencies and δ



have forward discounts in closed form at longer horizons. Interestingly, even though exchange rates are predictable in the model, since $\chi > 0$, the statistical evidence for exchange rate predictability is weak at the one-month horizon, as it is in the data.

6 Macro Factors and Currency Return Predictability

Sofar we have focused on the predictive power of the AFD, but the counter-cyclical nature of excess returns suggests that macro variables themselves might help to forecast excess returns, potentially above and beyond what is captured by the AFDs. We check this conjecture by focusing on the predictive power of the industrial production (IP) index, controlling for the AFD.

Suppose $\boldsymbol{z}_t$ is a vector of domestic factors. If one of these is not spanned by interest rates (i.e. $\chi = \frac{1}{2}\gamma$) but does effect conditional expected returns (i.e. the price of local risk is positive, $\gamma > 0$) then one needs to look beyond forward discounts for other macroeconomic variables that forecast excess currency returns. Evidence from the term structure of U.S. interest rates suggest that business cycle variables such as the growth of industrial production contain information about risk premia in the bond markets that is not captured by the interest rates themselves (Duffee (2008), Ludvigson and Ng (2009), Joslin et al. (2010)). In our context, if we are looking to identify those components of the domestic state variable $\boldsymbol{z}_t$ that are not captured by interest rate differentials, we expect a U.S.-specific macroeconomic variable to have forecasting power for currency excess returns, as well as spot exchange rate changes.

We use $\overline{rx}^k_{t\to t+k}$ to denote the k-month ahead excess return on basket j between time t and $t+k$, as well as the corresponding regression for exchange rate changes. Table X reports two sets of regression results for each basket i:

$$\overline{rx}^i_{t\to t+k} = \kappa_0 + \kappa_{IP}\Delta \log IP_t + \kappa^j_{\mathbf{f}}(\overline{f}^j_{t\to t+k} - \overline{s}^j_t) + \eta^i_t,$$

$$-\overline{\Delta s}^i_{t\to t+k} = \zeta^j_0 + \zeta_{IP}\Delta \log IP_t + \zeta^j_{\mathbf{f}}(\overline{f}^j_{t\to t+k} - \overline{s}^j_t) + \eta^i_t.$$

We use the developed markets' AFD ($j = 1$) since it is the strongest predictor of returns on all baskets. The change in industrial production jointly with the AFD explain up to 25 percent of the variation in excess returns at the 12-month horizon. All the estimated slope coefficients are negative and, for horizons of 3 months and above, strongly statistically significant. Note that since we are controlling for the average forward of the developed markets basket, the IP coefficient for this basket is the same for excess returns and exchange rate changes, capturing the pure effect of the counter-cyclical risk premium on expected depreciation of the dollar, rather than the return stemming from the interest rate differential. Thus, holding interest rates constant, a one percentage point drop in the annual change in industrial production raises the dollar risk premium by 50-85 basis points per annum at monthly horizon and by as much as 80-115 basis points at the annual horizon, all coming from the expected appreciation of the foreign currencies against the dollar. Since the AFD itself counter-cyclical, the total effect is even greater, implying an increase in expected returns of up to 120 basis points for annual data. To save space, we do not report these results.

The U.S. industrial production appears highly correlated with similar indices in other developed countries. For example, its correlation with the average index for the G7 countries (excluding the U.S., and using 12-month changes in each index) is equal to 0.5. To check that the U.S.-specific component of the U.S. industrial production index matters most here, we run predictability tests using the residuals for the projection of these 12-month changes on the average foreign IP indices.

$$\begin{aligned}
\Delta \log IP_t &= \alpha + \beta \overline{\Delta \log IP_t} + IP_{res,t}, \\
\overline{rx}^i_{t\to t+k} &= \kappa_0 + \kappa_{IP_{res}} IP_{res,t} + \kappa^j_{\mathbf{f}} (\overline{f}^j_{t\to t+k} - \overline{s}^j_t) + \eta^i_{t+1},
\end{aligned}$$

where $\overline{\Delta \log IP_t}$ denotes the average of the 12-month changes in IP indices across 28 developed countries (excluding the U.S.).

As demonstrated in table XI, the predictive power of IP lies mostly in the U.S.-specific component of IP, denoted $IP_{res,t}$, for long-horizon returns. We obtain R^2s between 17 and 26 percent with the IP residuals for both average excess returns and average spot exchange rate changes. The slope coefficients are lower for the short-horizon returns, but larger for long horizons. For annual holding periods, a one percentage point decline in the U.S. IP relative to the world average implies a 140 to 160 basis point increase in the risk premium, *controlling* for the AFD.

6.1 Out-of-Sample

Finally, we check whether our predictors outperform the random walk in forecasting exchange rates out-of-sample. For each horizon, we compute the one-step ahead root-mean-square errors (RMSE) for the two sets of competing models, both estimated recursively: the random walk with drift (i.e., i.i.d. changes in average exchange rates for the basket) and the forecast based on one of the three sets of predictors: industrial production growth, IP together with the average forward discount of developed countries, and the AFD alone. We report three standard test statistics: the ratio of the two square root mean squared errors, the MSE_t test statistic of Diebold and Mariano (1995), and the ENC test statistic of Clark and McCracken (2001) (details of these statistics as well as the full set of results are in the Supplementary Appendix). Table XII reports our results, focusing on the developed-markets basket (the results are similar for other baskets). Panel A reports the results obtained using IP as the forecaster. Panel B reports results obtained using IP and AFD as forecasters. Finally, Panel C reports results obtained using the AFD. The details of the estimation procedure are in the separate appendix.

At the one-month horizon, Meese and Rogoff (1983)'s result stands. The ratio of the two mean squared errors is at best equal to one, and often below one. At longer horizons, however, changes in industrial production predict changes in exchange rates much better than a simple constant (the ratio of the two mean squared errors is 1.10). The Diebold and Mariano (1995)'s and Clark and McCracken (2001)'s statistics are positive at almost all horizons, and statistically significant. While the random walk is hard to beat as the best predictor of these changes in exchange rates, our results indicate that using business-cycle variables such as industrial production allows for some improvement in the forecasting power.

7 Conclusion

We have documented in this paper that returns in currency markets are highly predictable. The average forward discount and the change in the U.S. industrial production index explain one quarter of the subsequent variation in average annual excess returns realized by shorting the dollar and going long in baskets of currencies. The time variation in expected returns has a clear business cycle pattern: U.S. macroeconomic variables are powerful predictors of these returns, especially at longer holding periods, and expected currency returns are strongly counter-cyclical. We view these findings as supportive of a risk-based explanation of exchange rate fluctuations.

References

Akram, Q. Farooq, Dagfinn Rime, and Lucio Sarno, "Arbitrage in the Foreign Exchange Market: Turning on the Microscope," *Journal of International Economics*, 2008, *76* (2), 237–253.

Andrews, Donald W.K., "Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimation," *Econometrica*, 1991, *59* (1), 817–858.

Backus, David, Silverio Foresi, and Chris Telmer, "Affine Models of Currency Pricing: Accounting for the Forward Premium Anomaly," *Journal of Finance*, 2001, *56*, 279–304.

Bakshi, Gurdip, Peter Carr, and Liuren Wu, "Stochastic risk premiums, stochastic skewness in currency options, and stochastic discount factors in international economies," *Journal of Financial Economics*, January 2008, *87* (1), 132–156.

Bansal, Ravi and Amir Yaron, "Risks for the Long Run: A Potential Resolution of Asset Pricing Puzzles," *Journal of Finance*, 2004, *59* (4), 1481 – 1509.

— **and Magnus Dahlquist**, "The Forward Premium Puzzle: Different Tales from Developed and Emerging Economies," *Journal of International Economics*, 2000, *51*, 115–144.

Bekaert, Geert and Robert J. Hodrick, "Characterizing Predictable Components in Excess Returns on Equity and Foreign Exchange Markets," *The Journal of Finance*, 1992, *47* (2), 467–509.

— **and** — , "On biases in the measurement of foreign exchange risk premiums," *Journal of International Money and Finance*, 1993, *12*, 115–138.

——, ——, **and David A. Marshall**, "On Biases in Tests of the Expectations Hypothesis of the Term Structure of Interest Rates," *Journal of Financial Economics*, 1997, *44(3)*, 30948.

Brandt, Michael W., John H. Cochrane, and Pedro Santa-Clara, "International Risk-Sharing is Better Than You Think (or Exchange Rates are Much Too Smooth)," *Journal of Monetary Economics*, 2006, *53*, 671 – 698.

Brennan, Michael J. and Yihong Xia, "International Capital Markets and Foreign Exchange Risk," *Review of Financial Studies*, 2006, *19* (3), 753–795.

Campbell, John Y and Yasushi Hamao, "Predictable Stock Returns in the United States and Japan: A Study of Long-Term Capital Market Integration," *Journal of Finance*, March 1992, *47* (1), 43–69.

Campbell, J.Y. and J. H. Cochrane, "By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior," *Journal of Political Economy*, 1999, *107*, 205–251.

Clark, Todd E. and Michael W. McCracken, "Tests of equal forecast accuracy and encompassing for nested models," *Journal of Econometrics*, 2001, *105*, 85–110.

Cochrane, John H., *Asset Pricing*, Princeton, N.J.: Princeton University Press, 2005.

Colacito, Riccardo, "Six Anomalies Looking For a Model. A Consumption-Based Explanation of International Finance Puzzles," 2008. Mimeo.

—— **and Mariano Massimiliano Croce**, "Risks for the Long-Run and the Real Exchange Rate," September 2008. Available at SSRN: http://ssrn.com/abstract=1105496.

Cooper, Ilan and Richard Priestley, "Time-Varying Risk Premiums and the Output Gap," *Review of Financial Studies*, 2009, *22* (7), 2801–2833.

Cox, John C., Jonathan E. Ingersoll, and Stephen A. Ross, "A Theory of the Term Structure of Interest Rates," *Econometrica*, 1985, *53* (2), 385–408.

Diebold, F.X. and R.S. Mariano, "Comparing predictive accuracy," *Journal of Business and Economic Statistics*, 1995, *13*, 253–263.

Dong, Sen, "Macro Variables Do Drive Exchange Rate Movements: Evidence from a No-Arbitrage Model," 2006.

Duffee, Gregory R., "Information in (and not in) the term structure," 2008. Working Paper.

Engel, Charles and Kenneth D. West, "Exchange Rates and Fundamentals," *Journal of Political Economy*, 2005, *113* (3), 485–517.

Evans, Martin D.D. and Richard K. Lyons, "Meese-Rogoff Redux: Micro-Based Exchange Rate Forecasting," *American Economic Review*, 2005, *95* (2), 405414.

Frachot, Antoine, "A Reexamination of the Uncovered Interest Rate Parity Hypothesis," *Journal of International Money and Finance*, 1996, *15* (3), 419–437.

Froot, Kenneth and Richard Thaler, "Anomalies: Foreign Exchange," *The Journal of Economic Perspectives*, 1990, *4*, 179–192.

Gourinchas, Pierre-Olivier and Hélène Rey, "International Financial Adjustment," *Journal of Political Economy*, 2007, *115* (4), 665–703.

Goyal, Amit and Ivo Welch, "A Comprehensive Look at The Empirical Performance of Equity Premium Prediction," *Review of Financial Studies*, 2005, *21* (4), 1455–1508.

Hansen, Lars Peter and Robert J. Hodrick, "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," *The Journal of Political Economy*, October 1980, *88* (5), 829–853.

Harvey, Campbell R., "The World Price of Covariance Risk," *The Journal of Finance*, 1991, *46(1)*, 111–157.

Hong, Harrison and Motohiro Yogo, "Digging into Commodities," 2009. Working Paper.

Joslin, Scott, Marcel Priebsch, and Kenneth J. Singleton, "Risk Premiums in Dynamic Term Structure Models with Unspanned Macro Risks," May 2010. Stanford University.

Kilian, Lutz, "Exchange Rates and Monetary Fundamentals: What do we Learn from Long-Horizon Regressions?," *Journal of Applied Econometrics*, 1999, *14* (5), 491–510.

Ludvigson, Sydney C. and Serena Ng, "Macro Factors in Bond Risk Premia," *Review of Financial Studies, forthcoming*, 2009.

Lustig, Hanno, Nick Roussanov, and Adrien Verdelhan, "Common Risk Factors in Currency Returns," 2009. Working Paper.

Mark, Nelson C., "Exchange Rates and Fundamentals: Evidence on Long-Horizon Predictability," *American Economic Review*, 1995, *85* (1), 201–218.

Meese, Richard and Kenneth Rogoff, "Empirical Exchange Rate Models of the Seventies: Do they Fit Out-of-sample?," *Journal of International Economics*, 1983, *14*.

Newey, Whitney K. and Kenneth D. West, "A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica*, 1987, *55* (3), 703–708.

Piazzesi, Monika and Eric Swanson, "Futures Prices as Risk-Adjusted Forecasts of Monetary Policy," *Journal of Monetary Economics*, May 2008, *55* (4), 677–691.

Stambaugh, Robert F., "Predictive Regressions," *Journal of Financial Economics*, 1999, *54*, 375–421.

Table I: Summary Statistics

Horizon	1	2	3	6	12
		Panel A: Developed Countries			
		Average Forward Discount, $\overline{f}_{t\to t+1} - \overline{s}_t$			
Mean	1.00	0.98	0.95	0.86	0.68
Std.	2.20	2.11	2.06	1.96	1.82
Auto	0.91	0.96	0.97	0.98	0.98
		Average Spot Change, $-\overline{\Delta s}_{t\to t+1}$			
Mean	1.15	1.13	1.26	1.38	1.66
Std.	8.45	8.89	9.13	9.75	9.69
		Average Excess Returns, $\overline{rx}_{t+1}$			
Mean	2.15	2.12	2.22	2.25	2.37
Std.	8.54	9.05	9.36	10.14	10.25
		Panel B: Emerging Countries			
		Average Forward Discount, $\overline{f}_{t\to t+1} - \overline{s}_t$			
Mean	2.55	2.53	2.51	2.43	2.27
Std.	2.21	2.11	2.10	2.20	2.28
Auto	0.83	0.91	0.94	0.96	0.96
		Average Spot Change, $-\overline{\Delta s}_{t\to t+1}$			
Mean	-1.07	-1.05	-0.94	-0.93	-0.75
Std.	7.37	7.80	8.13	8.75	8.83
		Average Excess Returns, $\overline{rx}_{t+1}$			
Mean	1.55	1.48	1.55	1.40	1.54
Std.	7.51	7.85	8.19	8.92	9.36
		Panel C: All Countries			
		Average Forward Discount, $\overline{f}_{t\to t+1} - \overline{s}_t$			
Mean	1.82	1.79	1.76	1.66	1.44
Std.	1.74	1.65	1.62	1.61	1.57
Auto	0.84	0.93	0.95	0.96	0.97
		Average Spot Change, $-\overline{\Delta s}_{t\to t+1}$			
Mean	0.08	0.09	0.22	0.29	0.55
Std.	7.65	8.09	8.36	9.01	9.03
		Average Excess Returns, $\overline{rx}_{t+1}$			
Mean	1.97	1.91	1.99	1.95	2.09
Std.	7.79	8.23	8.55	9.33	9.55

Notes: This table reports the summary statistics of the currency baskets for developed countries, emerging markets, and all countries in our sample. We consider different horizons: 1, 2, 3, 6, and 12 months. For each basket $j \in \{Developed, Emerging, All\}$ and each horizon, the table presents the annualized means, standard deviations and autocorrelations of average forward discounts $\overline{f}^j_{t\to t+1} - \overline{s}^j_t$, average spot rate changes $-\overline{\Delta s}^j_{t\to t+1}$, and average log excess returns $\overline{rx}^j_{t+1}$, in percentage points. The sample period is 11/1983–6/2010.

Table II: Forecasting Returns and Exchange Rates with the AFD

Horizon	$\kappa_{\mathbf{f}}$	R^2	$\zeta_{\mathbf{f}}$	R^2	$\psi_{\mathbf{f}}$	R^2	$\zeta_{\mathbf{f}}$	R^2	$\psi_{\mathbf{f}}$	R^2	$\zeta_{\mathbf{f}}$	R^2
	Developed Countries				Emerging Countries				All Countries			
1	2.50	3.47	1.50	1.28	0.41	0.12	-0.52	0.20	2.11	1.84	1.04	0.46
HH	[2.85]		[1.71]		[0.51]		[-0.69]		[1.97]		[0.98]	
NW	[2.49]		[1.50]		[0.49]		[-0.71]		[1.76]		[0.88]	
VAR	[3.05]		[1.96]		[0.57]		[-0.84]		[2.35]		[1.18]	
Over/NW	[2.49]		[1.50]		[0.49]		[-0.71]		[1.76]		[0.88]	
2	2.53	5.83	1.53	2.22	0.36	0.15	-0.53	0.34	2.18	3.19	1.15	0.92
HH	[2.79]		[1.69]		[0.51]		[-0.78]		[2.06]		[1.10]	
NW	[2.30]		[1.39]		[0.56]		[-0.82]		[1.86]		[0.99]	
VAR	[3.35]		[1.96]		[0.66]		[-1.00]		[2.63]		[1.47]	
Over/NW	[2.55]		[1.60]		[1.00]		[-0.65]		[2.03]		[1.15]	
3	2.49	7.56	1.49	2.85	0.37	0.23	-0.49	0.39	2.14	4.09	1.13	1.19
HH	[2.73]		[1.64]		[0.61]		[-0.81]		[2.05]		[1.09]	
NW	[2.06]		[1.23]		[0.66]		[-0.83]		[1.66]		[0.89]	
VAR	[3.73]		[2.24]		[0.74]		[-1.00]		[2.75]		[1.56]	
Over/NW	[2.43]		[1.54]		[0.11]		[-0.99]		[1.94]		[1.07]	
6	2.48	11.72	1.48	4.52	0.76	1.74	-0.15	0.07	2.28	7.75	1.28	2.60
HH	[2.76]		[1.65]		[1.68]		[-0.33]		[2.38]		[1.34]	
NW	[1.93]		[1.15]		[1.54]		[-0.30]		[1.78]		[1.00]	
VAR	[5.00]		[3.11]		[2.18]		[-0.40]		[4.16]		[2.38]	
Over/NW	[2.54]		[1.61]		[0.84]		[-0.55]		[1.95]		[1.16]	
12	2.16	15.11	1.16	4.92	0.87	4.49	-0.06	0.03	1.83	9.07	0.81	2.01
HH	[2.41]		[1.30]		[2.29]		[-0.18]		[2.17]		[0.99]	
NW	[1.83]		[0.99]		[2.50]		[-0.19]		[1.82]		[0.83]	
VAR	[5.42]		[3.16]		[3.33]		[-0.24]		[4.62]		[2.14]	
Over/NW	[1.78]		[0.95]		[1.29]		[0.12]		[1.85]		[1.07]	

Notes: This table reports results of forecasting regressions for average excess returns and average exchange rate changes for baskets of currencies at horizons of one, two, three, six and twelve months. For each basket we report the R^2, and the slope coefficient in the time-series regression of the log currency excess return on the average log forward discount ($\kappa_{\mathbf{f}}$), and similarly the slope coefficient $\zeta_{\mathbf{f}}$ and the R^2 for the regressions of average exchange rate changes. The t-statistics for the slope coefficients in brackets are computed using the following methods. The *HH* use Hansen and Hodrick (1980) standard errors computed with the number of lags equal to the length of overlap plus one lag. The *NW* use Newey and West (1987) standard errors computed with the optimal number of lags following Andrews (1991). The *VAR*-based statistics are adjusted for the small sample bias using the bootstrap distributions of slope coefficients under the null hypothesis of no predictability, estimated by drawing from the residuals of a VAR with the number of lags equal to the length of overlap plus one lag. *Over/NW* t-statistics are for the regression coefficients estimated using non-overlapping observations only, computed using Newey-West. Data are monthly, from Barclays and Reuters (available via Datastream). The returns do not take into account bid-ask spreads. The sample period is 11/1983–6/2010.

Table III: Forecasting Returns and Exchange Rates with AFD of Developed Countries

Horizon	$\psi_{\mathbf{f}}$	R^2	$\zeta_{\mathbf{f}}$	R^2	$\psi_{\mathbf{f}}$	R^2	$\zeta_{\mathbf{f}}$	R^2
	Emerging Countries				All Countries			
1	1.78	2.28	1.51	1.69	2.25	3.36	1.62	1.81
HH	[2.29]		[1.92]		[2.78]		[2.00]	
NW	[1.97]		[1.63]		[2.40]		[1.72]	
VAR	[2.46]		[2.26]		[2.96]		[2.12]	
Over/NW	[1.97]		[1.63]		[2.40]		[1.72]	
2	1.78	3.85	1.54	2.90	2.27	5.68	1.66	3.14
HH	[2.24]		[1.88]		[2.72]		[1.97]	
NW	[1.88]		[1.47]		[2.22]		[1.57]	
VAR	[2.56]		[2.34]		[3.17]		[2.36]	
Over/NW	[2.00]		[1.69]		[2.48]		[1.82]	
3	1.73	4.78	1.49	3.60	2.22	7.23	1.61	3.98
HH	[2.10]		[1.76]		[2.62]		[1.89]	
NW	[1.70]		[1.34]		[1.99]		[1.41]	
VAR	[2.99]		[2.52]		[3.42]		[2.68]	
Over/NW	[1.86]		[1.54]		[2.32]		[1.72]	
6	1.74	7.45	1.51	5.85	2.22	11.08	1.62	6.30
HH	[2.02]		[1.70]		[2.59]		[1.87]	
NW	[1.58]		[1.27]		[1.87]		[1.33]	
VAR	[3.95]		[3.60]		[4.87]		[3.90]	
Over/NW	[2.01]		[1.62]		[2.46]		[1.79]	
12	1.56	9.42	1.34	7.82	1.93	13.90	1.33	7.35
HH	[1.80]		[1.50]		[2.29]		[1.55]	
NW	[1.55]		[1.20]		[1.83]		[1.20]	
VAR	[4.63]		[4.18]		[5.70]		[3.89]	
Over/NW	[2.17]		[1.65]		[2.01]		[1.32]	

Notes: This table reports results of forecasting regressions for average excess returns and average exchange rate changes for baskets of currencies at horizons of one, two, three, six and twelve months. For each basket we report the R^2, and the slope coefficient in the time-series regression of the log currency excess return of a given basket on the average log forward discount for developed countries ($\kappa_{\mathbf{f}}$), and similarly the slope coefficient $\zeta_{\mathbf{f}}$ and the R^2 for the regressions of average exchange rate changes. The t-statistics for the slope coefficients in brackets are computed using the following methods. The *HH* use Hansen and Hodrick (1980) standard errors computed with the number of lags equal to the length of overlap plus one lag. The *NW* use Newey and West (1987) standard errors computed with the optimal number of lags following Andrews (1991). The *VAR*-based statistics are adjusted for the small sample bias using the bootstrap distributions of slope coefficients under the null hypothesis of no predictability, estimated by drawing from the residuals of a VAR with the number of lags equal to the length of overlap plus one lag. *Over/NW* t-statistics are for the regression coefficients estimated using non-overlapping observations only, computed using Newey-West methods. Data are monthly, from Barclays and Reuters (available via Datastream). The returns do not take into account bid-ask spreads. The sample period is 11/1983–6/2010.

Table IV: Predictability Using Bilateral Forward Discount and US Investor Average Forward Discount: Panel Regressions

	Developed Countries				Emerging Countries				All countries			
k	$\tilde{\kappa}_{\mathbf{f}}$	$\tilde{\kappa}_f$	$\tilde{\zeta}_{\mathbf{f}}$	$\tilde{\zeta}_f$	$\tilde{\kappa}_{\mathbf{f}}$	$\tilde{\kappa}_f$	$\tilde{\zeta}_{\mathbf{f}}$	$\tilde{\zeta}_f$	$\tilde{\kappa}_{\mathbf{f}}$	$\tilde{\kappa}_f$	$\tilde{\zeta}_{\mathbf{f}}$	$\tilde{\zeta}_f$
1	1.94	0.54	1.94	-0.46	1.75	1.05	1.75	0.05	1.67	0.92	1.67	-0.08
Robust	[2.15]	[1.08]	[2.15]	[-0.92]	[2.36]	[2.32]	[2.36]	[0.12]	[2.23]	[2.37]	[2.23]	[-0.19]
NW	[1.94]	[0.54]	[1.94]	[-0.46]	[1.75]	[1.05]	[1.75]	[0.05]	[1.67]	[0.92]	[1.67]	[-0.08]
2	2.04	0.51	2.04	-0.49	1.60	1.11	1.60	0.11	1.60	0.98	1.60	-0.02
Robust	[2.55]	[0.94]	[2.55]	[-0.91]	[2.43]	[2.12]	[2.43]	[0.21]	[2.44]	[2.18]	[2.44]	[-0.04]
NW	[2.04]	[0.51]	[2.04]	[-0.49]	[1.60]	[1.11]	[1.60]	[0.11]	[1.60]	[0.98]	[1.60]	[-0.02]
3	2.14	0.34	2.14	-0.66	1.42	1.23	1.42	0.23	1.45	1.05	1.45	0.05
Robust	[2.80]	[0.59]	[2.80]	[-1.16]	[2.31]	[2.44]	[2.31]	[0.45]	[2.41]	[2.35]	[2.41]	[0.11]
NW	[2.14]	[0.34]	[2.14]	[-0.66]	[1.42]	[1.23]	[1.42]	[0.23]	[1.45]	[1.05]	[1.45]	[0.05]
6	2.18	0.27	2.18	-0.73	1.32	1.25	1.32	0.25	1.40	1.07	1.40	0.07
Robust	[3.05]	[0.48]	[3.05]	[-1.33]	[2.29]	[2.79]	[2.29]	[0.56]	[2.74]	[2.66]	[2.74]	[0.17]
NW	[2.18]	[0.27]	[2.18]	[-0.73]	[1.32]	[1.25]	[1.32]	[0.25]	[1.40]	[1.07]	[1.40]	[0.07]
12	1.87	0.21	1.87	-0.79	1.21	1.48	1.21	0.48	1.15	1.21	1.15	0.21
Robust	[3.70]	[0.50]	[3.70]	[-1.89]	[2.26]	[2.99]	[2.26]	[0.97]	[2.57]	[2.75]	[2.57]	[0.47]
NW	[1.87]	[0.21]	[1.87]	[-0.79]	[1.21]	[1.48]	[1.21]	[0.48]	[1.15]	[1.21]	[1.15]	[0.21]

Notes: This table reports results of panel regressions for average excess returns and average exchange rate changes for individual currencies at horizons of one, two, three, six and twelve months, on both the average forward discount for developed countries and the currency specific forward discount, as well as currency fixed effects (to allow for different drifts). For each group of countries (developed, emerging, and all) we report the slope coefficients on the average log forward discount for developed countries ($\kappa_{\mathbf{f}}$) and on the individual forward discount(κ_f), and similarly the slope coefficient $\zeta_{\mathbf{f}}$ and ζ_f for the exchange rate changes. The t-statistics for the slope coefficients in brackets are computed using the following methods. *Robust* use the robust standard errors clustered by month and country; *NW* use Newey and West (1987) standard errors computed with the number of lags equal to the horizon of forward discount plus one month. Data are monthly, from Barclays and Reuters (available via Datastream). The returns do not take into account bid-ask spreads. The sample period is 11/1983–6/2010.

Table V: Contemporaneous Correlations Between Expected Excess Returns or AFDs and Macroeconomic and Financial Variables

Panel A: Developed countries

Horizon, k	IP	Pay	$Help$	$Term$	Def	VIX
1.00	−0.32	−0.19	−0.13	0.45	0.28	−0.09
2.00	−0.32	−0.20	−0.15	0.46	0.28	−0.08
3.00	−0.33	−0.19	−0.16	0.46	0.28	−0.08
6.00	−0.34	−0.21	−0.20	0.46	0.26	−0.06
12.00	−0.40	−0.27	−0.28	0.45	0.20	−0.05

Panel B: Emerging countries

Horizon, k	IP	Pay	$Help$	$Term$	Def	VIX
1	-0.11	-0.15	-0.14	0.28	-0.36	0.20
2	-0.12	-0.17	-0.15	0.30	-0.38	0.21
3	-0.12	-0.18	-0.16	0.29	-0.39	0.21
6	-0.09	-0.19	-0.15	0.25	-0.41	0.24
12	-0.05	-0.24	-0.15	0.19	-0.45	0.23

Notes: This table reports the contemporaneous correlation between AFDs and different macroeconomic and financial variables x_t: the 12-month percentage change in industrial production (IP), the 12-month percentage change in the total U.S. non-farm payroll (Pay), and the 12-month percentage change of the Help-Wanted index ($Help$), the default spread (Def), the slope of the yield curve ($Term$) and the CBOE $S\&P$ 500 volatility index (VIX). Data are monthly, from Datastream and Global Financial Data. The sample period is 11/1983–6/2010.

Table VI: Forecasting Returns and Exchange Rates with U.S.-specific component of AFD of Developed Countries

Horizon	$\psi_{\mathbf{f}}$	R^2	$\zeta_{\mathbf{f}}$	R^2	$\psi_{\mathbf{f}}$	R^2	$\zeta_{\mathbf{f}}$	R^2	$\psi_{\mathbf{f}}$	R^2	$\zeta_{\mathbf{f}}$	R^2
	Developed Countries				Emerging Countries				All Countries			
1	2.21	2.51	1.22	0.77	1.49	1.48	1.27	1.10	1.97	2.38	1.37	1.19
HH	[2.33]		[1.29]		[1.80]		[1.53]		[2.26]		[1.58]	
NW	[2.00]		[1.11]		[1.56]		[1.31]		[1.95]		[1.36]	
VAR	[2.65]		[1.47]		[2.02]		[1.74]		[2.55]		[1.81]	
Over/NW	[2.00]		[1.11]		[1.56]		[1.31]		[1.95]		[1.36]	
2	2.26	4.31	1.27	1.40	1.50	2.51	1.30	1.91	2.00	4.09	1.42	2.12
HH	[2.31]		[1.30]		[1.77]		[1.51]		[2.23]		[1.58]	
NW	[1.93]		[1.10]		[1.53]		[1.24]		[1.87]		[1.31]	
VAR	[2.88]		[1.66]		[2.28]		[1.97]		[2.83]		[2.10]	
Over/NW	[2.10]		[1.25]		[1.59]		[1.39]		[2.03]		[1.48]	
3	2.22	5.52	1.22	1.75	1.42	2.97	1.23	2.24	1.94	5.08	1.36	2.60
HH	[2.22]		[1.24]		[1.62]		[1.38]		[2.11]		[1.49]	
NW	[1.70]		[0.95]		[1.32]		[1.08]		[1.63]		[1.14]	
VAR	[3.24]		[1.84]		[2.39]		[2.15]		[3.13]		[2.30]	
Over/NW	[1.86]		[1.10]		[1.40]		[1.20]		[1.80]		[1.32]	
6	2.21	8.55	1.20	2.76	1.39	4.37	1.21	3.44	1.91	7.60	1.34	3.98
HH	[2.22]		[1.23]		[1.52]		[1.29]		[2.05]		[1.44]	
NW	[1.56]		[0.87]		[1.16]		[0.96]		[1.47]		[1.02]	
VAR	[4.42]		[2.52]		[3.27]		[2.88]		[4.26]		[3.00]	
Over/NW	[1.93]		[1.17]		[1.47]		[1.25]		[1.87]		[1.37]	
12	1.95	11.21	0.95	3.01	1.25	5.50	1.08	4.66	1.68	9.54	1.10	4.64
HH	[2.01]		[1.00]		[1.34]		[1.14]		[1.83]		[1.21]	
NW	[1.54]		[0.77]		[1.13]		[0.90]		[1.46]		[0.94]	
VAR	[5.07]		[2.60]		[3.73]		[3.39]		[4.84]		[3.23]	
Over/NW	[1.29]		[0.50]		[1.49]		[1.23]		[1.50]		[0.88]	

Notes: This table reports results of forecasting regressions for average excess returns and average exchange rate changes for baskets of currencies at horizons of one, two, three, six and twelve months. For each basket we report the R^2, and the slope coefficient in the time-series regression of the log currency excess return of a given basket on the average log forward discount for developed countries ($\kappa_{\mathbf{f}}$), and similarly the slope coefficient $\zeta_{\mathbf{f}}$ and the R^2 for the regressions of average exchange rate changes. The t-statistics for the slope coefficients in brackets are computed using the following methods. The *HH* use Hansen and Hodrick (1980) standard errors computed with the number of lags equal to the length of overlap plus one lag. The *NW* use Newey and West (1987) standard errors computed with the optimal number of lags following Andrews (1991). The *VAR*-based statistics are adjusted for the small sample bias using the bootstrap distributions of slope coefficients under the null hypothesis of no predictability, estimated by drawing from the residuals of a VAR with the number of lags equal to the length of overlap plus one lag. *Over/NW* t-statistics are for the regression coefficients estimated using non-overlapping observations only, computed using Newey-West and bootstrap methods. Data are monthly, from Barclays and Reuters (available via Datastream). The returns do not take into account bid-ask spreads. The sample period is 11/1983–6/2010.

Table VII: Calibrating The Symmetric Model

Panel A: 8 Targets – Moments of Real Variables				
	Full Model	Target	Target	Actual
		Monthly	Annual	Annual
β_{UIP}	$\frac{\chi}{\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)}$	-1.50	-1.50	-1.50
R^2_{UIP}	$\frac{2*\beta^2_{UIP}\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)^2*var(z)}{var(\Delta q)}$	3.40%	3.40%	3.40%
$E(r)$	$\theta\left[\alpha+\left(\chi-\frac{1}{2}\left(\gamma+\kappa\right)\right)+\left(\tau-\frac{1}{2}\delta^i\right)\right]$	0.14%	1.72%	1.47%
$Std(r)$	$\sqrt{\left(\chi-\frac{1}{2}\left(\gamma+\kappa\right)\right)^2 var(z^i)+\left(\tau-\frac{1}{2}\delta^i\right)^2 var(z^w)}$	0.17%	0.57%	0.95%
$Corr(r_t, r_{t-1})$	ϕ	0.92	0.37	0.28
$Std(\Delta q)$	$\sqrt{2\gamma\theta+2\chi^2 var(z^i)+o}$	2.89%	10.00%	14.89%
$Std(m)$	$\sqrt{(\gamma+\delta+\kappa)\theta+\chi^2 var(z^i)+\tau^2 var(z^w)}$	14.43%	50.00%	108.00%
$Corr(r_t, r^i_t)$	$\left(\tau-\frac{1}{2}\delta^i\right)^2\frac{Var(z^w)}{Var(r)}$	0.30	0.30	0.27
$E(rx^{dollar}_t)$	$\gamma\theta$	0.04%	0.50%	0.45%
$Feller$	$2(1-\phi)\frac{\theta}{Var(z^w)}$	20.00	20.00	20.00
Panel B: 3 Targets – Moments of Inflation				
$Std(inflation)$	$\sqrt{(\eta^w)^2 var(z^w)+\sigma^2_\pi}$	0.32%	1.10%	1.08%
R^2	$\frac{(\eta^w)^2 var(z^w)}{var(inflation)}$	0.28	0.28	0.28
$E(inflation)$	$\pi_0+\eta^w\theta$	0.24%	2.91%	2.64%
Panel C: Moments of Nominal Variables				
	Full Model	Implied	Implied	
		Monthly	Annual	
$E(r)$	$\theta\left[\alpha+\left(\chi-\frac{1}{2}\left(\gamma+\kappa\right)\right)+\left(\tau+\eta^w-\frac{1}{2}\delta^i\right)\right]-\frac{1}{2}\sigma^2_\pi$	0.39%	4.69%	4.66%
$Std(r)$	$\sqrt{\left(\chi-\frac{1}{2}\left(\gamma+\kappa\right)\right)^2 var(z^i)+\left(\tau+\eta^w-\frac{1}{2}\delta^i\right)^2 var(z^w)}$	0.14%	0.50%	0.83%
$Std(\Delta q)$	$\sqrt{2\gamma\theta+2\chi^2 var(z^i)+2\sigma^2_\pi+o}$	3.91%	11.07%	14.89%
$Corr(r_t, r^i_t)$	$\left(\tau+\eta^w-\frac{1}{2}\delta^i\right)^2\frac{Var(z^w)}{Var(r)}$	0.78	0.78	0.02

Note that $var(z^w)=\frac{\sigma^2_w\theta}{1-\phi^2}$ and $var(z^i)=\frac{\sigma^2_i\theta}{1-\phi^2}$. $o=2(\delta+\kappa)\theta-2E\left(\sqrt{\delta^i z^w_t+\kappa^i z_t}\right)\left(\sqrt{\delta^i z^w_t+\kappa^i z^i_t}\right)$ is an order of magnitude smaller than the other terms. The inflation process is given by $\pi^i_{t+1}=\pi_0+\eta^w z^w_t+\sigma_\pi\epsilon^i_{t+1}$.

Table VIII: Parameter Values

Pricing Kernel Parameters						
α (%)	χ	γ	κ	$\delta*$	$\underline{\delta}$	$\overline{\delta}$
1.85	2.14	0.05	7.0786	6.09		
Factor and Inflation Dynamics						
ϕ	θ (*in bp*)	σ (%)	η^w	σ^π	π_0 (%)	
0.92	7.40	0.77	0.98	0.27	-0.49	

This table reports the parameter values for the calibrated version of the full model. All countries share the same parameter values except for δ. $\delta*$ is the parameter for the home country. These 11 parameters were chosen to match the 11 moments in Table VII. The parameters δ^i are linearly spaced on the interval $[\underline{\delta}, \overline{\delta}]$. α, σ and π_0 are reported in percentages. θ is reported in basis points.

Table IX: Forecasting Returns and Exchange rates with AFD - Simulated Data

Horizon	$\kappa_{\mathbf{f}}$	R^2	$\zeta_{\mathbf{f}}$	R^2
1	2.36	5.57	1.36	1.92
HH	[3.25]		[1.87]	
NW	[3.13]		[1.80]	
Over - NW	[3.13]		[1.80]	

Notes: Simulated sample of $T = 336$ monthly observations for $N = 30$ countries. This table reports results of forecasting regressions for one-month returns and one-month changes in exchange rates using the one-month average forward discount rate. Basket of 30 countries. The average country has the same δ as the home country (U.S.).

Table X: Forecasting Returns and Exchange Rates with Industrial Production and AFD

Horizon	κ_{IP}	$\kappa_{\mathbf{f}}$	W	R^2	κ_{IP}	$\zeta_{\mathbf{f}}$	W	R^2	κ_{IP}	$\kappa_{\mathbf{f}}$	W	R^2	κ_{IP}	$\zeta_{\mathbf{f}}$	W	R^2	κ_{IP}	$\kappa_{\mathbf{f}}$	W	R^2	κ_{IP}	$\zeta_{\mathbf{f}}$	W	R^2
	Developed Countries								Emerging Countries								All Countries							
1	-0.52	2.21	8.36	3.95	-0.52	1.22	3.73	1.77	-0.86	0.23	3.27	1.91	-0.85	-0.70	3.29	2.03	-0.65	1.68	5.00	2.72	-0.66	0.60	2.44	1.41
HH	[-0.92]	[2.29]	[0.27]		[-0.93]	[1.26]	[20.01]		[-1.68]	[0.29]	[41.73]		[-1.66]	[-0.90]	[37.45]		[-1.23]	[1.50]	[10.49]		[-1.25]	[0.55]	[51.10]	
NW	[-0.88]	[2.06]	[1.43]		[-0.88]	[1.13]	[30.37]		[-1.72]	[0.27]	[37.86]		[-1.70]	[-0.86]	[37.52]		[-1.21]	[1.37]	[15.08]		[-1.23]	[0.50]	[53.86]	
VAR	[-0.94]	[2.59]	[0.00]		[-0.91]	[1.36]	[0.00]		[-1.75]	[0.32]	[0.00]		[-1.81]	[-1.03]	[0.00]		[-1.26]	[1.84]	[0.00]		[-1.35]	[0.65]	[0.00]	
Over/NW	[-0.88]	[2.06]	[1.43]		[-0.88]	[1.13]	[30.37]		[-1.72]	[0.27]	[37.86]		[-1.70]	[-0.86]	[37.52]		[-1.21]	[1.37]	[15.08]		[-1.23]	[0.50]	[53.86]	
2	-0.64	2.16	11.52	7.07	-0.64	1.16	7.14	3.51	-0.94	0.14	6.32	4.04	-0.93	-0.74	4.88	4.21	-0.74	1.64	7.53	5.24	-0.75	0.61	4.92	3.07
HH	[-1.31]	[2.24]	[0.14]		[-1.32]	[1.20]	[11.71]		[-2.12]	[0.20]	[17.15]		[-2.09]	[-1.06]	[16.24]		[-1.65]	[1.52]	[3.43]		[-1.65]	[0.57]	[26.67]	
NW	[-2.08]	[2.11]	[0.09]		[-2.08]	[1.13]	[3.64]		[-2.24]	[0.20]	[6.48]		[-2.20]	[-1.04]	[16.24]		[-2.11]	[1.71]	[2.72]		[-2.10]	[0.64]	[15.85]	
VAR	[-1.51]	[2.58]	[0.00]		[-1.51]	[1.37]	[0.00]		[-2.81]	[0.28]	[0.00]		[-2.66]	[-1.23]	[0.00]		[-1.99]	[2.00]	[0.00]		[-2.07]	[0.77]	[0.00]	
Over/NW	[-0.91]	[2.17]	[0.70]		[-0.91]	[1.25]	[22.05]		[-1.72]	[0.65]	[17.22]		[-1.71]	[-1.05]	[40.66]		[-1.22]	[1.67]	[4.10]		[-1.23]	[0.75]	[36.71]	
3	-0.71	2.06	24.98	9.72	-0.71	1.06	20.30	5.12	-1.00	0.14	7.72	6.39	-0.99	-0.71	6.57	6.46	-0.82	1.52	10.17	7.57	-0.82	0.52	9.09	4.79
HH	[-1.63]	[2.21]	[0.09]		[-1.63]	[1.14]	[8.01]		[-2.49]	[0.23]	[5.90]		[-2.44]	[-1.13]	[5.09]		[-2.08]	[1.53]	[1.72]		[-2.07]	[0.52]	[14.07]	
NW	[-4.01]	[1.85]	[0.00]		[-4.01]	[0.95]	[0.00]		[-2.60]	[0.22]	[2.36]		[-2.55]	[-1.03]	[5.45]		[-3.07]	[1.49]	[0.32]		[-3.01]	[0.51]	[0.79]	
VAR	[-2.12]	[2.87]	[0.00]		[-2.26]	[1.51]	[0.00]		[-3.50]	[0.22]	[0.00]		[-3.50]	[-1.29]	[0.00]		[-2.82]	[2.06]	[0.00]		[-2.75]	[0.57]	[0.00]	
Over/NW	[-1.42]	[2.11]	[1.23]		[-1.42]	[1.18]	[19.48]		[-2.45]	[-0.14]	[7.69]		[-2.38]	[-1.35]	[5.37]		[-2.09]	[1.60]	[5.46]		[-2.05]	[0.61]	[20.57]	
6	-0.86	1.92	51.16	17.14	-0.86	0.92	43.63	10.37	-1.14	0.56	8.41	15.32	-1.12	-0.34	6.87	13.58	-0.96	1.59	11.94	15.92	-0.95	0.59	10.58	11.13
HH	[-2.59]	[2.28]	[0.00]		[-2.59]	[1.09]	[0.26]		[-3.19]	[1.08]	[0.04]		[-3.17]	[-0.66]	[0.34]		[-3.15]	[2.06]	[0.01]		[-3.12]	[0.78]	[0.27]	
NW	[-5.43]	[1.63]	[0.00]		[-5.45]	[0.78]	[0.00]		[-2.62]	[0.90]	[1.37]		[-2.62]	[-0.53]	[4.40]		[-3.25]	[1.64]	[0.06]		[-3.25]	[0.61]	[0.22]	
VAR	[-3.50]	[3.64]	[0.00]		[-3.75]	[1.83]	[0.00]		[-5.65]	[1.50]	[0.00]		[-5.71]	[-0.93]	[0.00]		[-4.38]	[2.91]	[0.00]		[-4.52]	[1.08]	[0.00]	
Over/NW	[-1.91]	[2.07]	[0.00]		[-1.91]	[1.14]	[0.22]		[-2.80]	[0.32]	[1.42]		[-2.74]	[-1.08]	[2.25]		[-2.76]	[1.74]	[0.15]		[-2.70]	[0.67]	[1.98]	
12	-0.89	1.48	18.53	24.93	-0.89	0.48	14.22	15.96	-1.14	0.76	10.99	26.83	-1.09	-0.17	8.72	23.05	-1.00	1.14	12.55	24.36	-0.97	0.15	10.24	18.11
HH	[-3.47]	[1.73]	[0.00]		[-3.47]	[0.56]	[0.00]		[-3.41]	[1.60]	[0.00]		[-3.46]	[-0.37]	[0.06]		[-3.64]	[1.71]	[0.00]		[-3.65]	[0.22]	[0.01]	
NW	[-3.38]	[1.36]	[0.00]		[-3.37]	[0.44]	[0.01]		[-2.93]	[1.48]	[0.15]		[-2.95]	[-0.33]	[1.07]		[-3.18]	[1.38]	[0.03]		[-3.18]	[0.18]	[0.30]	
VAR	[-5.87]	[3.95]	[0.00]		[-6.27]	[1.28]	[0.00]		[-9.24]	[2.79]	[0.00]		[-9.00]	[-0.69]	[0.00]		[-7.58]	[2.93]	[0.00]		[-8.16]	[0.42]	[0.00]	
Over/NW	[-4.47]	[0.98]	[0.00]		[-4.47]	[0.20]	[0.00]		[-4.77]	[0.63]	[0.00]		[-4.77]	[-0.88]	[0.00]		[-5.06]	[0.89]	[0.00]		[-4.93]	[0.03]	[0.00]	

Notes: This table reports results of forecasting regressions for average excess returns and average exchange rate changes for baskets of currencies at horizons of one, two, three, six and twelve months. For each basket we report the R^2, and the slope coefficients in the time-series regression of the log currency excess return on the 12-month change in the U.S. Industrial Production Index (κ_{IP}) and on the average log forward discount ($\kappa_{\mathbf{f}}$), and similarly the slope coefficients ζ_{IP}, $\zeta_{\mathbf{f}}$ and the R^2 for the regressions of average exchange rate changes. The t-statistics for the slope coefficients in brackets are computed using the following methods. The *HH* use Hansen and Hodrick (1980) standard errors computed with the number of lags equal to the length of overlap plus one lag. The *NW* use Newey and West (1987) standard errors computed with the optimal number of lags following Andrews (1991). The *VAR*-based statistics are adjusted for the small sample bias using the bootstrap distributions of slope coefficients under the null hypothesis of no predictability, estimated by drawing from the residuals of a VAR with the number of lags equal to the length of overlap plus one lag. *Over/NW* t-statistics are for the regression coefficients estimated using non-overlapping observations only, computed using Newey-West methods. We also report the Wald tests (W) of the hypothesis that both slope coefficients are jointly equal to zero; the percentage p-values in brackets are for the χ^2-distribution under the parametric cases (HH and NW) and for the bootstrap distribution of the F statistic under VAR. Data are monthly, from Barclays and Reuters (available via Datastream). The returns do not take into account bid-ask spreads. The sample period is 11/1983–6/2010.

Table XI: Forecasting Returns and Exchange Rates with Industrial Production Residual and AFD

Horizon	κ_{IP}	$\kappa_{\mathbf{f}}$	W	R^2	κ_{IP}	$\zeta_{\mathbf{f}}$	W	R^2	κ_{IP}	$\kappa_{\mathbf{f}}$	W	R^2	κ_{IP}	$\zeta_{\mathbf{f}}$	W	R^2	κ_{IP}	$\kappa_{\mathbf{f}}$	W	R^2	κ_{IP}	$\zeta_{\mathbf{f}}$	W	R^2
	Developed Countries								Emerging Countries								All Countries							
1	-0.16	2.48	6.68	3.49	-0.16	1.48	2.48	1.30	-0.70	0.49	0.78	0.54	-0.74	-0.44	1.43	0.69	-0.44	2.09	3.39	1.99	-0.46	1.02	1.04	0.64
HH	[-0.19]	[2.74]	[1.02]		[-0.19]	[1.63]	[38.27]		[-0.86]	[0.61]	[85.61]		[-0.91]	[-0.56]	[75.22]		[-0.55]	[1.97]	[23.54]		[-0.58]	[0.98]	[78.31]	
NW	[-0.18]	[2.42]	[5.06]		[-0.18]	[1.45]	[53.08]		[-0.81]	[0.58]	[88.48]		[-0.85]	[-0.54]	[75.52]		[-0.52]	[1.79]	[35.79]		[-0.55]	[0.89]	[83.57]	
VAR	[-0.22]	[2.96]	[0.01]		[-0.20]	[1.82]	[0.00]		[-1.10]	[0.70]	[0.03]		[-1.19]	[-0.64]	[0.03]		[-0.65]	[2.26]	[0.00]		[-0.70]	[1.10]	[0.03]	
Over/NW	[-0.18]	[2.42]	[5.06]		[-0.18]	[1.45]	[53.08]		[-0.81]	[0.58]	[88.48]		[-0.85]	[-0.54]	[75.52]		[-0.52]	[1.79]	[35.79]		[-0.55]	[0.89]	[83.57]	
2	-0.61	2.44	7.88	6.26	-0.61	1.44	3.51	2.67	-1.03	0.49	3.00	1.82	-1.03	-0.40	2.21	2.01	-0.82	2.14	5.72	4.15	-0.81	1.11	2.40	1.90
HH	[-0.86]	[2.68]	[0.37]		[-0.86]	[1.58]	[22.00]		[-1.47]	[0.68]	[56.07]		[-1.46]	[-0.58]	[45.02]		[-1.21]	[2.09]	[9.19]		[-1.20]	[1.10]	[50.62]	
NW	[-0.86]	[2.39]	[2.09]		[-0.87]	[1.41]	[33.79]		[-1.43]	[0.81]	[42.77]		[-1.42]	[-0.66]	[58.65]		[-1.13]	[2.17]	[9.62]		[-1.12]	[1.14]	[54.76]	
VAR	[-1.04]	[3.10]	[0.00]		[-1.05]	[1.84]	[0.00]		[-2.10]	[0.80]	[0.00]		[-2.08]	[-0.72]	[0.00]		[-1.60]	[2.54]	[0.00]		[-1.60]	[1.34]	[0.01]	
Over/NW	[-0.36]	[2.55]	[2.48]		[-0.36]	[1.59]	[39.75]		[-0.99]	[1.39]	[52.46]		[-0.97]	[-0.52]	[76.37]		[-0.69]	[2.22]	[12.34]		[-0.68]	[1.25]	[63.50]	
3	-0.78	2.36	7.16	8.56	-0.78	1.36	3.59	3.90	-1.16	0.52	3.67	3.14	-1.14	-0.34	3.10	3.27	-0.96	2.08	5.00	5.95	-0.94	1.07	2.55	3.04
HH	[-1.26]	[2.66]	[0.29]		[-1.27]	[1.53]	[16.74]		[-1.75]	[0.82]	[39.47]		[-1.73]	[-0.55]	[24.03]		[-1.59]	[2.14]	[7.38]		[-1.56]	[1.11]	[40.06]	
NW	[-1.20]	[2.15]	[3.59]		[-1.20]	[1.24]	[32.54]		[-1.69]	[0.94]	[31.26]		[-1.66]	[-0.60]	[40.97]		[-1.45]	[1.97]	[15.12]		[-1.42]	[1.02]	[51.55]	
VAR	[-1.61]	[3.58]	[0.00]		[-1.59]	[2.04]	[0.00]		[-2.59]	[0.88]	[0.00]		[-2.60]	[-0.74]	[0.00]		[-2.14]	[2.80]	[0.00]		[-2.14]	[1.43]	[0.01]	
Over/NW	[-0.79]	[2.51]	[3.55]		[-0.79]	[1.57]	[38.32]		[-1.39]	[0.56]	[64.54]		[-1.41]	[-0.70]	[30.77]		[-1.32]	[2.15]	[15.74]		[-1.31]	[1.24]	[55.92]	
6	-1.18	2.24	8.84	15.64	-1.18	1.24	5.49	8.74	-1.55	0.93	6.17	10.54	-1.51	0.02	4.16	8.82	-1.32	2.17	7.59	13.67	-1.29	1.17	4.47	8.64
HH	[-2.17]	[2.84]	[0.01]		[-2.16]	[1.57]	[2.37]		[-2.37]	[1.98]	[2.94]		[-2.35]	[0.05]	[8.53]		[-2.35]	[2.87]	[0.16]		[-2.30]	[1.55]	[7.08]	
NW	[-1.91]	[2.05]	[0.97]		[-1.91]	[1.14]	[11.14]		[-2.02]	[1.81]	[7.15]		[-2.03]	[0.04]	[24.34]		[-2.00]	[2.33]	[2.60]		[-1.96]	[1.25]	[20.53]	
VAR	[-3.01]	[4.34]	[0.00]		[-3.13]	[2.52]	[0.00]		[-4.54]	[2.48]	[0.00]		[-4.57]	[0.02]	[0.00]		[-3.77]	[3.92]	[0.00]		[-3.72]	[2.19]	[0.00]	
Over/NW	[-1.21]	[2.68]	[0.09]		[-1.21]	[1.65]	[8.68]		[-2.08]	[1.39]	[20.18]		[-2.23]	[-0.11]	[6.48]		[-1.79]	[2.69]	[0.76]		[-1.83]	[1.62]	[14.20]	
12	-1.40	1.77	31.53	25.87	-1.41	0.78	25.64	17.04	-1.72	1.05	13.60	24.52	-1.65	0.11	10.22	20.70	-1.51	1.67	17.74	23.96	-1.45	0.65	13.53	17.51
HH	[-4.02]	[2.31]	[0.00]		[-4.02]	[1.01]	[0.00]		[-3.64]	[2.85]	[0.00]		[-3.63]	[0.32]	[0.02]		[-4.03]	[2.83]	[0.00]		[-3.90]	[1.13]	[0.00]	
NW	[-4.61]	[1.82]	[0.00]		[-4.60]	[0.80]	[0.00]		[-3.20]	[2.74]	[0.01]		[-3.17]	[0.29]	[0.30]		[-3.88]	[2.44]	[0.00]		[-3.67]	[0.97]	[0.01]	
VAR	[-5.08]	[4.46]	[0.00]		[-5.41]	[2.05]	[0.00]		[-7.20]	[3.88]	[0.00]		[-7.36]	[0.42]	[0.00]		[-6.10]	[4.09]	[0.00]		[-6.09]	[1.66]	[0.00]	
Over/NW	[-1.89]	[1.75]	[0.00]		[-1.90]	[0.90]	[0.01]		[-2.78]	[1.70]	[1.77]		[-2.94]	[0.42]	[0.86]		[-2.42]	[2.26]	[0.00]		[-2.43]	[1.29]	[0.01]	

Notes: This table reports results of forecasting regressions for average excess returns and average exchange rate changes for baskets of currencies at horizons of one, two, three, six and twelve months. For each basket we report the R^2, and the slope coefficients in the time-series regression of the log currency excess return on the 12-month change in the U.S. Industrial Production Index orthogonalized with respect to the world average Industrial Production (κ_{IP}) and on the average log forward discount ($\kappa_{\mathbf{f}}$), and similarly the slope coefficients ζ_{IP}, $\zeta_{\mathbf{f}}$ and the R^2 for the regressions of average exchange rate changes. The t-statistics for the slope coefficients in brackets are computed using the following methods. The *HH* use Hansen and Hodrick (1980) standard errors computed with the number of lags equal to the length of overlap plus one lag. The *NW* use Newey and West (1987) standard errors computed with the optimal number of lags following Andrews (1991). The *VAR*-based statistics are adjusted for the small sample bias using the bootstrap distributions of slope coefficients under the null hypothesis of no predictability, estimated by drawing from the residuals of a VAR with the number of lags equal to the length of overlap plus one lag. *Over/NW* t-statistics are for the regression coefficients estimated using non-overlapping observations only, computed using Newey-West methods. Data are monthly, from Barclays and Reuters (available via Datastream). The returns do not take into account bid-ask spreads. The sample period is 11/1983–6/2010.

Table XII: Out-of-Sample Exchange Rate Predictability: Comparison with a Random Walk

k	$RMSE_{RW}$	$RMSE$	*Ratio*	MSE_t	ENC
Panel A: IP					
1	2.37	2.37	1.00	0.12	0.89
			(0.13)	(0.14)	(0.14)
2	3.62	3.57	1.01	0.69	2.05
			(0.01)	(0.05)	(0.01)
3	4.52	4.41	1.02	0.74	2.42
			(0.00)	(0.04)	(0.01)
6	6.94	6.73	1.03	0.54	3.21
			(0.00)	(0.05)	(0.00)
12	9.74	8.89	1.10	1.46	5.31
			(0.00)	(0.01)	(0.00)
Panel B: IP and AFD					
1	2.37	2.38	1.00	-0.19	0.68
			(0.28)	(0.22)	(0.17)
2	3.62	3.59	1.01	0.42	1.84
			(0.03)	(0.10)	(0.02)
3	4.52	4.43	1.02	0.76	2.65
			(0.00)	(0.04)	(0.00)
6	6.94	6.68	1.04	0.73	3.22
			(0.00)	(0.03)	(0.00)
12	9.74	9.05	1.08	1.28	4.72
			(0.00)	(0.01)	(0.00)
Panel C: AFD					
1	2.37	2.37	1.00	0.16	1.08
			(0.15)	(0.19)	(0.09)
2	3.62	3.62	1.00	-0.07	1.34
			(0.30)	(0.23)	(0.04)
3	4.52	4.51	1.00	0.14	2.05
			(0.10)	(0.17)	(0.01)
6	6.94	6.93	1.00	0.09	2.68
			(0.13)	(0.21)	(0.00)
12	9.74	9.38	1.04	1.30	4.08
			(0.00)	(0.02)	(0.00)

Notes: This table reports one-step-ahead out-of-sample predictability test statistics. We first assume that the average changes in exchange rates against the U.S. dollar for the developed markets basket follow a random walk with drift. $RMSE_{RW}$ denotes the corresponding square root of the mean squared error (in percentages). We then use the twelve-month change in the industrial production index (IP) and/or average forward discount for the same basket (AFD) to predict changes in exchange rates $RMSE$ denotes the corresponding square root of the mean squared error (in percentages). We add three test statistics: the ratio of the two square root mean squared errors ($Ratio = RMSE_{RW}/RMSE$), the Diebold-Mariano (MSE_t) and the Clark-McCraken (ENC) statistics. Each model is estimated recursively. Using information up to date t, we use the model to predict the changes in exchange rates between t and $t+1$. We use at least half of the sample to estimate the model. P-values for the test statistics reported in the parentheses are computed via bootstrap under the null hypothesis of no predictability. They are obtained from bootstrapping the whole procedure assuming a VAR with the number of lags equal to the horizon of forward discount for the predictor variable. Panel A uses the industrial production as predictor, Panel B uses both IP and the average forward discount across developed countries currencies, and Panel C uses only the AFD. Data are monthly, obtained from Datastream. The sample period is 11/1983 - 06/2010.