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Risk Appetite and Exchange Rates

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Abstract

We present evidence that the growth of U.S.-dollar-denominated banking sector liabilities forecasts appreciations of the U.S. dollar, both in-sample and out-of-sample, against a large set of foreign currencies. We provide a theoretical foundation for a funding liquidity channel in a global banking model where exchange rates fluctuate as a function of banks' balance sheet capacity. We estimate prices of risk using a cross-sectional asset pricing approach and show that the U.S. dollar funding liquidity forecasts exchange rates because of its association with time-varying risk premia. Our empirical evidence shows that this channel is separate from the more familiar "carry trade" channel. Although the financial crisis of 2007-09 induced a structural shift in our forecasting variables, when we control for this shift, the forecasting relationship is preserved.

Key words: asset pricing, financial intermediaries, exchange rates

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1 Introduction

The pivotal role of the U.S. dollar in international capital markets has several dimensions. In addition to being the premier reserve currency held by central banks around the world, the U.S. dollar is also the currency that underpins cross-border banking. To the extent that global banks use a centralized funding model in which U.S. dollar funds are deployed globally through portfolio allocation decisions, U.S. dollar bank funding conditions will have global repercussions through the portfolio decisions of global banks.

In this paper, we outline a channel linking the size of U.S. dollar-denominated bank liabilities to global risk premia, and track the consequences empirically for exchange rate movements. The status of the U.S. dollar as the dominant funding currency for cross-border banking means that U.S. dollar bank funding conditions will affect U.S. dollar-denominated risk premia globally, including assets that are traded in other currencies. When U.S. dollar risk premia fall without a comparable fall in the foreign currency-denominated risk premia for the same asset, the expected U.S. dollar-denominated return will be lower than the foreign currency-denominated return. For these two features to hold simultaneously, there must be an expected U.S. dollar *appreciation* in equilibrium. In short, we would expect easier U.S. dollar funding conditions to be followed by subsequent appreciations of the U.S. dollar.

In our empirical analysis, we uncover evidence consistent with such a channel. We show that short-term U.S. dollar funding aggregates – primary dealer repos and financial commercial paper outstanding – forecast appreciations of the U.S. dollar against a broad cross-section of currencies, both for advanced countries as well as for some emerging countries. The forecastability holds both in sample and out of sample. Consistent with a risk-based mechanism, our forecasting results for currency excess returns are even stronger than the results for exchange rate changes, particularly among the group of advanced countries.

It is important to distinguish our funding liquidity channel from the more familiar "carry trade" mechanism that rests on interest rate differences across currencies.[1] We find that expansions in short-term U.S. dollar bank funding forecast dollar appreciations

[1] Empirical studies of carry trades include Lustig, Roussanov and Verdelhan(2011), Brunnermeier, Nagel and Pedersen (2008), Gagnon and Chaboud (2008) and Burnside, Eichenbaum, Kleshchelski and Rebelo (2007), among others. Jylha and Suominen (2011) investigate the role of hedge fund capital in carry trades. Hattori and Shin (2009) examine the role of the interoffice accounts of foreign banks in Japan for the yen carry trade.

against both high and low interest rate currencies, suggesting that the mechanism underlying our funding liquidity channel is distinct from the carry trade channel.[2] In addition, controlling for interest rate differentials and the absolute level of U.S. short-term interest rates does not change the forecasting power of short-term funding aggregates.[3]

By focusing on risk premia, our findings are in the spirit of the asset pricing approach to exchange rates of Fama (1984), Hodrick (1989) and Dumas and Solnik (1995), but our approach is distinguished by the emphasis on funding aggregates.

Although the U.S. dollar is the dominant funding currency for cross-border banking (on which more below), the logic underlying our mechanism should hold more generally provided that short-term funding in a particular currency plays an important cross-border role in a particular region or asset class. As a cross check, we conduct a supplementary empirical exercise using short-term liability aggregates denominated in euros and yen. In our panel studies, we find that just as expansions in dollar-funded balance sheets forecast dollar appreciations, expansions in euro (yen) funded balance sheets forecast appreciations in the euro (yen). However, the effects are weaker than for the U.S. dollar.

While our approach is notable in that it uses only U.S. variables to forecast the movements of the dollar against other currencies, our data source also has its limitations. Chief among them is that many foreign intermediaries that use U.S. dollar funding markets are not captured in our data.[4] If such foreign intermediaries operate with large dollar liabilities, there may be fluctuations in dollar funding liquidity that are not fully represented in our data. The severe financial crisis and the accompanying dollar appreciation in the second half of 2008 following the Lehman Brothers collapse had such a flavor as foreign intermediaries were widely reported as scrambling to roll over their dollar liabilities, resulting in a sharp appreciation of the U.S. dollar. Modeling of the crisis period would therefore benefit from a more comprehensive database of dollar funding.

The outline of our paper is as follows. We first set the stage with our empirical analysis by investigating the role of U.S. short-term funding aggregates in explaining exchange rate movements, in both in-sample and out-of-sample forecasting exercises, for a sample of 23

[2] For our sample period, the Yen is well known as a funding currency in the carry trade, while the Australian and New Zealand dollars are favored destination currencies in the carry trade. Nevertheless, expansions in short-term U.S. dollar funding forecasts dollar appreciations against all three currencies.

[3] In fact, our short-term funding aggregates drive out the forecasting ability of the U.S. dollar average forward discout (see Lustig, Roussanov and Verdelhan, 2014) and U.S. net external assets (see Gourinchas and Rey, 2007).

[4] Our data on repos and financial commercial paper includes only U.S. financial intermediaries plus foreign intermediaries with U.S. subsidiaries.

currencies. We then discuss how our results relate to the empirical literature on the carry trade, and how the funding liquidity channel explored in our paper differs from the standard carry trade logic. Having established the forecasting power of the funding aggregates, we provide an asset pricing perspective for the results by sketching a model of U.S. dollar credit supply in the context of cross-border banking. The model yields pricing predictions that we then test in a dynamic asset pricing setting.

2 Empirical Analysis

2.1 Structure of Cross-Border Banking

In addition to being the world's most important reserve currency and an invoicing currency for international trade, the U.S. dollar is the funding currency of choice for global banks. A recent BIS (2010) study notes that as of September 2009, the United States hosted the branches of 161 foreign banks who collectively raised over $1 trillion dollars' worth of wholesale bank funding, of which $645 billion was channeled for use by their headquarters. Money market funds in the United States are an important source of wholesale bank funding for global banks. Baba, McCauley and Ramaswamy (2009) note that by mid-2008, over 40% of the assets of U.S. prime money market funds were short-term obligations of foreign banks, with the lion's share owed by European banks.

Even in *net terms*, foreign banks channel large amounts of dollar funding to head office. That is, the funding channeled to head office is larger than the funding received by the branch from head office. The BIS (2010) study finds that foreign bank branches had a net positive interoffice position in September 2009 amounting to $468 billion vis-à-vis their headquarters. As as also noted by the BIS report, many banks use a centralized funding model in which available funds are deployed globally through a centralized portfolio allocation decision.[5]

2.2 Data

The empirical analysis that follows uses weekly, monthly, and quarterly data on the nominal exchange rates of 23 countries against the U.S. dollar and two U.S. dollar indices. Our initial investigation covers the period 1/1993-12/2014. The countries include nine advanced countries (Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden,

[5]Cetorelli and Goldberg (2011, 2012) provide extensive evidence that internal capital markets serve to reallocate funding within global banking organizations.

Switzerland, UK) and fourteen emerging countries (Chile, Colombia, Czech, Republic, Hungary, India, Indonesia, Korea, Philippines, Poland, Singapore, South Africa, Taiwan, Thailand, Turkey). We have excluded countries with fixed or highly controlled exchange rate regimes over most of the sample period. The bilateral exchange rate data are provided by Datastream. The U.S dollar indices are from the Federal Reserve Board Statistical Releases.

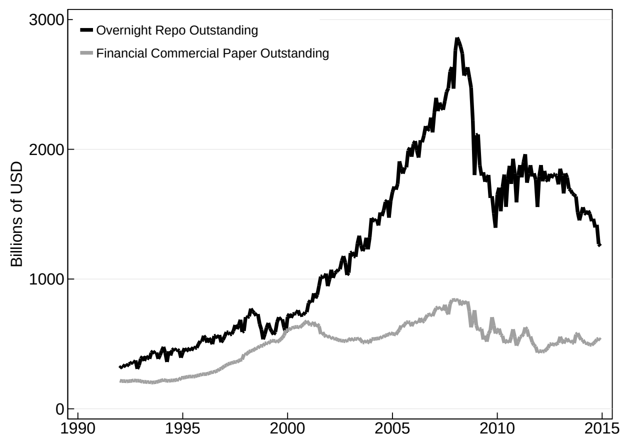

Figure 1: Primary dealer overnight repos and financial commercial paper outstanding, 1/1993-12/2014.

Our main forecasting variables are constructed from the outstanding stocks of U.S. dollar financial commercial paper (hencefort, commercial paper) and overnight repurchase agreements of the Federal Reserve's primary dealers (henceforth, repos).[6] These data are published weekly by the Federal Reserve Board and the Federal Reserve Bank of New York, respectively. A plot of the repos and commercial paper outstanding is provided in Figure 1, which shows that even though both variables have exhibited strong growth up to the financial crisis they have hardly moved in lockstep. During the financial crisis, both repo and commercial paper contracted sharply. While commercial paper stabilized after the financial crisis, repo continues to contract. These patterns suggest that the repo market has undergone a structural break since 2008.

For the purpose of forecasting either exchange rates or returns, we will generate detrended repo and commercial paper series. Figure 2 plots the detrended series of the logs of these variables. The detrending (with respect to a linear time trend) is performed *out of sample* in order to avoid look-ahead bias. The monthly correlation between the

[6]The primary dealers are a group of designated banks and securities broker-dealers who have a trading relationship with the Federal Reserve Bank of New York.

detrended series of log repos and log commercial paper is −.73 between 1993 and 2007, and −.33 between 2010 and 2015, but strongly positive during the financial crisis (2008 and 2009 with .82 correlation). This observation suggests that the two funding aggregates are substitutes in normal times, but co-moved during the crisis. When funding liquidity dried up, both the commercial paper and the repo market collapsed.

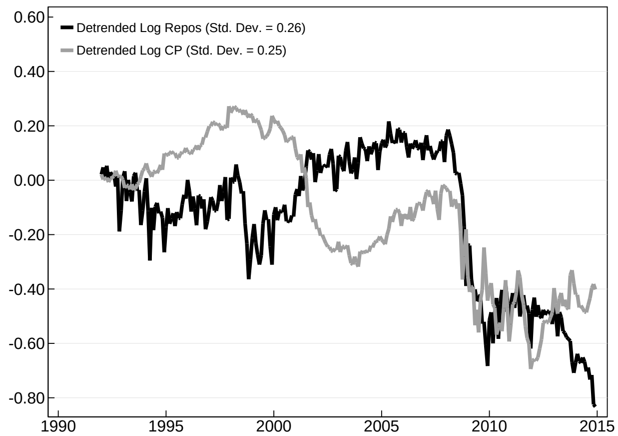

Figure 2: Out-of-sample detrended series of primary dealer overnight repos and financial commercial paper outstanding, 1/1993-12/2014.

In cross-sectional pricing exercises and robustness checks, we also employ country-level data on short-term interest rates and aggregate equity returns. The interest rates are 30-day money market rates (or equivalent), which are often most accessible to foreign investors.[7] The equity data correspond to the returns on the country's main stock-market index. These variables are obtained from Datastream, Haver, and Bloomberg.

2.3 Forecasting Exchange Rates

Despite numerous studies and a wide variety of approaches, forecasting nominal exchange rates at short horizons has remained an elusive goal. Meese and Rogoff's (1983) milestone paper finds that a random walk model of exchange rates fares no worse in forecasting exercises than macroeconomic models, and often does much better.

Evans and Lyons (2002, 2005) show that private order flow information helps forecast exchange rates, but forecasting exchange rates using public information alone has seen less success. Froot and Ramadorai (2005) show that institutional investor order flow helps explain transitory discount rate news of exchange rates, but not longer term cash

[7]For Turkey, we use the overnight rate.

flow news. Rogoff and Stavrakeva (2008) argue that even the most recent attempts that employ panel forecasting techniques and new structural models are inconclusive once their performance is evaluated over different time windows or with alternative metrics: Engel, Mark and West (2007) implement a monetary model in a panel framework to find limited forecastability at quarterly horizons for 5 out of 18 countries but their model's performance deteriorates after the 1980s. Molodtsova and Papell (2009) introduce a Taylor rule as a structural fundamental and exhibit evidence that their single equation framework outperforms driftless random walk for 10 out of 12 countries at monthly forecast horizons. However, their results are not robust to alternative test statistics, which Rogoff and Stavrakeva attribute to a severe forecast bias. Finally, Gourinchas and Rey (2007) develop a new external balance model, which takes into account capital gains and losses on the net foreign asset position. Their model forecasts changes in trade-weighted and FDI-weighted U.S. dollar exchange rate one quarter ahead and performs best over the second half of the 1990s and early 2000s.

Engel and West (2005) have provided a rationalization for the relative success of the random walk model by showing how an asset pricing approach to exchange rates leads to the predictions of the random walk model under plausible assumptions on the underlying stochastic processes and discount rates. In particular, when the discount factor is close to one and the fundamentals can be written as a sum of a random walk and a stationary process, the asset pricing formula puts weight on realizations of the fundamentals far in the distant future – the expectations of which are dominated by the random walk component of the sum. For plausible parameter values, they show that the random walk model is a good approximation of the outcomes implied by the theory.

In this paper, we part company with earlier approaches by focusing on U.S. dollar funding liquidity. We show that short-term liability aggregates of U.S. financial intermediaries have robust forecasting power for the bilateral movements of the U.S. dollar against a large number of currencies, both in sample and out of sample.

2.4 In-Sample Forecasting Regressions

Our in-sample analysis entails a set of regressions of (i) exchange rate percentage changes and (ii) currency excess returns on lagged forecasting variables.[8] The exchange rates are defined as the units of foreign currency that can be purchased with one U.S. dollar.

[8] Using log differences of the exchange rates does not alter the results qualitatively.

Hence, an *increase* in a country's exchange rate corresponds to an appreciation of the dollar against that currency. The currency excess returns correspond to a long position in the foreign risk-free bond funded by risk-free borrowing in U.S. dollars. We define currency excess returns from the perspective of a U.S. dollar investor as follows

$$R_{i,t+1} = \underbrace{\frac{\varepsilon^i_{t+1}}{\varepsilon^i_t}}_{\substack{\text{Exchange Rate} \\ \text{Appreciation}}} - \underbrace{\frac{1+r^{US}_{f,t}}{1+r^i_{f,t}}}_{\substack{\text{Interest Rate} \\ \text{Carry}}} \tag{1}$$

where ε is the amount of foreign currency per dollar, and $r^{US}_{f,t}$ and $r^i_{f,t}$ are the one month money market rates for the US and the set of foreign countries in our sample.

We will focus on two forecasting variables, the detrended series of U.S. dollar repos and financial commercial paper outstanding. We also include control variables, such as the U.S. short-term interest rate and the interest rate differential between a particular currency and the U.S. dollar. The time period under consideration is 1993-2014.

2.4.1 Regressions for Individual Exchange Rates and Currency Excess Returns

As a preliminary exercise, we consider simple ordinary-least squares regressions of monthly percentage changes in exchange rates (Table 1) and monthly currency excess returns (Table 2) on one-month lags of our two funding aggregates.

To account for possible structural breaks in our balance sheet aggregates during the financial crisis, we include regressors that interact them with a post-2007 dummy. The forecasting results for both exchange rate changes and excess returns are qualitatively similar: commercial paper is significant for all of the advanced economies for both exchange rates and currency returns, and there is no evidence of a structural break for commercial paper. For emerging markets, commercial paper is significant for eight out of 13 countries, while for currency returns it is significant for six countries. The sign of the forecasting relationship for commercial paper is the same for all countries: higher funding liquidity forecasts a dollar appreciation, and a compression of dollar denominated currency returns.

Overnight repo forecasts four currencies and excess returns significantly, three of which are developed. For repo, there is strong evidence of a structural break since the financial crisis: while the sign of the forecasting coefficient is the same for repo and commercial paper prior to the financial crisis, the sign of repo flips for repo interacted with the post

2007 dummy. We attribute this change in the sign of the forecasting power of repo to the structural change in the funding of the primary dealer sector since the crisis.

The fact that the direction of the commercial paper forecasting is unchanged since the crisis, while the sign of repo changes is perhaps surprising. Interoffice claims exhibit a similar structural break as repo, and hence the correlation between repo and interoffice claims stays positive, while the correlation of interoffice claims and commercial paper switches sign in the post-2007 sample.

Since our sample of cross rates includes both high and low interest rate countries, the empirical findings of Tables Table 1 and Table 2 suggest that the forecasting power of the short-term funding variables derive from a source different from the more familiar carry trade incentives. For some countries, the economic power of the forecasts is substantial: for example, the lagged funding aggregates forecast 7.2% of the variation in the New Zealand dollar monthly exchange rate changes and 7.3% of the variation in monthly excess returns.

One may be concerned that the persistence of our forecasting variables translates into finite-sample bias that inflates the predictive regression coefficients (Stambaugh, 1999). To investigate this possibility, we compute the correction proposed by Lewellen (2004), which adjusts the estimated regression coefficient using the "worst-case bias" that assumes a true autocorrelation of one in the forecasting variable. For the U.S. dollar trade-weighted index against major currencies (Table 1), the bias in the coefficient of overnight repos is -0.0054 while the upward bias in the coefficient of financial commercial paper is 0.0006 prior to 2007. Post 2007, the respective biases are .0099 and .0148. These estimated "worst-case" biases are small compared to the magnitudes of the estimated regression coefficients.

2.4.2 Panel Regressions

Since our short-term funding aggregates forecast U.S. dollar appreciations against all currencies, we may conduct our investigation in the context of a panel regression. Given the nature of our panel, it is possible that the prediction errors are correlated both among different dollar cross rates in the same time period and different time periods within the same cross rate. Hence, we calculate standard errors which allow for two dimensions (currency and time) of within-cluster correlation (see Cameron, Gelbach and Miller, 2006; Thompson, 2011; and Petersen, 2008).

The results from our monthly panel regressions are presented in Table 3 and 4 (for the sample of advanced countries) and Table 5 and 6 (for the whole sample of countries). As before, the results in tables 3 and 5 are for percentage changes in exchange rates against the U.S. dollar and those in tables 4 and 6 are for currency excess returns funded in U.S. dollars. The panel specifications echo the same message as our country-by-country regressions: High U.S. dollar liquidity today tends to be followed by lower dollar-based currency returns and appreciating dollar going forward. For advanced countries, column (i) of Table 3 demonstrate that both funding aggregates are highly statistically significant forecasters of monthly exchange rate changes. We again find a structural break in the sign of the forecasting relationship for repo, but not for commercial paper.

We present the expected exchange rate appreciation in Figure 3. The forecastable component is computed as the predicted value from column (i) of Table 3. The figure shows that there is strong time series variation in expected exchange rate movements over time.

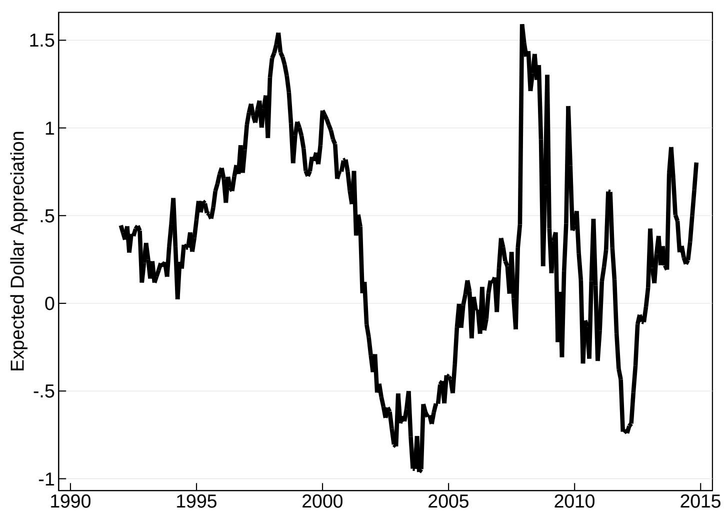

Figure 3: The figure shows the forecastable component of exchange rate changes from the panel regression reported in Table 3, column (i).

Columns (ii)-(iii) of Tables 3 and 4 show that the shows that the forecasting power of the funding aggregates for both exchange rates and currency returns is unaffected by including past exchange rate changes.

Columns (iv)-(viii) of Tables 3 and 4 show that the statistical significance of the regression coefficients of repo and commercial paper is preserved as one includes lags of common controls, including the interest rate differential (or "carry," defined as the difference between the foreign short-term interest rate and the U.S. short-term interest rate), the VIX implied volatility index, and the stock market return differential (difference between the annual return on the foreign stock market and the annual return on the U.S. stock market). We also control for the interaction of the VIX with the carry and the interaction of the TED spread (difference between Libor and U.S. Treasury bill rate) with the carry, following the finding of Brunnermeier, Nagel and Pedersen (2008) that these variables forecast exchange rate movements related to unwinding of carry trades.

The magnitudes of the regression coefficients of repo and commercial paper are also preserved across all specifications. In our exchange rate forecasts of Table 3, a one standard deviation (0.26) increase in detrended repo forecasts a roughly 0.7 percentage point increase in the rate of U.S. dollar appreciation; similarly, a one standard deviation (0.25) increase in detrended commercial paper forecasts a 1.0 percentage point increase in the rate of dollar appreciation over the following month. Table 4's results for currency excess returns are even stronger. It is also notable that the addition of controls has only limited impact on the explanatory power of the regressions: the adjusted R-squared statistic increases from 3.1% to 5.3% as one accounts for the full set of controls.

We emphasize that the power of our regressors, U.S. dollar repos and commercial paper, stems from their ability to predict equilibrium returns and it increases at longer forecast horizons. This result is illustrated for our exchange rate forecasts in Figure 4, which plots the time-series of adjusted R-squared for month-ahead to year-ahead forecast horizons. We see that the time-series explanatory power of the regression increases from 4.4% to 9.1% for quarter-ahead forecasts and to 14.7% for six-months- ahead forecasts. The highest explanatory power is obtained at the nine-month horizon where our two funding aggregates are able to forecast nearly 18% of the time-series variation in future exchange rate changes.

Tables 5 and 6 display the panel regression results for the whole sample of both advanced and emerging countries. We see that lagged commercial paper continues to be a robust forecaster of excess currency returns and exchange rate changes across all specifications (i)-(viii) while the statistical significance of lagged repo varies across specifications. This finding is consistent with the single-country regressions of Tables 1 and 2, which suggest that the predictive ability of repos is strongest for the advanced countries. Accordingly, the combined explanatory power of our funding aggregates is lower for the whole sample of countries, where trends and interest rate differentials tend to play a greater role

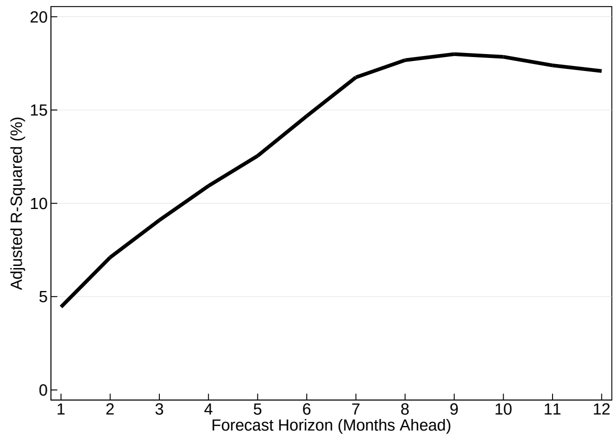

Figure 4: Forecasting exchange rate changes several months ahead. Time-series explanatory power in the panel of 9 advanced countries, 1/1993-12/2014.

(see columns (ii)-(iii)).

2.5 Events of 2008-09

It is important to qualify our results in the light of the significant deterioration in financial market liquidity in the global financial crisis of 2008-09, and the structural changes in the nature of financial intermediation that have taken place since the crisis.

The conjunction of sharp U.S. dollar appreciation and contracting U.S. credit aggregates, which followed the bankruptcy of Lehman Brothers in the second half of 2008, could be attributed in part to contemporaneous shifts in risk appetite due to a series of shocks from the unfolding crisis. But we find it more plausible to appeal to the fact that non-U.S. financial intermediaries (especially in emerging Europe, Latin America and Asia) were funding their operations with short-term U.S. dollar obligations. The second half of 2008 was associated with sharp depreciations of such emerging market currencies as their financial intermediaries scrambled to roll over their dollar funding. In addition, it is possible that the policy actions (such as the FX swap agreements among central banks) in response to the malfunctioning of foreign exchange markets lead to significantly different determination of risk premia in the crisis compared to normal times.

We examine the statistical significance of our U.S.-based forecasting variables over time in Figure 5. We implement the panel regression specification of Table 3, column (i), recursively for 1/1993-11/2014 and plot the t-statistics of lagged repo and lagged financial commercial paper from these regressions. The figure confirms that both repo and commercial paper were statistically significant forecasters of the U.S. dollar exchange rate growth prior to the financial crisis. Following the Lehman bankruptcy, however, the statistical significance of lagged repos deteriorates substantially, and continues to do so through the end of the sample. The statistical significance of lagged commercial paper, on the other hand, revives in 2009.

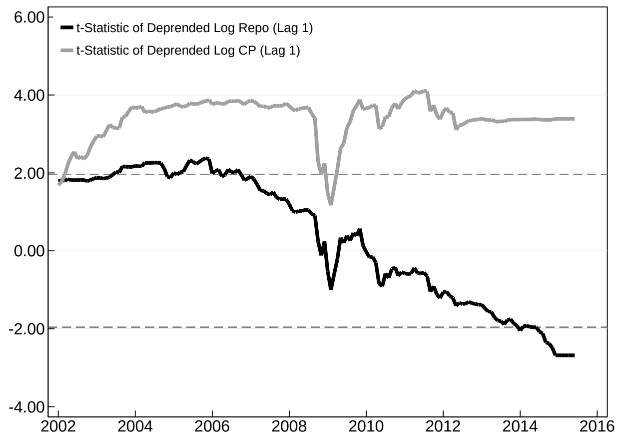

Figure 5: Statistical significance of lagged U.S. funding aggregates as predictors of the U.S. dollar exchange rate. The t-statistics are obtained from recursive panel regressions of exchange rate percentage changes on lagged repo and lagged commercial paper with standard errors clustered by currency and month (see column (i) of Table 3). The critical value 1.96 corresponds to significance at 5% level.

In order to investigate the impact of contemporaneous shifts in U.S. funding aggregates on the U.S. dollar exchange rate, we compute innovations to our forecasting variables as the residuals from regressions of detrended log repo and detrended log commercial paper on their own lags. We then use these fitted residuals together with lagged repo and lagged commercial paper in our familiar panel regression, implemented recursively for 1/1993-11/2014. The results are displayed in Figure 6, which shows the statistical significance of repo and financial commercial paper innovations over time. While the contemporaneous shocks in our funding aggregates have been statistically insignificant over most of the sample period, the shocks to financial commercial paper temporarily become a more significant predictor of contemporaneous exchange rate changes following the Lehman bankruptcy. That is, the sharp contractions in U.S. funding aggregates over the recent financial crisis were indeed associated with contemporaneous U.S. dollar appreciations.

Nonetheless, the lesson of the post-Lehman liquidity crisis is that the movements of a major funding currency such as the U.S. dollar during an acute crisis stage may not be

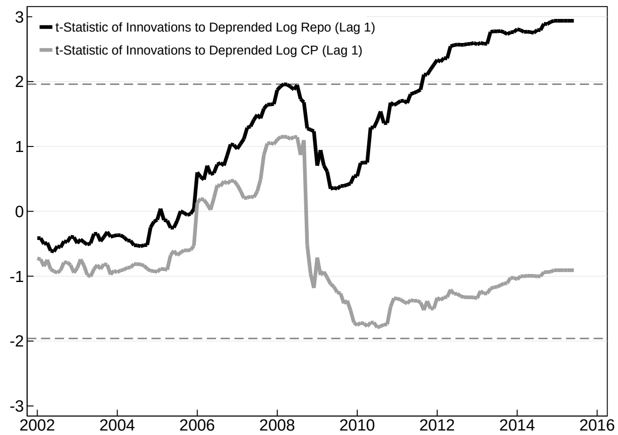

Figure 6: Statistical significance of innovations in U.S. funding aggregates as predictors of contemporanous changes in the U.S. dollar exchange rate. The t-statistics are obtained from recursive panel regressions of exchange rate percentage changes on lagged repo, lagged commercial paper, and their fitted innovations, with standard errors clustered by currency and month. The critical value -1.96 corresponds to significance at 5% level.

easily captured by U.S. financial variables alone. Thus, we urge caution in interpreting our results when drawing lessons for the recent crisis. Furthermore, the structure of the U.S. repo market appears to have changed fundamentally since the crisis, so that increases in repo funding are no longer significant predictors of exchange rate appreciations.

2.5.1 Funding Liquidity Channel and Carry Trade Channel

In addition to uncovering a new funding liquidity channel of exchange rate determination, our panel regressions distinguish it from the more familiar carry trade channel. For the sample of advanced countries (Table 3), the effect of the interest rate differential on the U.S. dollar cross rates is insignificant.[9] The unpredictable nature of the carry trade channel outside of advanced countries is exemplified in our panel regression for the whole sample of 23 countries (Table 5), where the sign of the interest differential term is surprisingly *positive* and significant. Although this finding is at variance with the usual carry trade mechanism, our U.S. dollar funding liquidity variables remain significant in this sample, reflecting the importance of dollar-funded risky positions across the world.

[9] In a recent paper, Lustig, Roussanov and Verdelhan (2014) show that the average forward discount of the U.S. dollar has predictive ability for the average excess returns earned by U.S. investors investing a basket of foreign currencies. Our forecasting regressions control for the individual interest rate differentials (forward discounts). Included in same regression with our short-term funding aggregates, the average forward discount is statistically insignificant.

2.6 Out-of-Sample Forecasting Regressions

As is well known, the high in-sample forecasting power of a regressor does not guarantee robust out-of-sample performance, which is more sensitive to mis-specification problems. To show the extent to which the above in-sample results survive this tougher test, we turn to investigate the forecastability of exchange rate changes out of sample.

The out-of-sample performance of the monthly forecasting regressions is displayed in Table 7. In order to exploit both time and cross-sectional variation in the data, the coefficient estimates are generated using the panel specification of Table 5. The recursive regression uses the first 4 years (1/1993-12/1996) of the sample as a training period and begins the out-of-sample estimation of betas in 1/1997. We show the our of sample results for the 1/1997-12/2007 period in the first column, and for the 1/1997-12/2014 sample in the second column.

We compare the predictive power of our funding liquidity model against the random walk benchmark, as is standard in the literature on out-of-sample forecasting. This benchmark is nested in the "unrestricted" specifications, which allows one to evaluate its performance using the Clark-West (2006) adjusted difference in mean squared errors: $MSE_r - (MSE_u - adj.)$. The Clark-West test accounts for the small-sample forecast bias ($adj.$), which works in favor of the simpler restricted models and is present in the Diebold-Mariano/West tests that employ the unadjusted statistic $MSE_r - MSE_u$.[10] As Rogoff and Stavrakeva (2008) show, a significant Clark-West adjusted statistic implies that there exists an optimal combination between the unrestricted model and the restricted model, which will produce a combined forecast that outperforms the restricted model in terms of mean squared forecast error; i.e. the forecast will have a Diebold-Mariano/West statistic that is significantly greater than zero. The results in Table 7 indicate that the funding liquidity model outperforms both benchmarks for 6 out of 9 advanced countries and 6 out of 14 emerging countries for the pre crisis sample, and 8 out of 9 advanced countries and 10 out of 14 countries for the full sample. These out of sample results are very strong, and, to our knowledge, not found for any other variable in previous foreign exchange forecasting literature.

[10]See Diebold and Mariano (1995) and West (1996).

3 Asset Pricing Perspective

Having established our benchmark empirical findings, we now turn our attention to how these results can be given firmer theoretical foundations. It is illuminating to begin by taking the cue from our empirical results, which showed that the forecasting power of our funding liquidity variables is separate from the usual "carry trade" explanation for exchange rates, which emphasizes the relative attractiveness of currencies of high interest rate countries. In particular, we showed that expansions in U.S. dollar funding aggregates forecast appreciations of the dollar against both high and low-yielding currencies. Thus, the rationale for our findings is very different from the carry trade literature.

Funding liquidity conditions provide a possible explanation for why the U.S. dollar may strengthen even when the U.S. interest rate decreases. It is when funding conditions are favorable that financial institutions are able to build up the size of their balance sheets through greater short-term debt (see Adrian and Shin, 2008b). Thus, more favorable funding conditions seem to increase the *appetite* of financial intermediaries to take risk. To the extent that foreign currencies are regarded as risky assets by dollar-funded investors, high dollar funding liquidity should be associated with low equilibrium expected returns on these assets. That is, high dollar funding liquidity should forecast appreciations of the dollar. In order to investigate the funding liquidity hypothesis more systematically, we now proceed to work out a theoretical global banking framework that will give rise to testable predictions for global currency risk premia.

3.1 U.S. Dollar-denominated Risk Premium

We sketch a model of credit supply and U.S. dollar-denominated risk premium that will motivate our empirical asset pricing analysis. A stylistic structure of cross-border banking is given in Figure 7. Consider global banks that borrow in the U.S. dollar wholesale funding market, and supply credit in U.S. dollars to borrowers across the world. Banks are risk neutral and maximize profit subject only to a Value-at-Risk (VaR) constraint that limits the probability of bank failure. Specifically, the VaR constraint stipulates that the probability of bank failure must remain below some (small) threshold level $\alpha > 0$, consistent with the regulatory requirements laid down by the Basel Committee (BCBS (2005)).

The notation to be used is given in Figure 8. The bank lends out C dollars of credit at date 0 at rate r, so that the bank is owed $(1 + r)\,C$ dollars in date 1. The lending is

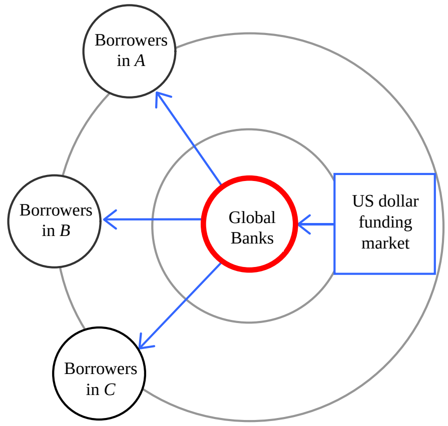

Figure 7: Structure of cross-border banking

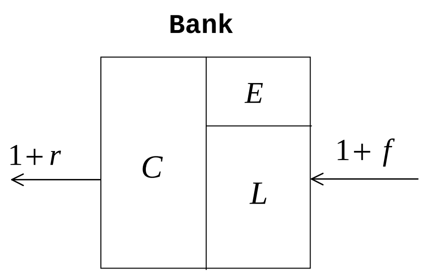

Figure 8: Notation for bank balance sheet. C is the amount lent out at date 0, financed with equity E and U.S. dollar funding L.

financed from the combination of equity E and debt funding L, where L is raised in the U.S. dollar wholesale funding market. The cost of debt financing is f so that the bank owes $(1 + f)\,L$ at date 1 (its notional liabilities).

The bank lends to a continuum of borrowers around the world, with total lending being C dollars. Each borrower repays with probability $1 - \varepsilon$ and defaults with probability ε. The correlation in defaults across loans follows the Vasicek (2002) model, which has served as the backbone of Basel capital requirements (BCBS (2005)). Borrower j repays the loan when $Z_j > 0$, where Z_j is the random variable

$$Z_j = -\Phi^{-1}(\varepsilon) + \sqrt{\rho}Y + \sqrt{1-\rho}X_j \tag{2}$$

and $\Phi(.)$ is the c.d.f. of the standard normal distribution, Y and $\{X_j\}$ are independent standard normal random variables, and ρ is a constant between zero and one. Y has the interpretation of the global factor that drives project outcomes across the world, while

X_j is the idiosyncratic factor for borrower j. Importantly, the parameter ρ is the weight on the global factor. Note that the probability of default is

$$\begin{aligned}\Pr\left(Z_j < 0\right) &= \Pr\left(\sqrt{\rho}Y + \sqrt{1-\rho}X_j < \Phi^{-1}\left(\varepsilon\right)\right) \\ &= \Phi\left(\Phi^{-1}\left(\varepsilon\right)\right) = \varepsilon \end{aligned} \quad (3)$$

Conditional on Y, defaults are independent. The bank can remove idiosyncratic risk by keeping C fixed but diversifying across borrowers. In the limit, the realized value of assets is a function of Y only by the law of large numbers. The realized value of the bank's assets at date 1 is given by the random variable $w\left(Y\right)$ defined by

$$\begin{aligned} w\left(Y\right) &\equiv \left(1+r\right)C \cdot \Pr\left(Z_j \geq 0|Y\right) \\ &= \left(1+r\right)C \cdot \Pr\left(\sqrt{\rho}Y + \sqrt{1-\rho}X_j \geq \Phi^{-1}\left(\varepsilon\right)|Y\right) \\ &= \left(1+r\right)C \cdot \Phi\left(\tfrac{Y\sqrt{\rho}-\Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \end{aligned} \quad (4)$$

The c.d.f. of $w\left(Y\right)$ is given by

$$\begin{aligned} F\left(z\right) &= \Pr\left(w \leq z\right) \\ &= \Pr\left(Y \leq w^{-1}\left(z\right)\right) \\ &= \Phi\left(w^{-1}\left(z\right)\right) \\ &= \Phi\left(\frac{1}{\sqrt{\rho}}\left(\Phi^{-1}\left(\varepsilon\right) + \sqrt{1-\rho}\Phi^{-1}\left(\frac{z}{\left(1+r\right)C}\right)\right)\right) \end{aligned} \quad (5)$$

The density over the realized assets of the bank is the derivative of (5) with respect to z.

Figure 9 plots the densities over asset realizations, and shows how the density shifts to changes in the default probability ε (left hand panel) or to changes in ρ (right hand panel). Higher values of ε imply a first degree stochastic dominance shift left for the asset realization density, while shifts in ρ imply a mean-preserving shift in the density around the mean realization $1-\varepsilon$.

The bank takes its equity E as given and adjusts the size of its loan book C and funding L so as as to keep its probability of default to $\alpha > 0$.[11] Since the bank is risk-neutral and maximizes profit, the VaR constraint binds whenever expected profit to lending is positive. The constraint is that the bank limits lending so as to keep the probability of its own failure to α. Assume that $\alpha < \varepsilon$. Since the bank fails when the asset realization

[11]See Adrian and Shin (2010, 2014) for empirical evidence that banks take equity as given and adjust leverage by adjusting the size of their balance sheet.

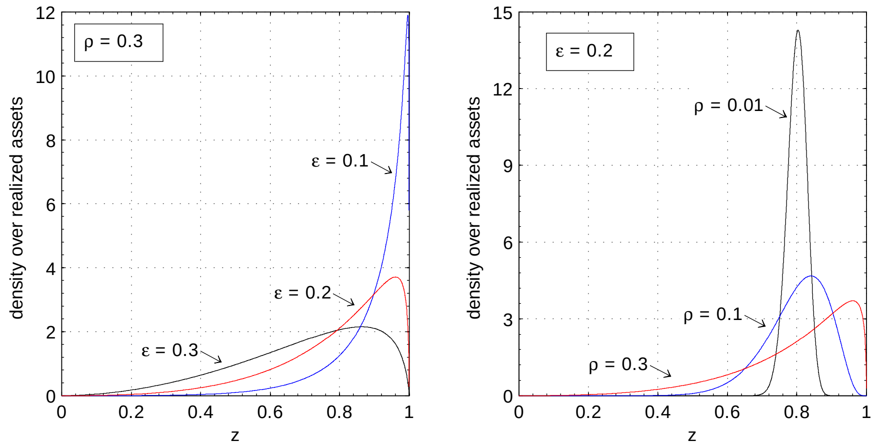

Figure 9: The two charts plot the densities over realized assets when $C(1+r) = 1$. The left hand charts plots the density over asset realizations of the bank when $\rho = 0.1$ and ε is varied from 0.1 to 0.3. The right hand chart plots the asset realization density when $\varepsilon = 0.2$ and ρ varies from 0.01 to 0.3.

falls below its notional liabilities $(1+f)L$, the bank's credit supply C satisfies

$$\Pr(w < (1+f)L) = \Phi\left(\frac{\Phi^{-1}(\varepsilon)+\sqrt{1-\rho}\Phi^{-1}\left(\frac{(1+f)L}{(1+r)C}\right)}{\sqrt{\rho}}\right) = \alpha \tag{6}$$

Re-arranging (6), we can derive an expression for the ratio of notional liabilities to notional assets for the bank.

$$\frac{\text{Notional liabilities}}{\text{Notional assets}} = \frac{(1+f)L}{(1+r)C} = \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha) - \Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{7}$$

From here on, we will use the shorthand φ to denote this ratio of notional liabilities to notational assets. That is,

$$\varphi(\alpha,\varepsilon,\rho) \equiv \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha)-\Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{8}$$

Note that φ is a normalized leverage ratio, lying between zero and one. We can solve for C and bank funding L from (7) and the balance sheet identity $C = E + L$.

$$C = \frac{E}{1-\frac{1+r}{1+f}\cdot\varphi} \qquad \text{and} \qquad L = \frac{E}{\frac{1+f}{1+r}\cdot\frac{1}{\varphi}-1} \tag{9}$$

Note that both C and L are proportional to bank equity E, so that an aggregation property holds for C and L. Therefore, the leverage of the *bank* and the *banking sector* are interchangeable, and is given by

$$\text{Leverage } = \frac{C}{E} = \frac{1}{1 - \frac{1+r}{1+f} \cdot \varphi} \tag{10}$$

Our condition that $\alpha < \varepsilon$ ensures that the expression inside $\Phi(.)$ in (8) flips sign from negative to positive as ρ increases from zero to one. Figure 10 plots the notional debt to assets ratio φ as a function of the common risk factor ρ when $\alpha = 0.1\%$. The dark line is when $\varepsilon = 1\%$, while the light line is when $\varepsilon = 0.5\%$. Since the bank's leverage is monotonic in φ, leverage declines in ρ and ε.

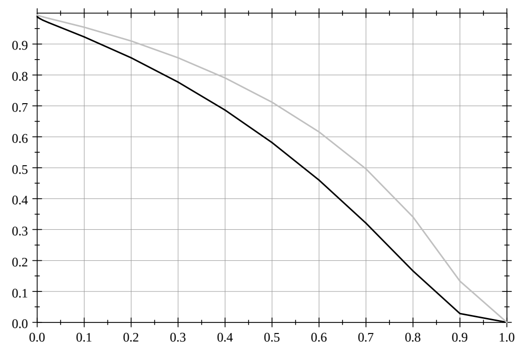

Figure 10: Plot of notional debt to assets ratio $\varphi(\alpha, \varepsilon, \rho)$. This chart plots φ as a function of ρ with $\alpha = 0.001$. Dark line is when $\varepsilon = 0.01$. Light line is when $\varepsilon = 0.005$.

Credit market clearing determines the equilibrium loan rate r, and hence the risk premium. Since the default probability of loans is ε, the U.S. dollar-denominated risk premium is given by

$$\pi \equiv (1 - \varepsilon)(1 + r) - 1 \tag{11}$$

Now consider a decline in global risk, represented by a fall in ρ. Then, leverage increases through an increase in φ, which feeds into an increase in the U.S. dollar bank funding aggregate L. When the credit demand curve is downward sloping, an increase in bank funding aggregates is associated with a fall in the U.S. dollar-denominated lending rate r. For fixed ε, the U.S. dollar-denominated risk premium is increasing in the lending rate r, so that the comparative statics of the risk premium depends on the bank funding aggregate L. We thus have our key prediction.

Proposition 1. *With a decline in ρ, U.S. dollar-denominated risk premium π declines and U.S. dollar-denominated bank funding aggregate L increases.*

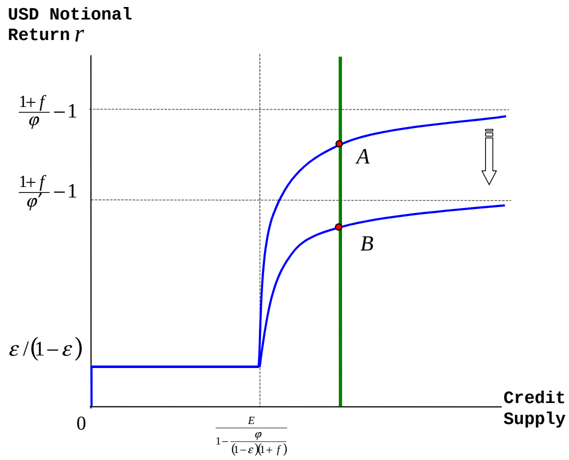

Figure 11: Compression of U.S. dollar risk premium as a result of increased bank leverage

Figure 11 plots the determination of U.S. dollar notional return r as a function of bank credit supply. The credit demand is depicted as being vertical, but any downward-sloping demand will entail the same comparative statics. Note that credit supply C is zero if $r < \varepsilon/(1-\varepsilon)$, and goes to infinity as r approaches the asymptote $((1+f)/\varphi)-1$ from below.

The consequences for exchange rates depend on what happens to the *local currency-denominated* risk premium for the same asset. The fundamentals of the borrower's credit risk is unchanged in that ε has been fixed in the comparative statics experiment in Proposition 1. Denote by $1+\hat{r}$ the local currency-denominated notional return on lending, and let $1+a^e$ be the expected U.S. dollar appreciation relative to the local currency. Then, the equalization of U.S. dollar-denominated returns and local currency-denominated returns implies:

$$1+r = \frac{1+\hat{r}}{1+a^e} \tag{12}$$

If $1+\hat{r}$ is unaffected by a change in ρ, then from Proposition 1, a decline in ρ is associated with a fall in r and an increase in a^e. Both coincide with an increase in L. In other words, an increase in L is associated with an expected *appreciation* of the U.S. dollar. Even if $1+\hat{r}$ is affected by the shift in ρ, provided that $\hat{r}$ does not fall as much as r, there will be an expected U.S. dollar appreciation.

Empirical Hypothesis. Confining attention to shifts in global factor ρ, an increase in U.S. dollar-denominated bank funding aggregate L is accompanied by an expected appreciation of the U.S. dollar.

Note that our empirical hypothesis is an additional effect to the usual carry trade channel. Distinguishing the U.S. dollar risk premium from the local currency risk premium is in the same spirit as the recent work of Lustig, Roussanov and Verdelhan (2011, 2014), who posit a two-factor pricing kernel in explaining exchange rates.

3.2 Dynamic Asset Pricing Framework

In order to test the empirical hypothesis of the global banking model, we follow Adrian, Crump, Moench (2015) and estimate a dynamic asset pricing model. We employ a set of cross sectional pricing factors X_t, and forecasting factors F_t. Forecasting factors play the role of determining the time variation in the pricing of risk, which in turn pin down conditional expected returns. The cross sectional pricing factors determine the unconditional pricing across assets. We use the following set of asset pricing factors:

$$C_t = \begin{bmatrix} FXPC1_t \\ FXPC2_t \\ CARRY_t \end{bmatrix}, \quad F_t = \begin{bmatrix} FXFF_t \\ CARRY_t \end{bmatrix}$$

where $FXPC1$ and $FXPC2$ denote the first two principal components from the cross section of currency excess returns, $CARRY$ denotes the high minus low carry return factor of Lustig, Roussanov and Verdelhan (2011), and FXFF denotes the exchange rate forecasting factor that we estimated from the panel regressions in Table 1 and displayed in Figure 3. We stack the two sets of factors into a vector of state variables $X_t = [C_t', \ F_t']'$.

Assuming a linear pricing kernel and prices of risk that are affine in the forecasting factors F_t, the beta representation of the Dynamic Asset Pricing Model is given by

$$R_{i,t+1} = \beta_i' (\lambda_0 + \Lambda_1 F_t) + \beta_i' u_{t+1} + e_{i,t+1}, \tag{13}$$

$$X_{t+1} = \mu + \Phi X_t + v_{t+1}, \qquad t = 1, \ldots, T. \tag{14}$$

where $\beta_i = Cov(R_{i,t+1}, u_{t+1}) [Var(u_{t+1})]^{-1}$. In the vector autoregression of X_t, the set of shocks v_t associated with the cross sectional pricing factors C_t is denoted by u_t. The interpretation of the variables is as follows:

$$\beta_i' (\lambda_0 + \Lambda_1 F_t) = \textit{FX Risk Premium} \tag{15}$$

$$\beta_i' u_{t+1} = \textit{Priced FX Risk} \tag{16}$$

$$e_{i,t+1} = \textit{Idiosyncratic Risk} \tag{17}$$

The realized excess return, $R_{i,t+1}$, can thus be decomposed into the expected excess return, $\beta_i' (\lambda_0 + \Lambda_1 F_t)$, a component that is conditionally correlated with the innovations to the risk factors, $\beta_i' u_{t+1}$, and a return pricing error, $e_{i,t+1}$, that is conditionally orthogonal to the risk factor innovations. The expected excess return depends on the asset's exposures to the pricing factors of the model, β_i, as well as the associated prices of risk $\lambda_t = \lambda_0 + \Lambda_1 F_t$ which are affine functions of the forecasting factors.

To estimate the parameters of the dynamic asset pricing model, we use the regression-based estimator of Adrian, Crump, Moench (2015), who show that it is consistent and asymptotically normal. They further derive asymptotic standard errors that are robust to heteroskedasticity in the return pricing errors.[12]

Estimates for the prices of risk are given in Table 8. The first column of the table reports the constant price of risk λ_0 for the three cross sectional pricing factors. The second and third columns respectively show the time variation of the prices of risk associated with the carry factor and our FX forecasting factor. The last column provides the joint test of time variation in the pricing of risk of each of the three factors, either due to the time variation associated with the FX forecasting factor, or the carry factor. Table 9 reports the estimated betas of each currency on the cross sectional pricing factors.

The first thing to note in Table 8 is that both the FX forecasting factor and the carry factor are highly significant predictors of the first principal component of foreign exchange returns. And since the first principal component loads positive on each currency, the negative prediction coefficient associated with the FX forecasting factor implies that higher U.S. dollar funding liquidity forecasts a compression of expected currency returns. This result is consistent with our earlier panel estimation results. Furthermore, the significance of the forecasting relationship is robust to the inclusion of the carry factor, illustrating again the fact that the U.S. dollar funding liquidity channel is different from the carry trade channel. The second principal component also exhibits significant time variation in the pricing of risk, but only as a function of the carry return factor. We also find that the price of risk of the carry return factor varies significantly as a function of the carry return, but not of the funding liquidity factor. This is again illustrating the fact that the funding liquidity channel is distinct from the carry trade channel. The time variation in

[12]Importantly, this estimator nests the popular Fama-MacBeth two-pass regression estimator when both $\Lambda_1 = 0$ and $\Phi = 0$. That is, the Dynamic Asset Pricing Model estimator can be thought of as a generalized Fama-MacBeth estimator that explicitly allows for state variables and prices of risk to be time-varying.

the prices of risk is significant for all three pricing factors, as indicated by the Wald test reported in the last column.

The cross sectional pricing performance of the model can be gauged in Figure 12. The model has a fairly high cross sectional explanatory power with an R^2 of 50%. In comparison to the carry trade pricing literature (e.g. Lustig, Roussanov and Verdelhan (2011, 2014)), a key difference is that we are applying our pricing model to individual currency carry returns, not to carry sorted portfolios. Cross sectional R^2s for portfolios are generally higher than when individual currency excess returns are used.

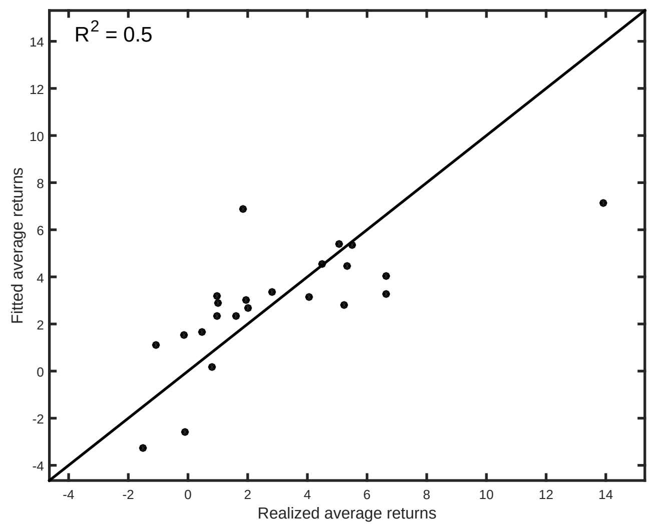

Figure 12: The plot shows the average excess returns across the 23 currency returns against the excess returns predicted by the dynamic asset pricing model.

The results from the dynamic asset pricing model show that the U.S. dollar funding liquidity as measured by the FX forecasting factor matters for the pricing of U.S. dollar cross rates due to its association with the marketwide U.S. dollar risk premium. The cross-sectional evidence supports our view that the forecastability of exchange rates uncovered in Tables 1-4 is in fact a reflection of systematic changes in risk premia. Higher dollar funding liquidity compresses the equilibrium returns on all risky dollar-funded positions, including those denominated in foreign currencies. This puts appreciation pressure on the dollar going forward.

4 Conclusion

The random walk model has been an important benchmark in explanations of exchange rate movements. Since Meese and Rogoff's (1983) milestone paper, finding a convincing alternative to the random walk benchmark has been an elusive goal. In this paper, we have presented two related contributions that shed light on how exchange rate movements can be understood in the context of broader financial conditions, which drive changes in the U.S. dollar risk premium.

First, building on the random walk model of exchange rates, we have demonstrated strong evidence that the short-term funding aggregates of financial intermediaries have a role in explaining future exchange rate movements—measured both in terms of exchange rate changes as well as in excess currency returns. Specifically, expansions in U.S. dollar components of financial intermediary short-term liabilities forecast appreciations of the U.S. dollar, both in sample and out of sample. The results hold for a broad range of dollar cross rates. We have shown how this result goes beyond the usual "carry trade" story, in favor of a parallel funding liquidity channel as expressed in short-term funding aggregates. Our hypothesis that funding liquidity conditions are important in the foreign exchange market is further bolstered by evidence from euro- and yen-based funding markets.

Second, motivated by our new empirical evidence on forecastability, we have constructed a simple global banking model where the risk appetite of financial investors varies over time with observable balance sheet components. Estimation of dynamic asset pricing relationships based on the global banking model suggests that the forecastability of exchange rates by our short-term funding aggregates is linked to time-variation in systematic risk premia.

Taken together, our two contributions are first steps toward a more general framework for thinking about exchange rate movements in the context of investors' funding liquidity. Our findings open up the possibility of understanding exchange rate movements and external adjustments in terms of financial cycles and the leverage adjustments of financial intermediaries that accompany them.

References

Adrian, Tobias, Richard Crump, Emanuel Moench (2015) "Regression based Estimation of Dynamic Asset Pricing Models,"*Journal of Financial Economics* 118(2), pp. 211?244.

Adrian, Tobias and Hyun Song Shin (2014) "Procyclical Leverage and Value at Risk," *Review of Financial Studies* 27(2), pp. 373–403.

Adrian, Tobias and Hyun Song Shin (2010) "Liquidity and Leverage," *Journal of Financial Intermediation* 19, pp. 418-437

Baba, Naohiko, Robert N. McCauley and Srichander Ramaswamy (2009) "U.S. Dollar Money Market Funds and Non-U.S. Banks" *BIS Quarterly Review*, March 2009, pp. 65-81.

Bank for International Settlements (2010) "Funding patterns and liquidity management of internationally active banks" CGFS Papers 39, Committee on the Global Financial System, May.

Basel Committee on Banking Supervision (2005) "International Convergence of Capital Measurement and Capital Standards: A Revised Framework", Bank for International Settlements, November 2005 http://www.bis.org/publ/bcbs118.pdf

Brunnermeier, Markus, Stefan Nagel and Lasse Pedersen (2008) "Carry Trades and Currency Crashes," *NBER Macroeconomics Annual 2008.*

Brunnermeier, Markus and Lasse Heje Pedersen (2009) "Market Liquidity and Funding Liquidity," *Review of Financial Studies* 22(6), pp. 2201-2238.

Burnside, Craig, Martin Eichenbaum, Isaac Kleshchelski, and Sergio Rebelo (2007), "The Returns to Currency Speculation," *NBER Working Paper* No. 12489.

Cameron, A. Colin, Jonah B. Gelbach, and Douglas L. Miller (2007), "Robust Inference with Multi-Way Clustering," *NBER Working Paper* No. T0327.

Cetorelli, Nicola and Linda S. Goldberg (2011) "Global Banks and International Shock Transmission: Evidence from the Crisis"*IMF Economic Review* 59(1) pp. 41-76.

Cetorelli, Nicola and Linda S. Goldberg (2012) "Banking Globalization and Monetary Transmission" *Journal of Finance* 67(5) pp. 1811-1843.

Clark, Todd E. and Kenneth D. West (2006) "Using Out-of-Sample Mean Squared Prediction Errors to Test the Martingale Difference Hypothesis," *Journal of Econometrics* 135(1-2), pp. 155-186.

Danielsson, Jon, Hyun Song Shin and Jean-Pierre Zigrand (2008) "Balance Sheet Capacity and Endogenous Risk" working paper, London School of Economics and Princeton University.

Diebold, Francis X. and Roberto S. Mariano (1995) "Comparing Predictive Accuracy," *Journal of Business and Economic Statistics* 13, pp. 253-265.

Dumas, Bernard and Bruno Solnik (1995) "The World Price of Foreign Exchange Risk," *Journal of Finance* 50, pp. 445-479.

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

Engel, Charles, Nelson C. Mark, Kenneth D. West, (2007) "Exchange Rate Models Are Not as Bad as You Think, " *NBER Macroeconomics Annual 2007* 22, pp. 381 - 441.

Evans, Martin D. and Richard K. Lyons. (2005) "Meese-Rogoff Redux: Micro-Based Exchange-Rate Forecasting," *American Economic Review Papers and Proceedings* 95, pp. 405–14.

Fama, Eugene (1984) "Forward and Spot Exchange Rates," *Journal of Monetary Economics* 14, pp. 19–38.

Froot, Kenneth, and Tarun Ramadorai (2005) "Currency Returns, Intrinsic Value, and Institutional Investor Flows," *Journal of Finance* 60, pp. 1535-1566.

Gagnon, Joseph E. and Alain Chaboud (2007) "What Can the Data Tell Us About Carry Trades in Japanese Yen?" *FRB International Finance Discussion Paper* 899.

Groen, Jan (2005) "Exchange Rate Predictability and Monetary Fundamentals in a Small Multi-Country Panel," *Journal of Money, Credit, and Banking* 37, pp. 495 - 516.

Gromb, Denis and Dimitri Vayanos (2002) "Equilibrium and Welfare in Markets with Financially Constrained Arbitrageurs," *Journal of Financial Economics* 66, pp. 361-407.

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

Hattori, Masazumi and Hyun Song Shin (2009) "Yen Carry Trade and the Subprime Crisis," *IMF Staff Papers*, pp. 384-409.

Hodrick, Robert (1989) "Risk, Uncertainty, and Exchange Rates," *Journal of Monetary Economics* 23, pp. 433-59.

Jylha, Petri and Matti Suominen (2011) "Speculative Capital and Currency Carry Trades," forthcoming, *Journal of Financial Economics* 99(1) (2011), pp. 60-75.

Lustig, Hanno, Nick Roussanov and Adrien Verdelhan (2011) "Common Risk Factors in Currency Markets,"*Review of Financial Studies* 24 (11), pp. 3731-3777.

Lustig, Hanno, Nick Roussanov and Adrien Verdelhan (2014) "Countercyclical Currency Risk Premia,"*Journal of Financial Economics* 111 (3), pp. 527–553.

Lyons, Richard K. (1997) "A Simultaneous Trade Model of the Foreign Exchange Hot Potato," *Journal of International Economics* 42, pp. 275-98.

Meese, Richard A., and Kenneth Rogoff (1983) "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?" *Journal of International Economics* 14, pp. 3-24.

Molodtsova, Tanya and David Papell (2009) "Out-of-Sample Exchange Rate Predictability with Taylor Rule Fundamentals,"*Journal of International Economics* 77(2), pp. 167-180.

Petersen, Mitchell A. (2008) "Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches," *Review of Financial Studies* 22, pp. 435-480.

Rogoff, Kenneth and Vania Stavrakeva (2008) "The Continuing Puzzle of Short Horizon Exchange Rate Forecasting,"NBER working paper 14071.

Shin, Hyun Song and Kwanho Shin (2010) "Procyclicality and Monetary Aggregates" NBER working paper 16836.

Thompson, Samuel B. (2011) "Simple Formulas for Standard Errors that Cluster by Both Firm and Time," *Journal of Financial Economics* 99(1), pp. 1-10.

West, Kenneth D. (1996) "Asymptotic Inference About Predictive Ability," *Econometrica* 64, pp. 1067-1084.

Table 1: Forecasting Monthly Changes in Exchange Rates

This table uses ordinary least squares regressions to forecast individual exchange rates. The dependent variable is the monthly percentage change in the U.S. dollar bilateral exchange rate against 23 currencies (in rows), and the percentage change in the U.S. dollar trade-weighted indices (broad, major currencies). Forecasting variables (in columns) are the one-month lags of detrended log repo and detrended log Financial commercial paper outstanding. The table reports point estimates with Newey-West t-statistics (using 4 lags) in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The sample period is 1993:1 - 2014:12.

Dependent Variable	Independent Variable										
Percent Change	Detrended Log				Detrended Log						
in Exchange Rate	Repo (Lag 1)		Repo (Lag 1, post-2007)		CP (Lag 1)		CP (Lag 1, post-2007)		Post-2007		Constant	R^2
usdxm	2.087*	(1.778)	−2.722	(-1.362)	3.324***	(3.571)	−1.397	(-0.738)	0.761	(0.842)	-0.060	5.8 %
usdxb	0.346	(0.362)	−0.703	(-0.404)	2.115***	(3.275)	−0.592	(-0.377)	0.486	(0.600)	0.129	5.9 %
aud	5.130***	(2.581)	−7.459*	(-1.883)	6.170***	(3.960)	1.901	(0.390)	2.543	(1.033)	0.000	5.7 %
cad	1.321	(0.877)	−0.357	(-0.147)	2.726**	(2.321)	−0.762	(-0.338)	1.575	(1.549)	-0.097	3.7 %
dem	1.179	(0.535)	−3.715	(-1.161)	3.738**	(2.166)	1.380	(0.341)	1.362	(0.908)	-0.048	4.0 %
jpy	4.075*	(1.676)	−7.516**	(-2.406)	3.219*	(1.936)	−1.828	(-0.593)	−0.855	(-0.795)	0.064	2.5 %
nzd	6.577***	(3.051)	−6.581*	(-1.730)	7.544***	(5.601)	−1.257	(-0.265)	2.768	(1.483)	-0.059	7.1 %
nok	1.281	(0.697)	−3.311	(-0.850)	3.568**	(2.515)	2.532	(0.647)	2.190	(1.145)	-0.074	4.2 %
sek	2.550	(1.176)	−4.969	(-1.355)	4.493***	(2.919)	2.740	(0.674)	2.228	(1.129)	0.039	4.6 %
chf	1.365	(0.639)	−3.430	(-1.108)	3.268**	(2.035)	−0.685	(-0.177)	0.164	(0.124)	-0.077	1.9 %
gbp	1.916	(1.251)	−0.072	(-0.025)	2.912**	(2.430)	−0.452	(-0.186)	2.251	(1.621)	-0.091	5.5 %
clp	−0.159	(-0.078)	0.828	(0.245)	2.375	(1.427)	0.345	(0.094)	1.584	(0.816)	0.168	2.5 %
cop	−3.542	(-1.373)	−0.844	(-0.205)	1.842	(0.920)	7.701	(1.646)	1.827	(0.832)	0.533	7.0 %
czk	0.118	(0.046)	−3.815	(-0.979)	3.763*	(1.782)	2.717	(0.529)	1.668	(0.821)	-0.207	4.2 %
huf	0.552	(0.262)	−4.948	(-1.175)	4.960***	(3.462)	4.909	(0.767)	2.383	(0.900)	0.456	5.3 %
inr	0.702	(0.444)	2.505	(1.141)	2.167**	(2.036)	−3.404	(-1.238)	1.291	(1.633)	0.195	5.5 %
idr	9.162	(1.196)	−8.038	(-0.986)	14.587*	(1.774)	−14.526*	(-1.704)	−0.585	(-0.394)	1.488	2.7 %
krw	2.457	(0.698)	0.614	(0.138)	4.125	(1.168)	−1.070	(-0.235)	2.661**	(2.146)	0.231	2.9 %
php	−0.467	(-0.173)	2.107	(0.735)	2.230	(1.122)	−1.268	(-0.515)	0.913*	(1.710)	0.311	3.3 %
pln	−2.413	(-1.280)	0.779	(0.196)	2.041	(1.435)	4.657	(0.849)	2.396	(0.849)	0.255	3.4 %
sgd	1.292	(0.864)	−2.587	(-1.359)	2.135*	(1.918)	0.722	(0.348)	0.592	(0.770)	-0.040	3.0 %
zar	3.452	(1.044)	−3.945	(-0.893)	6.033**	(2.319)	−0.496	(-0.099)	2.244	(1.231)	0.597	3.3 %
twd	2.306*	(1.733)	−3.559**	(-2.056)	2.366**	(2.160)	−0.235	(-0.125)	0.135	(0.162)	0.191	3.1 %
try	−4.888	(-1.152)	3.887	(0.769)	8.976***	(2.843)	−1.774	(-0.400)	0.611	(0.301)	2.871	11.4 %

Table 2: Forecasting Monthly Currency Excess Returns

This table uses ordinary least squares regressions to forecast excess returns on individual foreign currency positions. The dependent variable is the monthly excess return on a long position in the foreign currency funded by a short position in the U.S. dollar (in rows). Forecasting variables (in columns) are the one-month lags of detrended log repo and detrended log Financial commercial paper outstanding. The table reports point estimates with Newey-West t-statistics (using 4 lags) in parentheses; *** p < 0.01, ** p < 0.05, * p < 0.1. The sample period is 1993:1 - 2014:12.

Dependent Variable	Independent Variable											
Currency	Detrended Log				Detrended Log							
Excess Return	Repo (Lag 1)		Repo (Lag 1, post-2007)		CP (Lag 1)		CP (Lag 1, post-2007)		Post-2007		Constant	R^2
aud	−5.324***	(-2.672)	8.356**	(2.202)	−6.874***	(-4.365)	−1.342	(-0.284)	−1.989	(-0.889)	0.193	6.4 %
cad	−1.719	(-1.142)	0.987	(0.419)	−3.298***	(-2.802)	1.240	(0.561)	−1.389	(-1.472)	0.118	4.1 %
dem	−1.832	(-0.814)	4.720	(1.486)	−4.554***	(-2.583)	−0.550	(-0.139)	−1.058	(-0.755)	0.059	4.7 %
jpy	−4.662*	(-1.914)	7.926**	(2.540)	−3.826**	(-2.236)	2.492	(0.809)	1.069	(0.974)	-0.272	2.6 %
nzd	−6.207***	(-2.879)	6.662*	(1.793)	−7.884***	(-5.841)	1.826	(0.407)	−2.324	(-1.360)	0.363	7.2 %
nok	−2.299	(-1.211)	4.754	(1.262)	−4.544***	(-3.004)	−1.698	(-0.440)	−1.881	(-1.060)	0.202	4.6 %
sek	−3.613	(-1.620)	6.619*	(1.821)	−5.471***	(-3.437)	−2.218	(-0.550)	−2.020	(-1.088)	0.052	5.5 %
chf	−2.025	(-0.920)	4.291	(1.367)	−4.044**	(-2.483)	1.393	(0.365)	0.125	(0.095)	-0.050	2.6 %
gbp	−2.013	(-1.266)	0.536	(0.193)	−3.259**	(-2.559)	0.875	(0.363)	−2.066	(-1.593)	0.232	5.3 %
clp	−1.545	(-0.735)	1.646	(0.507)	−2.307	(-1.350)	−0.629	(-0.176)	−1.214	(-0.671)	0.523	1.4 %
cop	0.835	(0.305)	3.989	(0.983)	−0.476	(-0.238)	−8.520*	(-1.935)	−1.995	(-0.986)	0.615	3.5 %
czk	−0.396	(-0.141)	4.486	(1.121)	−2.865	(-1.211)	−3.739	(-0.736)	−1.650	(-0.856)	0.533	3.4 %
huf	−3.282	(-1.560)	8.683**	(2.227)	−5.250***	(-3.587)	−5.152	(-0.913)	−2.336	(-1.030)	0.465	5.3 %
inr	−0.873	(-0.557)	−2.258	(-1.066)	−2.102*	(-1.937)	2.790	(1.061)	−1.156	(-1.601)	0.174	4.8 %
idr	−4.100	(-0.638)	3.019	(0.436)	−3.547	(-0.543)	3.940	(0.571)	−0.441	(-0.355)	0.356	0.3 %
krw	−1.802	(-0.476)	−0.498	(-0.109)	−2.139	(-0.597)	−1.266	(-0.279)	−2.565**	(-2.433)	0.250	2.2 %
php	0.404	(0.148)	−1.935	(-0.662)	−1.667	(-0.837)	0.652	(0.260)	−1.071**	(-2.019)	0.437	2.4 %
pln	0.440	(0.243)	1.892	(0.506)	−1.105	(-0.754)	−6.072	(-1.215)	−2.702	(-1.066)	0.672	2.8 %
sgd	−0.937	(-0.616)	2.123	(1.102)	−2.183*	(-1.923)	−0.807	(-0.392)	−0.545	(-0.722)	-0.094	3.8 %
zar	−4.106	(-1.289)	5.272	(1.240)	−6.591**	(-2.464)	1.406	(0.285)	−1.780	(-1.050)	0.125	3.4 %
twd	−2.748**	(-2.131)	3.922**	(2.298)	−2.454**	(-2.283)	0.241	(0.130)	−0.111	(-0.134)	-0.233	3.6 %
try	−9.328	(-1.429)	11.232	(1.609)	−8.456**	(-2.011)	2.318	(0.450)	−3.466**	(-2.011)	1.572	6.2 %

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Table 3: Forecasting Monthly Changes in Exchange Rates (Advanced Countries)

This table uses panel regressions with currency and month fixed effects to forecast exchange rate changes. The dependent variable is the monthly percentage change in the U.S. dollar bilateral exchange rate against 9 advanced-country currencies. Forecasting variables are the one-month lags of detrended log repo and detrended log financial commercial paper outstanding. Control variables (each lagged by one month) are: the interest rate differential (carry), the annual stock market return differential, the U.S. interest rate, the annual growth of the VIX implied volatility index and the interaction of this variable with the interest rate differential, the annual growth of the TED spread (difference between Libor and U.S. Treasury bill rate) and the interaction of this variable with the interest rate differential. A lag of the dependent variable is included in (ii)-(viii). The table reports point estimates with t-statistics clustered by currency and month in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The sample period is 1993:1 - 2014:12.

	Dependent Variable: Percentage Change in Exchange Rate							
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Detrended Log Repo (Lag 1)	2.881**	3.141**		3.357***	3.534***	3.590***	3.843***	4.074***
	(2.179)	(2.532)		(2.752)	(2.987)	(2.888)	(3.030)	(3.211)
Detrended Log Repo (Lag 1, Post-2007)	-4.216*	-4.342**		-4.596**	-4.604**	-4.582**	-4.109**	-4.456**
	(-1.941)	(-2.048)		(-2.169)	(-2.203)	(-2.214)	(-1.994)	(-2.138)
Detrended Log CP (Lag 1)	4.211***	4.262***		4.585***	4.409***	4.611**	4.874***	5.069***
	(3.847)	(4.052)		(4.119)	(4.043)	(2.442)	(2.604)	(2.635)
Detrended Log CP (Lag 1, Post-2007)	0.367	0.100		-0.230	-0.444	-0.605	-1.349	-1.251
	(0.142)	(0.039)		(-0.091)	(-0.178)	(-0.208)	(-0.469)	(-0.439)
Exch. Rate Change (Lag 1)		0.023	0.045	0.023	0.030	0.030	0.033	0.030
		(0.557)	(0.997)	(0.557)	(0.743)	(0.750)	(0.820)	(0.756)
Interest Rate Differential (Lag 1)			-0.717	0.485	0.306	0.244	0.321	0.114
			(-0.961)	(0.732)	(0.498)	(0.359)	(0.472)	(0.171)
Stock Mkt. Ret. Dif. Ann (Lag 1)					-0.014**	-0.014**	-0.014**	-0.013**
					(-2.162)	(-2.161)	(-2.219)	(-2.231)
U.S. Interest Rate (Lag 1)						-0.287	0.070	-0.154
						(-0.134)	(0.033)	(-0.072)
VIX Growth Annual (Lag 1)							-0.006	-0.006
							(-1.413)	(-1.264)
Signed VIX Growth Annual (Lag 1)							0.000	-0.002
							(0.154)	(-0.733)
TED Growth Annual (Lag 1)								-0.001
								(-0.375)
Signed TED Growth Annual (Lag 1)								0.003***
								(2.592)
Post-2007	1.585	1.537		1.463	1.323	1.292	1.482	1.510
	(1.595)	(1.544)		(1.487)	(1.350)	(1.189)	(1.381)	(1.416)
Constant	-0.042	0.667	0.564	0.767**	0.724*	0.819	0.758	0.798
	(-0.342)	(1.642)	(1.396)	(1.969)	(1.765)	(0.922)	(0.865)	(0.896)
Observations	2367	2367	2367	2367	2330	2330	2330	2330
Adjusted R^2	0.031	0.046	0.017	0.045	0.048	0.047	0.050	0.053

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Table 4: Forecasting Monthly Currency Excess Returns(Advanced Countries)

This table uses panel regressions with currency and month fixed effects to forecast currency excess returns. The dependent variable is the monthly excess return on borrowing in the U.S. dollar to invest in 9 advanced-country currencies. Forecasting variables are the one-month lags of detrended log repo and detrended log financial commercial paper outstanding. Control variables (each lagged by one month) are: the interest rate differential (carry), the annual stock market return differential, the U.S. interest rate, the annual growth of the VIX implied volatility index and the interaction of this variable with the interest rate differential, the annual growth of the TED spread (difference between Libor and U.S. Treasury bill rate) and the interaction of this variable with the interest rate differential. A lag of the dependent variable is included in (ii)-(viii). The table reports point estimates with t-statistics clustered by currency and month in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The sample period is 1993:1 - 2014:12.

	Dependent Variable: Currency Excess Returns							
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Detrended Log Repo (Lag 1)	-3.338**	-3.631***		-3.405***	-3.582***	-3.660***	-3.939***	-4.170***
	(-2.567)	(-2.971)		(-2.766)	(-2.984)	(-2.921)	(-3.080)	(-3.257)
Detrended Log Repo (Lag 1, Post-2007)	5.022**	5.166**		4.900**	4.916**	4.886**	4.355**	4.724**
	(2.345)	(2.475)		(2.345)	(2.376)	(2.373)	(2.120)	(2.277)
Detrended Log CP (Lag 1)	-4.880***	-4.954***		-4.616***	-4.455***	-4.738**	-5.026***	-5.247***
	(-4.410)	(-4.666)		(-4.093)	(-4.027)	(-2.547)	(-2.734)	(-2.775)
Detrended Log CP (Lag 1, Post-2007)	0.243	0.549		0.203	0.408	0.633	1.461	1.358
	(0.096)	(0.217)		(0.081)	(0.164)	(0.221)	(0.520)	(0.488)
Exch. Rate Change (Lag 1)		-0.020	-0.041	-0.020	-0.026	-0.027	-0.030	-0.027
		(-0.495)	(-0.946)	(-0.495)	(-0.668)	(-0.675)	(-0.757)	(-0.690)
Interest Rate Differential (Lag 1)			1.802**	0.508	0.674	0.762	0.672	0.880
			(2.439)	(0.769)	(1.094)	(1.129)	(0.989)	(1.324)
Stock Mkt. Ret. Dif. Ann (Lag 1)					0.013**	0.013**	0.013**	0.012**
					(2.046)	(2.040)	(2.100)	(2.104)
U.S. Interest Rate (Lag 1)						0.403	-0.000	0.253
						(0.193)	(-0.000)	(0.122)
VIX Growth Annual (Lag 1)							0.007	0.006
							(1.545)	(1.405)
Signed VIX Growth Annual (Lag 1)							-0.000	0.002
							(-0.133)	(0.771)
TED Growth Annual (Lag 1)								0.001
								(0.310)
Signed TED Growth Annual (Lag 1)								-0.003***
								(-2.602)
Post-2007	-1.284	-1.237		-1.315	-1.183	-1.140	-1.352	-1.377
	(-1.376)	(-1.318)		(-1.407)	(-1.268)	(-1.113)	(-1.336)	(-1.371)
Constant	0.102	-0.793**	-0.455	-0.689*	-0.657	-0.790	-0.722	-0.771
	(0.746)	(-1.994)	(-1.158)	(-1.819)	(-1.641)	(-0.916)	(-0.848)	(-0.893)
Observations	2367	2367	2367	2367	2330	2330	2330	2330
Adjusted R^2	0.036	0.053	0.026	0.053	0.055	0.055	0.058	0.062

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Table 5: Forecasting Monthly Changes in Exchange Rates (All Countries)

This table uses panel regressions with currency and month fixed effects to forecast exchange rate changes. The dependent variable is the monthly percentage change in the U.S. dollar bilateral exchange rate against 9 advanced-country currencies. Forecasting variables are the one-month lags of detrended log repo and detrended log financial commercial paper outstanding. Control variables (each lagged by one month) are: the interest rate differential (carry), the annual stock market return differential, the U.S. interest rate, the annual growth of the VIX implied volatility index and the interaction of this variable with the interest rate differential, the annual growth of the TED spread (difference between Libor and U.S. Treasury bill rate) and the interaction of this variable with the interest rate differential. A lag of the dependent variable is included in (ii)-(viii). The table reports point estimates with t-statistics clustered by currency and month in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The sample period is 1993:1 - 2014:12.

	Dependent Variable: Percentage Change in Exchange Rate							
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Detrended Log Repo (Lag 1)	1.448	1.551		2.309*	2.184*	2.385*	2.572*	2.765**
	(1.131)	(1.203)		(1.946)	(1.858)	(1.820)	(1.935)	(2.071)
Detrended Log Repo (Lag 1, Post-2007)	-2.312	-2.497		-3.239	-2.889	-2.913	-2.573	-3.055
	(-1.070)	(-1.201)		(-1.573)	(-1.412)	(-1.406)	(-1.263)	(-1.489)
Detrended Log CP (Lag 1)	4.259***	4.016***		4.093***	3.857***	4.452**	4.630**	4.878**
	(3.732)	(3.804)		(3.853)	(3.645)	(2.158)	(2.238)	(2.297)
Detrended Log CP (Lag 1, Post-2007)	0.086	0.325		0.214	0.034	-0.464	-0.958	-0.794
	(0.030)	(0.115)		(0.076)	(0.012)	(-0.149)	(-0.305)	(-0.255)
Exch. Rate Change (Lag 1)		0.084***	0.077***	0.061**	0.063***	0.063***	0.065***	0.065***
		(3.243)	(2.683)	(2.399)	(2.686)	(2.706)	(2.890)	(2.861)
Interest Rate Differential (Lag 1)			0.574***	0.556***	0.556***	0.549***	0.553***	0.556***
			(7.793)	(7.078)	(6.683)	(6.764)	(6.970)	(7.018)
Stock Mkt. Ret. Dif. Ann (Lag 1)					-0.005	-0.005	-0.005	-0.004
					(-0.999)	(-0.995)	(-1.011)	(-0.920)
U.S. Interest Rate (Lag 1)						-0.697	-0.462	-0.628
						(-0.351)	(-0.234)	(-0.310)
VIX Growth Annual (Lag 1)							-0.005	-0.004
							(-1.204)	(-1.081)
Signed VIX Growth Annual (Lag 1)							0.001	-0.001
							(0.536)	(-0.849)
TED Growth Annual (Lag 1)								-0.001
								(-0.355)
Signed TED Growth Annual (Lag 1)								0.003***
								(3.030)
Post-2007	1.454	1.410		1.514	1.394	1.294	1.447	1.466
	(1.446)	(1.445)		(1.548)	(1.458)	(1.181)	(1.350)	(1.356)
Constant	0.295*	2.950***	0.974**	0.976**	1.235	1.523***	1.453***	1.493***
	(1.658)	(6.886)	(2.219)	(2.319)	.	(9.167)	(10.900)	(5.346)
Observations	6049	6049	6049	6049	5963	5963	5963	5963
Adjusted R^2	0.023	0.054	0.050	0.069	0.069	0.069	0.070	0.072

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Table 6: Forecasting Monthly Currency Excess Returns(All Countries)

This table uses panel regressions with currency and month fixed effects to forecast currency excess returns. The dependent variable is the monthly excess return on borrowing in the U.S. dollar to invest in 9 advanced-country currencies. Forecasting variables are the one-month lags of detrended log repo and detrended log financial commercial paper outstanding. Control variables (each lagged by one month) are: the interest rate differential (carry), the annual stock market return differential, the U.S. interest rate, the annual growth of the VIX implied volatility index and the interaction of this variable with the interest rate differential, the annual growth of the TED spread (difference between Libor and U.S. Treasury bill rate) and the interaction of this variable with the interest rate differential. A lag of the dependent variable is included in (ii)-(viii). The table reports point estimates with t-statistics clustered by currency and month in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The sample period is 1993:1 - 2014:12.

	Dependent Variable: Currency Excess Returns							
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Detrended Log Repo (Lag 1)	-2.339*	-2.552**		-1.868	-1.799	-1.890	-2.094	-2.289*
	(-1.884)	(-2.098)		(-1.611)	(-1.559)	(-1.503)	(-1.644)	(-1.790)
Detrended Log Repo (Lag 1, Post-2007)	3.587*	3.753*		3.084	2.825	2.836	2.439	2.933
	(1.694)	(1.831)		(1.531)	(1.409)	(1.401)	(1.217)	(1.460)
Detrended Log CP (Lag 1)	-3.685***	-3.776***		-3.707***	-3.679***	-3.950**	-4.143**	-4.400**
	(-3.343)	(-3.537)		(-3.616)	(-3.507)	(-2.010)	(-2.106)	(-2.200)
Detrended Log CP (Lag 1, Post-2007)	-0.697	-0.548		-0.649	-0.291	-0.065	0.494	0.328
	(-0.254)	(-0.203)		(-0.240)	(-0.111)	(-0.022)	(0.165)	(0.111)
Exch. Rate Change (Lag 1)		-0.006	-0.041	-0.027	-0.030	-0.030	-0.032	-0.031
		(-0.224)	(-1.440)	(-1.059)	(-1.174)	(-1.175)	(-1.265)	(-1.239)
Interest Rate Differential (Lag 1)			0.480***	0.501***	0.505***	0.508***	0.503***	0.501***
			(4.532)	(4.427)	(4.416)	(4.591)	(4.634)	(4.615)
Stock Mkt. Ret. Dif. Ann (Lag 1)					0.001	0.001	0.001	0.001
					(0.359)	(0.355)	(0.372)	(0.227)
U.S. Interest Rate (Lag 1)						0.317	0.051	0.226
						(0.165)	(0.027)	(0.117)
VIX Growth Annual (Lag 1)							0.005	0.005
							(1.292)	(1.171)
Signed VIX Growth Annual (Lag 1)							-0.001	0.002
							(-0.375)	(1.054)
TED Growth Annual (Lag 1)								0.001
								(0.337)
Signed TED Growth Annual (Lag 1)								-0.003***
								(-3.021)
Post-2007	-1.489	-1.478		-1.384	-1.281	-1.235	-1.407	-1.426
	(-1.601)	(-1.608)		(-1.518)	(-1.427)	(-1.216)	(-1.415)	(-1.422)
Constant	0.281**	0.504	-0.717*	-0.701*	-1.055	-1.186***	-1.104***	-1.147***
	(2.053)	(1.434)	(-1.873)	(-1.948)	.	(-3.882)	(-3.725)	(-3.213)
Observations	6049	6049	6049	6049	5963	5963	5963	5963
Adjusted R^2	0.020	0.036	0.030	0.050	0.049	0.049	0.051	0.053

Table 7: Forecasting Monthly Changes in Exchange Rates

This table investigates the out-of-sample forecastability of monthly percentage changes in the U.S. dollar bilateral exchange rate relative to 23 foreign currencies. We compare the performance of our funding liquidity model against a benchmark random walk model. The forecasting variables are the one-month lags of detrended log repo and detrended log financial commercial paper outstanding, the interaction of the lagged funding variables with a post-2007 dummy variable, the post-2007 dummy, and currency fixed effects. The table reports the Diebold-Mariano/West difference in mean-squared errors and the Clark-West adjusted difference in mean-squared errors. The p-values associated with the Clark-West statistic aredisplayed; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. We consider two out-of-sample periods: 1997:1 - 2007:12, and 1997:1 - 2014:12.

	1997:1 - 2007:12			1997:1 - 2014:12		
	ΔMSE	$\Delta MSE - Adj.$	p-value	ΔMSE	$\Delta MSE - Adj.$	p-value
aud	0.425	0.845 ***	0.005	-1.072	2.290 **	0.049
cad	0.013	0.466 **	0.038	-2.048	1.304 **	0.037
dem	0.080	0.532 **	0.043	-1.476	1.839 *	0.072
jpy	-0.232	0.226	0.261	-2.351	1.007	0.164
nzd	0.513	0.974 ***	0.002	0.057	3.430 **	0.033
nok	-0.013	0.446	0.112	-1.445	1.897 **	0.010
sek	0.157	0.592 **	0.032	-0.060	3.266 ***	0.003
chf	-0.108	0.362	0.140	-1.474	1.890 *	0.085
gbp	-0.048	0.403 *	0.069	-1.982	1.338 **	0.029
clp	0.139	0.480 **	0.019	-2.278	1.027	0.146
cop	0.484	1.444 ***	0.002	-0.233	3.536 ***	0.005
czk	0.044	0.569	0.128	-0.423	2.946 **	0.038
huf	-0.088	1.355 ***	0.004	0.103	4.092 *	0.073
inr	0.054	0.535 ***	0.007	-2.699	0.669 *	0.094
idr	1.118	5.110	0.204	-0.833	5.193	0.101
krw	0.029	0.678	0.292	0.047	3.532 *	0.058
php	0.035	0.587	0.171	-2.914	0.525	0.165
pln	-0.513	0.687	0.109	0.352	4.155 **	0.030
sgd	-0.274	0.127	0.298	-2.282	1.035 *	0.078
zar	0.637	1.442 **	0.017	-1.548	2.160 *	0.090
twd	-0.177	0.261	0.202	-2.296	1.040 **	0.024
thb	-0.507	0.102	0.465	-2.660	0.796	0.160
try	2.046	22.406 ***	0.000	-1.091	17.081 ***	0.000

Table 8: Price of Risk Estimates

The table reports the estimated price of risk matrices λ_0 and Λ_1 from the dynamic asset pricing model $R_{i,t+1} = \beta_i' (\lambda_0 + \Lambda_1 F_t) + \beta_i' u_{t+1} + e_{i,t+1}$, where u_t are the shocks to $FXPC1_t, FXPC2_t, CARRY_t$, and F_t are the forecasting factors $FXFF_t, CARRY_t$. The first and second principal components of currency excess returns are denoted $FXPC1_t$ and $FXPC2_t$. The Lustig, Roussanov and Verdelhan (2011, 2014) carry factor is denoted $CARRY_t$, and the return forecasting factor from Table 1 is $FXFF_t$. The test assets are the 23 countries with sample data from 1993 to 2014. Robust standard errors reported in parenthesis are calculated as in Adrian, Crump, Moench (2013). *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level. W_{Λ_1} denotes the joint significance test for each row of the Λ_1 matrix.

	λ_0	CARRY	$FXFF$	W_{Λ_1}
FX PC1	0.019***	0.062**	-0.035***	17.362***
	(0.007)	(0.030)	(0.010)	(0.000)
FX PC2	-0.006	0.055***	0.010	8.576**
	(0.005)	(0.021)	(0.007)	(0.014)
CARRY	0.048**	0.234***	-0.043	10.371***
	(0.020)	(0.086)	(0.028)	(0.006)

Table 9: Factor Risk Exposure Estimates

The table reports the estimated β_is from the dynamic asset pricing model $R_{i,t+1} = \beta_i' (\lambda_0 + \Lambda_1 F_t) + \beta_i' u_{t+1} + e_{i,t+1}$, where u_t are the shocks to $FXPC1_t, FXPC2_t, CARRY_t$, and F_t are the forecasting factors $FXFF_t, CARRY_t$. The first and second principal components of currency excess returns are denoted $FXPC1_t$ and $FXPC2_t$. The Lustig, Roussanov and Verdelhan (2011, 2014) carry factor is denoted $CARRY_t$, and the return forecasting factor from Table 1 is $FXFF_t$. The test assets are the 23 countries with sample data from 1993 to 2014. Robust standard errors reported in parenthesis are calculated as in Adrian, Crump, Moench (2013). *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

	$\beta_{\text{FX PC1}}$	$s.e.(\beta_{\text{FX PC1}})$	$\beta_{\text{FX PC2}}$	$s.e.(\beta_{\text{FX PC2}})$	β_{CARRY}	$s.e.(\beta_{\text{CARRY}})$
aud	0.116***	(0.015)	-0.063***	(0.009)	1.820***	(0.028)
cad	0.260***	(0.016)	-0.111***	(0.017)	-3.624***	(0.013)
dem	0.161***	(0.014)	0.105***	(0.017)	-9.020***	(0.022)
jpy	0.250***	(0.020)	-0.082***	(0.017)	0.652***	(0.017)
nzd	0.247***	(0.011)	-0.126***	(0.014)	-1.121***	(0.038)
nok	0.255***	(0.015)	-0.132***	(0.018)	-1.170***	(0.009)
sek	0.271***	(0.024)	-0.075***	(0.010)	-6.336***	(0.021)
chf	0.136***	(0.032)	-0.109***	(0.027)	0.255***	(0.019)
gbp	0.130***	(0.016)	-0.064	(0.059)	1.714***	(0.021)
clp	0.121***	(0.020)	-0.048***	(0.018)	3.289***	(0.019)
cop	0.288***	(0.021)	-0.147***	(0.024)	-1.943***	(0.025)
czk	0.294***	(0.021)	-0.186***	(0.018)	1.271***	(0.016)
huf	0.092***	(0.036)	-0.050	(0.087)	2.099***	(0.030)
inr	0.349***	(0.025)	0.868***	(0.019)	-0.011	(0.027)
idr	0.206***	(0.017)	-0.019	(0.046)	0.372***	(0.028)
krw	0.088*	(0.048)	0.097	(0.633)	2.049***	(0.511)
php	0.269	(1.050)	-0.193	(0.729)	1.978***	(0.724)
pln	0.134	(0.732)	0.029	(0.738)	-0.490	(0.825)
sgd	0.209	(0.944)	-0.084	(0.962)	6.436***	(0.788)
zar	0.100	(0.796)	0.034	(0.589)	-0.365	(0.715)
twd	0.159	(1.645)	0.194	(0.671)	0.340	(0.864)
thb	0.183	(0.374)	-0.120	(1.123)	5.842***	(0.497)
try	0.223	(0.913)	0.098	(1.567)	-9.534***	(0.985)