Risk Appetite and Exchange Rates[1]

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May 18, 2010

[1]The views expressed in this paper are those of the authors and do not necessarily represent those of the Federal Reserve Bank of New York or the Federal Reserve System.

What Drives Short-Term Movements in Exchange Rates?

Three Broad Strands of Literature

1. Forecasting FX growth hard at short horizons, out of sample
   - Recent challengers of Meese and Rogoff (1983) random walk benchmark: Engle, Mark and West (2007), Gourinchas and Rey (2007), Molodtsova and Papell (2008), ...
2. Failure of the Uncovered Interest Parity due to risk premia (?)
   - Fama (1984), Dumas and Solnik (1995), Lustig et al. (2010), ...
3. Flows — 80% of FX volume due to interdealer trading
   - Low information content at short horizons: Lyons (1997), Froot et al. (2005), ...

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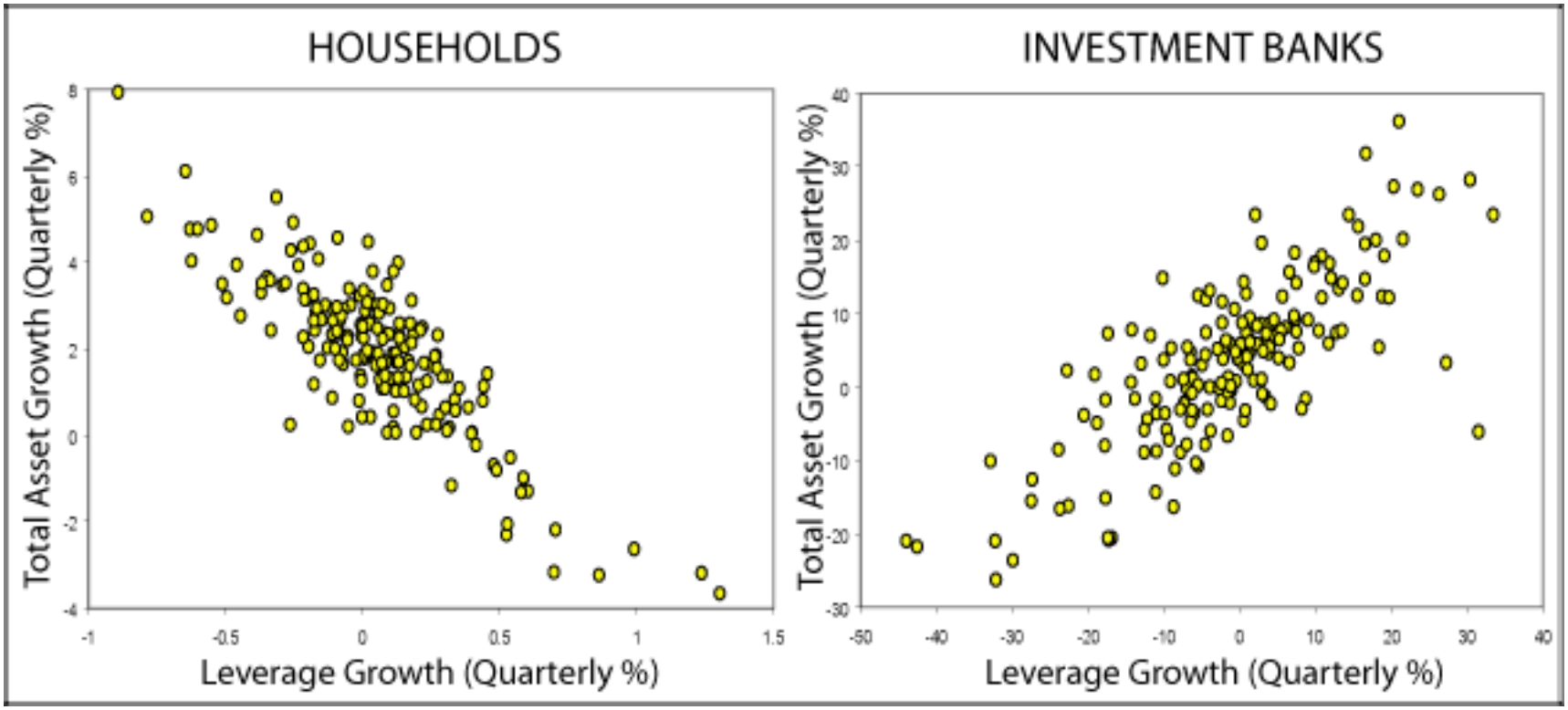
We show that:

1. Risk appetite of USD-funded intermediaries forecasts the USD
2. Forecastability due to systematic fluctuations in risk premia

What is Special about Leveraged Financial Intermediaries?



Risk appetite of intermediaries fluctuates with market conditions
(Adrian and Shin, 2007)

Fluctuating Risk Appetite Reflected in Asset Prices

Intermediary risk appetite and market-wide risk premia:

- Adrian and Shin (2007): forecasting the VIX
- Etula (2009): forecasting commodity returns
- Adrian, Moench, Shin (2009): link to macroeconomy

Theories of funding constraints and procyclical leverage:

- Brunnermeier and Pedersen (2008): funding liquidity
- Danielsson, Shin and Zigrand (2009): endogenous risk
- Adrian and Shin (2008): microeconomic foundation for VaR

Our Contribution

Premise: FX positions much like other risky investments:

- Consider a USD funded investment in riskless foreign debt:

$$r^i_{t+1} = \left(1 + r^i_{f,t}\right) \frac{\epsilon^i_{t+1}}{\epsilon^i_t} - \left(1 + r^{US}_{f,t}\right)$$

- Only risk from future changes in the exchange rate ϵ^i_{t+1}
- As the risk preferences of USD-funded investors change, USD should adjust to accommodate new risk premia

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Effective risk aversion of USD-funded investors $\sim$ short-term USD credit aggregates [overnight repo and financial CP]:

- Higher USD funding liquidity $\longrightarrow$ USD-funded investors require lower risk premia $\longrightarrow$ expected USD appreciation

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Effective risk aversion of USD-funded investors $\sim$ short-term USD credit aggregates [overnight repo and financial CP]:

- Higher USD funding liquidity $\longrightarrow$ USD-funded investors require lower risk premia $\longrightarrow$ expected USD appreciation

Separate from the familiar "carry trade" channel:

- Higher USD funding liquidity $\longrightarrow$ USD expected to appreciate against *both* high and low-yield currencies

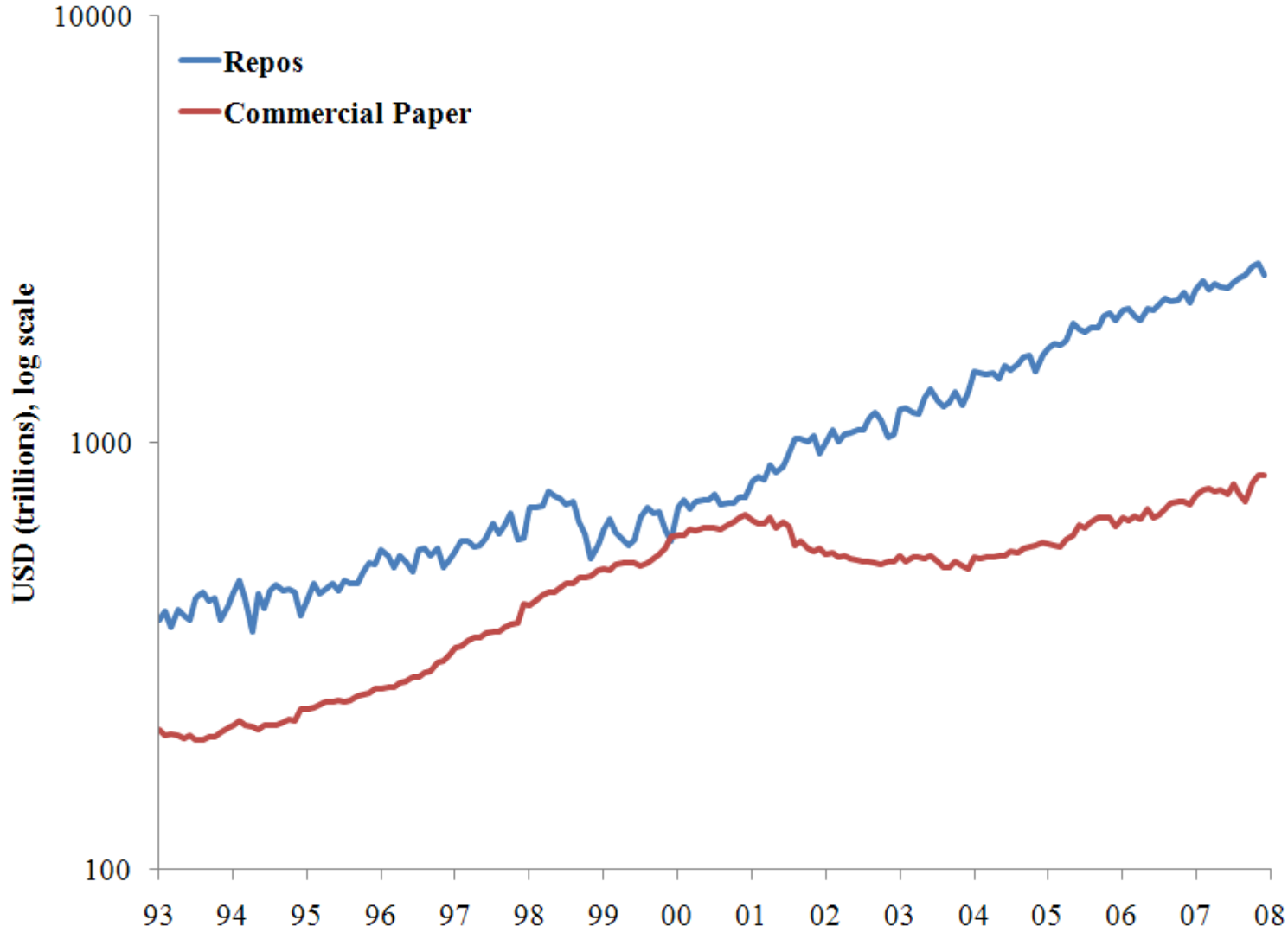
Roadmap

1. New evidence on FX forecastability
   - In-sample and out-of-sample
2. Funding constraints in asset pricing
   - Toward a theoretical framework
3. Reconciling theory and empirics
   - Is the forecastability due to risk or mispricing?

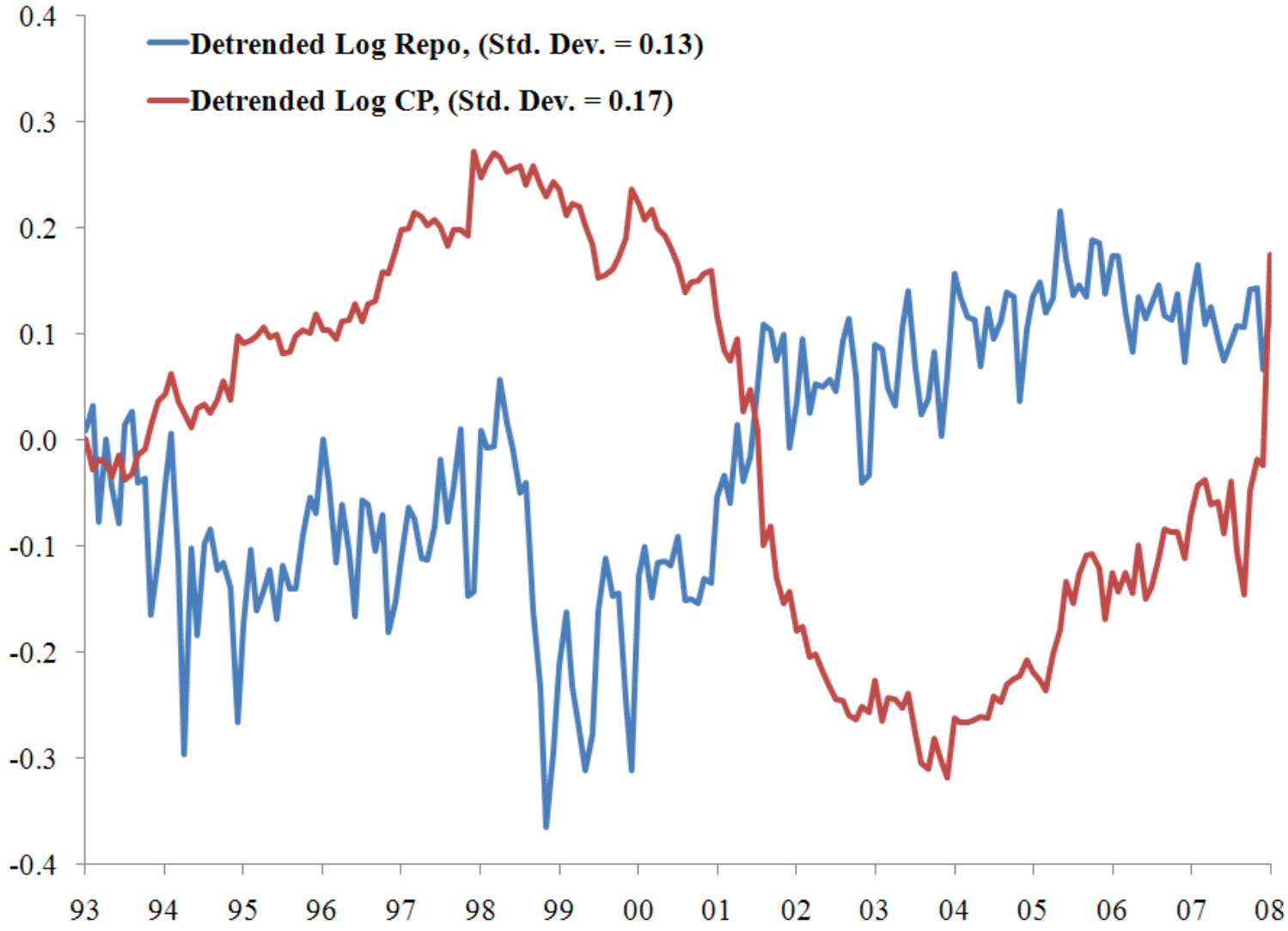
Data (1/1993-12/2007)

- Exchange rates:
  - Advanced countries: Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, UK
  - Emerging markets: Chile, Colombia, Czech Republic, Hungary, India, Indonesia, Korea, Philippines, Poland, Singapore, South Africa, Taiwan, Thailand, Turkey
- Interest rates:
  - 30 day money market rates (or equivalent) of each country
- USD short-term credit aggregates:
  - Primary Dealer Overnight Repos and Financial Commercial Paper Outstanding
  - Published weekly by the Federal Reserve

Primary Dealer Repos and Financial Commercial Paper



Repos and Commercial Paper, Detrended Out of Sample



Empirical Strategy

1. In-sample analysis
   - OLS regressions
   - Panel regressions (s.e. robust to cross-sectional and time-series correlation)
2. Out-of-sample analysis
   - Betas estimated recursively from panel regressions

Monthly Forecasting (Advanced Countries)

	Independent Variables		
Exchange Rate Growth (%)	Repo Lag	CP Lag	R^2
Australia	4.669**	3.419***	6.6%
Canada	1.382	2.022**	4.1%
Germany	1.320	2.977***	4.5%
Japan	4.686**	0.993	2.0%
New Zealand	6.252***	4.034***	8.3%
Norway	1.516	2.824***	3.5%
Sweden	2.773	3.127***	4.3%
Switzerland	2.143	2.480**	2.7%
UK	2.260	1.839**	3.2%

Monthly Forecasting (Emerging Markets)

	Independent Variables		
Exchange Rate Growth (%)	Repo Lag	CP Lag	R^2
Chile	-0.129	2.459**	3.7%
Colombia	-3.532	3.727***	7.0%
Czech Republic	0.050	3.703**	4.3%
Hungary	0.556	4.673***	7.9%
India	0.787	1.677***	2.3%
Indonesia	9.130	9.714	2.6%
Korea	2.540	2.851	1.4%
Philippines	-0.425	2.476*	2.3%
Poland	-2.028	3.302***	4.2%
Singapore	1.090	1.472**	3.0%
South Africa	3.494	4.195**	3.8%
Taiwan	2.202*	1.131	3.3%
Thailand	-1.209	2.927	2.0%
Turkey	-5.009	11.580***	10.1%

Robustness: Monthly Panel (Advanced Countries)

Dependent Variable: Exchange Rate Growth (%)					
LAGGED	(i)	(ii)	(iii)	(iv)	(v)
Repo	3.000**	2.952**			
CP	4.231***	4.191***			
FX Growth		0.005			
Carry					
Stock Mkt.					
U.S. Yield					
VIX Growth					
Signed VIX					
TED Growth					
Signed TED					
Constant	-0.038	-0.047			
Adjusted R^2	3.7%	3.7%			

*** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.1, s.e. clusted by currency and time

Robustness: Monthly Panel (Developed Countries)

Dependent Variable: Exchange Rate Growth (%)					
LAGGED	(i)	(ii)	(iii)	(iv)	(v)
Repo	3.000**	2.952**	2.775**		
CP	4.231***	4.191***	3.949***		
FX Growth		0.005	0.004		
Carry			-0.037*		
Stock Mkt.					
U.S. Yield					
VIX Growth					
Signed VIX					
TED Growth					
Signed TED					
Constant	-0.038	-0.047	-0.035		
Adjusted R^2	3.7%	3.7%	3.8%		

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Robustness: Monthly Panel (Developed Countries)

Dependent Variable: Exchange Rate Growth (%)					
LAGGED	(i)	(ii)	(iii)	(iv)	(v)
Repo	3.000**	2.952**	2.775**	3.399**	
CP	4.231***	4.191***	3.949***	4.980***	
FX Growth		0.005	0.004	-0.005	
Carry			-0.037*	-0.057***	
Stock Mkt.				-0.005	
U.S. Yield				-0.119	
VIX Growth					
Signed VIX					
TED Growth					
Signed TED					
Constant	-0.038	-0.047	-0.035	0.436	
Adjusted R^2	3.7%	3.7%	3.8%	4.4%	

*** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.1, s.e. clusted by currency and time

Robustness: Monthly Panel (Developed Countries)

Dependent Variable: Exchange Rate Growth (%)					
LAGGED	(i)	(ii)	(iii)	(iv)	(v)
Repo	3.000**	2.952**	2.775**	3.399**	3.723***
CP	4.231***	4.191***	3.949***	4.980***	5.115***
FX Growth		0.005	0.004	-0.005	-0.007
Carry			-0.037*	-0.057***	-0.061***
Stock Mkt.				-0.005	-0.004
U.S. Yield				-0.119	-0.119
VIX Growth					0.001
Signed VIX					-0.002
TED Growth					-0.003
Signed TED					0.001**
Constant	-0.038	-0.047	-0.035	0.436	0.490
Adjusted R^2	3.7%	3.7%	3.8%	4.4%	4.6%

*** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.1, s.e. clusted by currency and time

Robustness: Monthly Panel (All Countries)

Dependent Variable: Exchange Rate Growth (%)					
LAGGED	(i)	(ii)	(iii)	(iv)	(v)
Repo	1.501	1.173	1.963	2.073	2.294*
CP	4.259***	3.671***	3.739***	4.145**	4.130**
FX Growth		0.120***	0.062**	0.061**	0.061**
Carry			0.051***	0.050***	0.049***
Stock Mkt.				-0.001	-0.000
U.S. Yield				-0.046	-0.040
VIX Growth					0.002
Signed VIX					0.000
TED Growth					-0.003*
Signed TED					0.001
Constant	0.303*	0.258	-0.011	0.179	0.200
Adjusted R^2	2.4%	3.8%	7.7%	7.4%	7.5%

*** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.1, s.e. clusted by currency and time

Weekly and Quarterly Panels (Advanced Countries)

	Exchange Rate Growth (%)	
LAGGED	Weekly	Quarterly
Repo	0.800**	5.914
CP	1.035***	11.265***
FX Growth	-0.030	-0.062
Constant	-0.021	-0.118
Adjusted R^2	0.9%	9.2%

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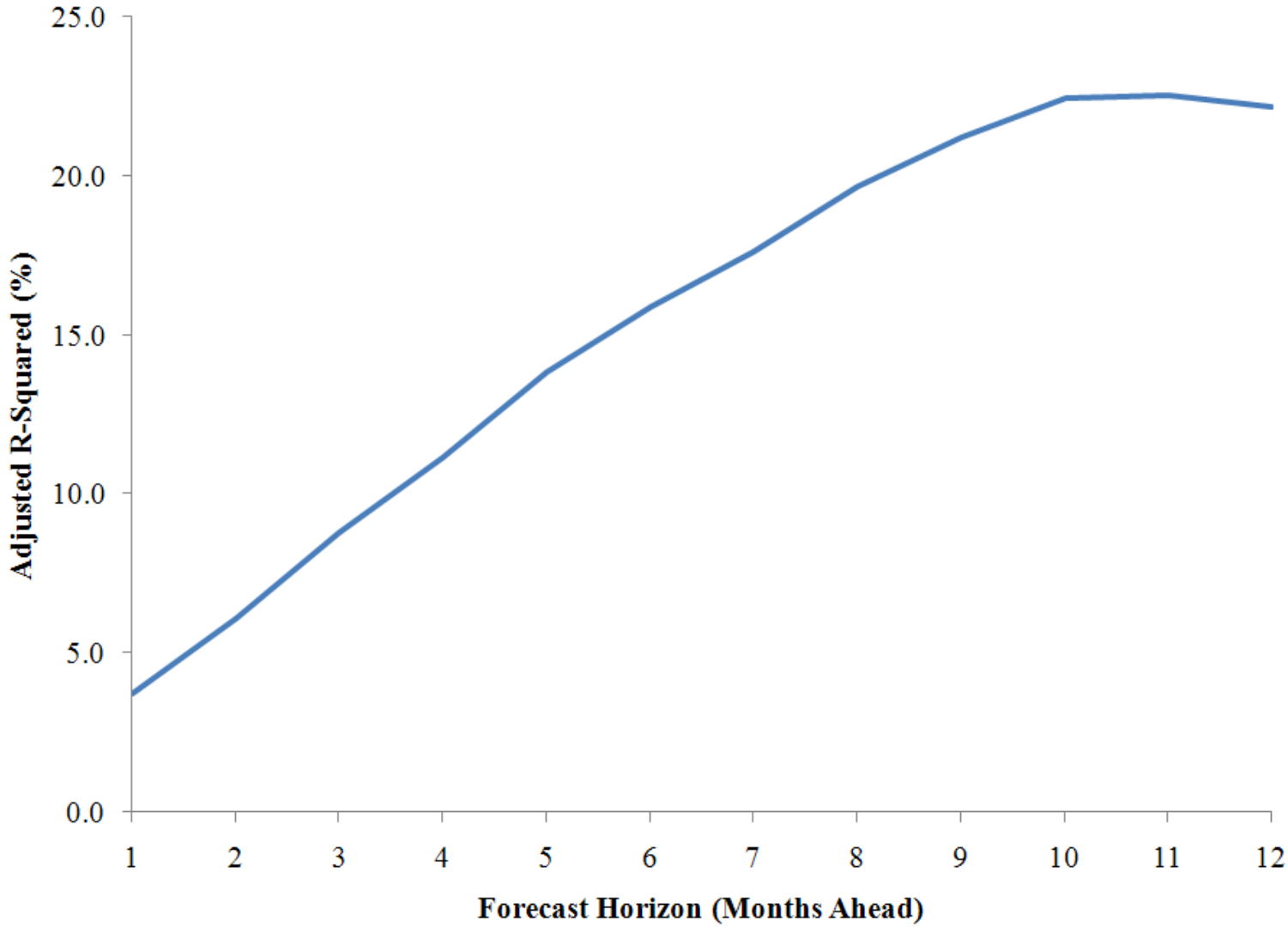
Forecasting Power Increases with Forecast Horizon



Greater economic importance at longer horizons

Analogous Evidence from Europe and Japan

	Exchange Rate Growth (%)	
	Euro-Based	Yen-Based
LAGGED	Panel	Panel
Euro Repos	0.023**	
Yen Repos		0.010**
Exch. Rate Growth	-0.005	0.148
Constant	-0.001	0.850***
Adjusted R^2	1.2%	4.2%

*** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.1, s.e. clusted by currency and time

Out-of-Sample Results (Advanced Countries)

	Random Walk Benchmark		AR(1) Benchmark	
	$\Delta MSE\text{-}Adj.$	p-value	$\Delta MSE\text{-}Adj.$	p-value
Australia	0.899**	0.005	0.858***	0.003
Canada	0.528**	0.020	0.449**	0.028
Germany	0.588**	0.035	0.544**	0.037
Japan	0.358	0.186	0.344	0.156
New Zealand	1.030***	0.006	1.023***	0.002
Norway	0.584*	0.066	0.548*	0.069
Sweden	0.683**	0.018	0.647**	0.020
Switzerland	0.469*	0.099	0.417*	0.099
UK	0.523**	0.031	0.471**	0.027

Adj. = Clark-West (2006) adjustment.

Out-of-Sample Results (Emerging Markets)

	Random Walk		AR(1)	
	$\Delta MSE\text{-}Adj.$	p-value	$\Delta MSE\text{-}Adj.$	p-value
Chile	0.502**	0.012	0.508**	0.035
Colombia	1.464***	0.002	0.628**	0.014
Czech Republic	0.650	0.102	0.630*	0.080
Hungary	1.363***	0.006	0.847**	0.011
India	0.575***	0.006	0.402***	0.003
Indonesia	4.572	0.220	2.078*	0.074
Korea	0.203	0.434	0.488	0.211
Philippines	0.416	0.273	0.279	0.223
Poland	0.636	0.137	0.511*	0.075
Singapore	0.141	0.307	0.267	0.151
South Africa	1.545***	0.009	1.033**	0.032
Taiwan	0.350	0.123	0.301	0.102
Thailand	-0.081	0.474	0.219	0.333
Turkey	21.730***	0.000	1.637***	0.001

Roadmap

1. *New evidence on FX forecastability*
   - *In-sample and out-of-sample*
2. **Funding constraints in asset pricing**
   - **Toward a theoretical framework**
3. *Reconciling theory and evidence*
   - *Is the forecastability due to risk or mispricing?*

Environment

Take the perspective of a USD-based financial investor who holds an internationally diversified portfolio. Two types:

1. Leveraged financial intermediaries (e.g. investment banks)
2. Other financial institutions (e.g. commercial banks, insurance companies, finance arms of non-financial corporations)

If the portfolio is invested in riskless bonds:

- *Excess* return on such dollar-funded "carry trade":

$$r^i_{t+1} = \left(1 + r^i_{f,t}\right) \frac{\epsilon^i_{t+1}}{\epsilon^i_t} - \left(1 + r^{US}_{f,t}\right)$$

- Only risk from changes in the exchange rate ϵ^i_{t+1} $\left[\frac{\text{USD}}{\text{currency } i}\right]$

Leveraged Financial Intermediaries (Active Investors)

Assets	Liabilities
Securities	$Equity\ (w_t^A)$ $\sim 70\%$ Repos & CP $\sim 25\%$ Other Debt

Maximize expected return on equity subject to a VaR constraint:

$$\max_{\mathbf{y}_t^A} E_t\left(\mathbf{y}_t^{A\prime}\mathbf{r}_{t+1}\right) \quad s.t.\ VaR_t \leq w_t^A$$

- Intermediaries lever up until $VaR_t = w_t^A$
- VaR_t is a multiple κ of equity volatility $\rightarrow$ constraint becomes $\kappa w_t^A \sqrt{Var_t\left(\mathbf{y}_t^{A\prime}\mathbf{r}_{t+1}\right)} \leq w_t^A$

Intermediary Funding Constraints and Risk Appetite

Simple mean-variance tradeoff:

$$\mathcal{L}_t = E_t\left(\mathbf{y}_t^{A\prime}\mathbf{r}_{t+1}\right) - \phi_t\left[\kappa\sqrt{Var_t\left(\mathbf{y}_t^{A\prime}\mathbf{r}_{t+1}\right)} - 1\right],$$

with the FOC:

$$\mathbf{y}_t^A = \frac{1}{\kappa\phi_t}\left[Var_t\left(\mathbf{r}_{t+1}\right)\right]^{-1} E_t\left(\mathbf{r}_{t+1}\right),$$

where $\mathbf{y}_t^A$ is the intermediary's optimal portfolio choice.

- $\frac{1}{\kappa\phi_t}$ measures **risk appetite**
- Tighter funding constraints $\longrightarrow$ greater $\kappa\phi_t$ $\longrightarrow$ must reduce leverage

Passive Investors and Market Clearing

*P*assive investors have constant risk aversion γ, such that:

$$\mathbf{y}_t^P = \frac{1}{\gamma} \left[Var_t \left(\mathbf{r}_{t+1} \right) \right]^{-1} E_t \left(\mathbf{r}_{t+1} \right).$$

By market clearing, the equilibrium excess return on position i is:

$$\begin{aligned} E_t \left(r_{t+1}^i \right) &= Cov_t \left(r_{t+1}^i, r_{t+1}^W \right) \frac{w_t^A + w_t^P}{w_t^A / \left(\kappa \phi_t \right) + w_t^P / \gamma} \\ &= Cov_t \left(r_{t+1}^i, r_{t+1}^W \right) \Gamma_t \end{aligned}$$

- r_{t+1}^W is the return on dollar wealth portfolio
- Γ_t is the **effective risk aversion** of dollar-based investors

How to Measure Effective Risk Aversion?

We show that in equilibrium:

$$\Gamma_t = \gamma \left[1 + \frac{w_t^A}{w_t^P} \left(1 - \frac{lev_t^A}{lev_t^{A\&P}} \right) \right],$$

where $lev_t = 1 + debt_t / w_t$ denotes financial leverage.

It follows that, for $r_{t+1}^i = \left(1 + r_{f,t}^i\right) \frac{\epsilon_{t+1}^i}{\epsilon_t^i} - \left(1 + r_{f,t}^{US}\right)$:

$$E_t \left(\frac{\epsilon_{t+1}^i}{\epsilon_t^i} \right) = \frac{1 + r_{f,t}^{US}}{1 + r_{f,t}^i} + Cov_t \left(\frac{\epsilon_{t+1}^i}{\epsilon_t^i}, r_{t+1}^W \right) \underbrace{\gamma \left[1 + \frac{w_t^A}{w_t^P} \left(1 - \frac{lev_t^A}{lev_t^{A\&P}} \right) \right]}_{\Gamma_t}$$

When leverage (funding liquidity) of intermediaries is high, equilibrium expected returns on risky positions are low. That is, the US dollar is expected to appreciate.

Roadmap

1. *New evidence on FX forecastability*
   - *In-sample and out-of-sample*
2. *Funding constraints in asset pricing*
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Do Repo and CP Reflect Effective Risk Aversion?

Do our *high-frequency* measures of funding liquidity (repos and CP) forecast USD because they contain information about Γ_t?

Following the theory, construct a measure effective risk aversion:

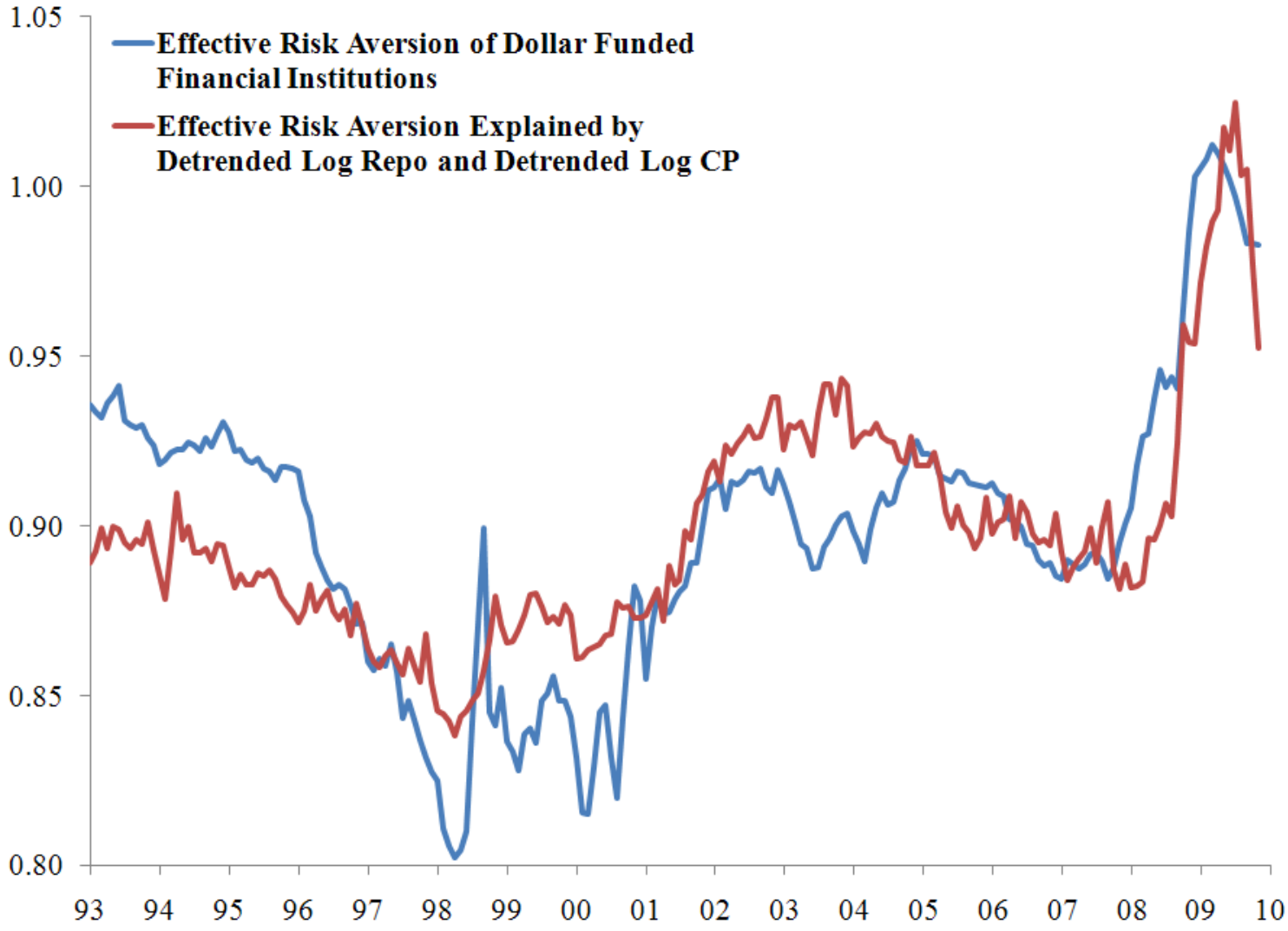
$$\hat{\Gamma}_t = 1 + \frac{\text{Dealer Equity}_t}{\text{All Fin. Equity}_t - \text{Dealer Equity}_t}\left(1 - \frac{\text{Dealer Leverage}_t}{\text{All Fin. Leverage}_t}\right)$$

- Repo and CP strongly related to $\hat{\Gamma}_t$:

$$\hat{\Gamma}_t = \underset{(463.03)}{0.890} - \underset{(-6.58)}{0.082}\, Repo_t - \underset{(-18.10)}{0.177}\, CP_t + error_{t+1},$$

with $R^2 = 62\%$.

Effective Risk Aversion of USD Funded Financials and its Projection onto Repos and CP



Do Repos and CP Forecast FX Because They Contain Info About Effective Risk Aversion?

1. Run:
$$FX\ Growth^i_{t+1} = a^i_0 + a^i_1 \hat{\Gamma}_t + resid^i_{t+1}$$
2. Test the hypothesis that $resid^i_{t+1}$ is not forecastable by $Repo_t$ and CP_t:

   $$resid^i_{t+1} = b^i_0 + b^i_{resid}\, resid^i_t + b^i_{Repo}\, Repo_t + b^i_{CP}\, CP_t + error^i_{t+1},$$

   (No Granger causality $\Leftrightarrow$ $b^i_{Repo} = b^i_{CP} = 0$).

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(No Granger causality $\Leftrightarrow$ $b^i_{Repo} = b^i_{CP} = 0$).

Result: *Cannot* reject $b^i_{Repo} = b^i_{CP} = 0$ for 9/9 advanced countries and 10/14 emerging markets

- Forecasting ability of repos and CP stems from their association with effective risk aversion
- Consistent with our simple theoretical framework

Predictability of Residual FX Growth (Advanced Countries)

$H_0: \quad b_i^{\text{Repo}} = b_i^{\text{CP}} = 0$	
	p-value
Australia	[0.3140]
Canada	[0.3024]
Germany	[0.4539]
Japan	[0.3520]
New Zealand	[0.1686]
Norway	[0.5230]
Sweden	[0.3716]
Switzerland	[0.7503]
UK	[0.2330]

Predictability of Residual FX Growth (Emerging Markets)

$H_0: \quad b_i^{\text{Repo}} = b_i^{\text{CP}} = 0$	
	p-value
Chile	[0.4681]
Colombia	[0.0436]**
Czech Republic	[0.3088]
Hungary	[0.0080]***
India	[0.3643]
Indonesia	[0.9824]
Korea	[0.8544]
Philippines	[0.7280]
Poland	[0.0789]*
Singapore	[0.9902]
South Africa	[0.5020]
Taiwan	[0.5319]
Thailand	[0.6132]
Turkey	[0.0195]**

Conclusion

1. Short-term U.S. dollar credit aggregates forecast dollar appreciations:
   - In-sample and out-of-sample
   - Weekly, monthly, quarterly horizons

2. Predictability attributable to time-varying effective risk aversion:
   - U.S. dollar funding liquidity determines expected returns on dollar-funded positions, including those in foreign currencies