Intermediary Leverage and Currency Risk Premium

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Carry Trade and Currency Risk Premium

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  - Not offset by exchange rate movement

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- Carry trade: Borrow low, lend high, positive return
- Risk-based view (Lustig, Roussanov, and Verdelhan, 2011)
  - JPY **less risky** than AUD: appreciate in recessions

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- An intermediary-based model of currency risk premium
  - Low nominal interest rate $\rightarrow$ High bank leverage
  - High bank leverage $\rightarrow$ Currency appreciation in recessions
- Empirical evidence in support of the model

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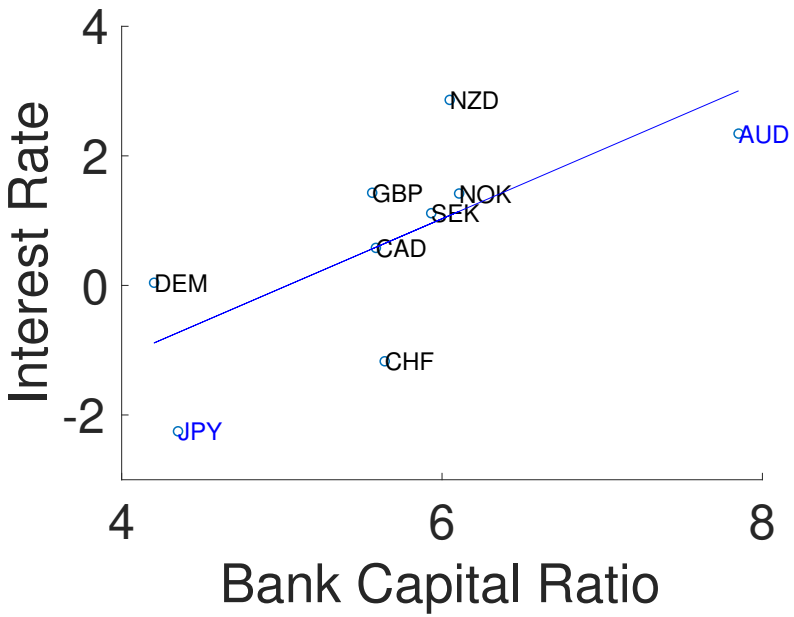
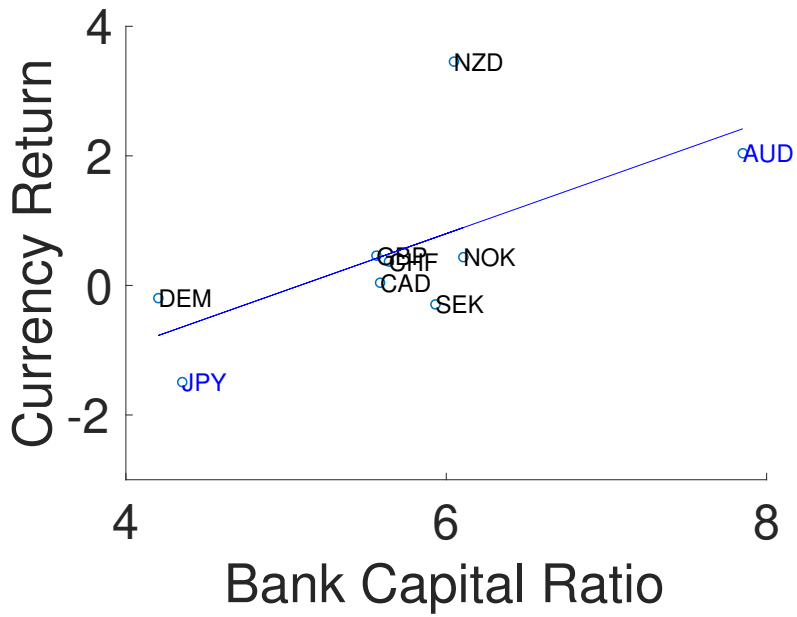
    - Banks are more willing to hold the foreign assets than savers

First-pass Evidence





Note: Time span from 1990 to 2015. Currency data at monthly frequency and bank capital ratio at annual frequency. German currency data are used before 1999 while euro data are used after 1999.

Empirics

- Low interest rate, high bank leverage, low currency return
- Low rate currencies appreciate in recessions when global bank stock return is low
- Carry trade *CAPM beta* increases with global stock return volatility

Contribution to the Literature

- Structural models of cross-sectional real currency premium
  - Hassan (2013), Richmond (2018), Ready, Roussanov, and Ward (2017, 2018), Colacito, Croce, Gavazzoni, and Ready (2018), Jiang (2018), Wiriadinata (2018)
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- Financial intermediation and currency return
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  - Contribution: Explain **carry trade risk premium** via intermediaries
- Risk taking effect of monetary policy
  - Bernanke and Kuttner (2005), Bruno and Shin (2015), Drechsler, Savov, and Schnabl (2017, 2018), Miranda-Agrippino and Rey (2018), Coimbra and Rey (2019)
  - Contribution: The currency market implications
- New evidence on interest rates, bank leverage, and currency returns

Environment (1/2)

- A **set** of small open economies, nontraded and traded goods (CES)

- Endowment: A tree delivers nontraded good X and traded good Y

$$\frac{dX}{X} = \mu_x dt + \sigma_x dB_x, Y = \bar{\tau} X$$

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- Modeling global systematic shock: the same shock dB_x hits all
  - Carry trade—exposure to global shock

Environment (2/2)

- Two agents with **recursive preferences** on the consumption basket
  - Risk aversion $\gamma_h > \gamma_b$
  - IES $\psi_h < \psi_b$ (Vissing-Jorgensen, 2002; Guvenen, 2006; 2009)
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  - Deposit, cash, local risky asset, a foreign asset
  - Foreign asset with exogenous return in traded good

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- Exogenously different nominal interest rates

The Liquidity Friction

- Bank holds cash w_c^b proportional to holding of the local risky asset w_h^b if $w_h^b > 1$ (Drechsler, Savov, and Schnabl, 2018)

$$w_c^b = \lambda(w_h^b - 1)$$

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    - $\frac{\lambda}{1+\lambda}$ foreign asset
    - No liquidity premium in currency excess return (Valchev, 2017)

▸ Discussion: The Liquidity Friction

Interest Rate and Bank Leverage

- Banks' budget constraint

$$\frac{dW^b}{W^b} = [\tilde{r} + w_h^b(\mu_s - \tilde{r}) + w_f^b(\mu_f - r) - c_x^b - Qc_y^b]dt + \Pi^b dt$$

$$+w_h^b \sigma_s' d\mathbf{B} + w_f^b \sigma_f' d\mathbf{B} + \underbrace{[...]}_{\text{0 in equilibrium}} dN$$

  - $\tilde{r} = r + \lambda i$ the effective real cost of borrowing for banks

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  - $\tilde{r} = r + \lambda i$ the effective real cost of borrowing for banks
- Optimal portfolio choice

$$\begin{bmatrix} w_h^b \\ w_f^b \end{bmatrix} = \underbrace{\frac{1}{\gamma_b} \begin{bmatrix} \sigma_s'\sigma_s & \sigma_s'\sigma_f \\ \sigma_s'\sigma_f & \sigma_f'\sigma_f \end{bmatrix}^{-1} \begin{bmatrix} \mu_s - r - \lambda i \\ \mu_f - r \end{bmatrix}}_{\text{tangency portfolio}} + \underbrace{\frac{1}{\gamma_b} \frac{1-\gamma_b}{1-\psi_b} \begin{bmatrix} \sigma_s'\sigma_s & \sigma_s'\sigma_f \\ \sigma_s'\sigma_f & \sigma_f'\sigma_f \end{bmatrix}^{-1} \begin{bmatrix} \sigma_s'\sigma_\Omega \\ \sigma_f'\sigma_\Omega \end{bmatrix} \frac{B_\Omega}{B}}_{\text{hedging portfolio}}$$

  - Interest rate lowers leverage w_b^h

Bank Leverage and Exchange Rate

- Consider a bad shock on endowment:

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- Why does nominal interest rate i matter?
  - Low $i \rightarrow$ High bank leverage $\rightarrow$ More appreciation with the bad shock

Expected Return: The Euler Equation

$$(\mu_f - r)dt = -cov\left(... - \gamma_j \frac{dW^j}{W^j}, \frac{dQ}{Q}\right)$$

- If Q comoves positively with W^j, $\mu_f - r$ should be positive

Roadmap for Numerical Results

- Cross-sectionally: interest rate, bank leverage, currency risk premium
  ▸ Cross section
- Time-series relation between interest rate and currency risk premium
  ▸ Time series
- Deviation from CIP and its interaction with currency risk premium
  ▸ CIP

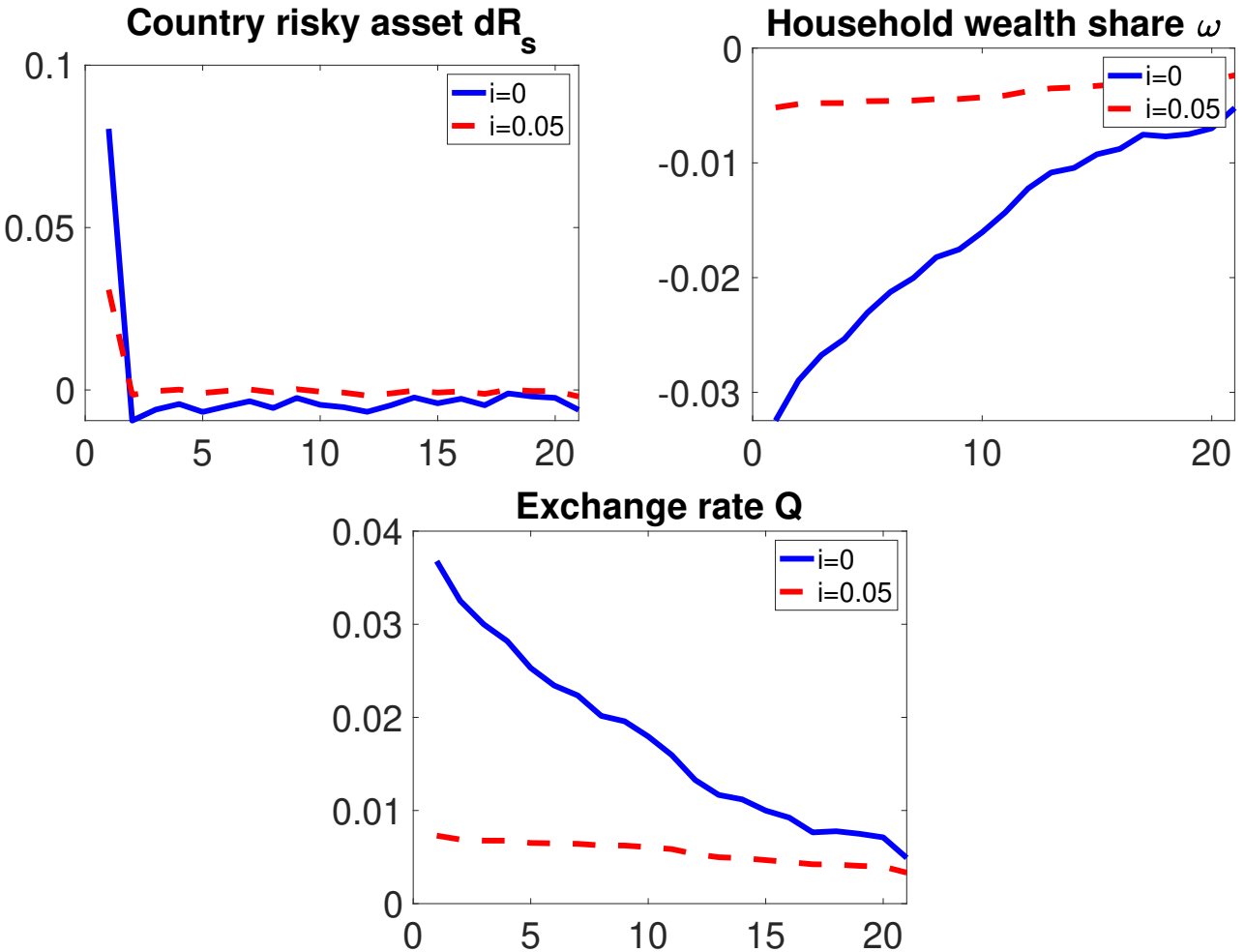
Key Parameters

Variable	Notation	Value
Households' risk aversion	γ_h	30
Bank's risk aversion	γ_b	5
Households' IES	ψ_h	1.2
Bank's IES	ψ_b	3
Size of funding shock	λ	0.2

λ: G10 average of liquid assets/total assets for the banking sector

▸ Parameters

Impulse Responses



Note: Impulse responses of various variables to a one standard deviation **positive** endowment shock in the two economies with $i = 0$ and $i = 0.05$.

Simulation: A Cross-Section with Fixed Interest Rates

Low interest rate i, high bank leverage w_h^b, appreciation in bad shock σ_{qx}, large asset return exposure σ_{sx}, high foreign currency risk premium $\mu_f - r$

i	0	1	2	3	4	5
w_h^b	1.946	1.924	1.812	1.571	1.454	1.373
σ_{sx}	8.237	6.455	5.286	4.151	3.667	3.155
σ_{qx}	5.425	3.595	2.836	2.253	1.817	1.215
$\mu_f - r$	2.111	1.131	0.876	0.859	0.743	0.454

▸ Leverage discussion ▸ Full results

Stock Market Implications

- Low-interest-rate countries' stock return load more on the global risk

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- Low-interest-rate countries' stock return load more on the global risk
  - Low interest rate $\rightarrow$ High bank leverage $\rightarrow$ Strong amplification
- Empirical evidence: Colacito, Croce, Gavazzoni, and Ready (2018)

Time-varying Carry Trade *CAPM Beta*

- Model Prediction: Carry trade *CAPM beta* increases in global stock market volatility

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  - Stock vol $\uparrow \rightarrow$ Wealth redistribution $\uparrow \rightarrow$ exchange rate movement $\uparrow$
  - Exchange rate comoves strongly with stock return
  - $corr(\beta, \overline{\sigma}_s) = 0.705$ in the simulation, and 0.645 in the data

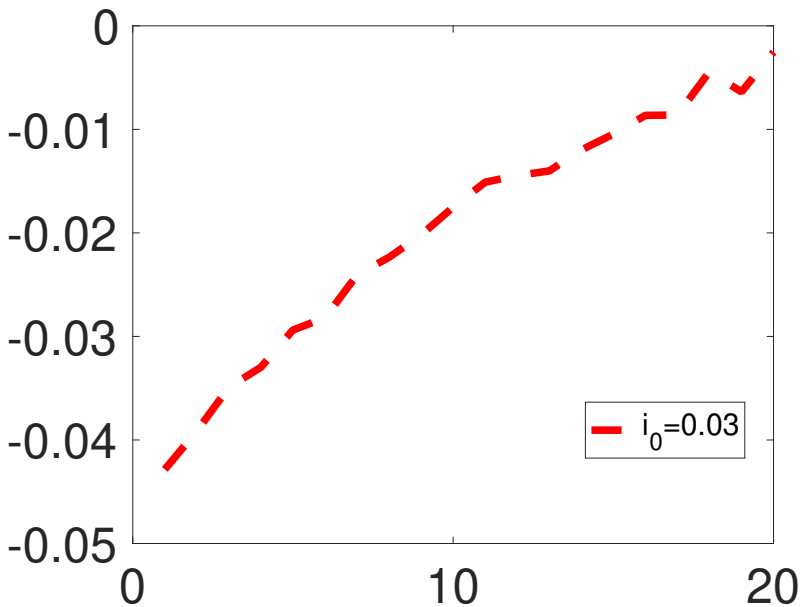
▸ Big Picture

Time Series

- Stochastic process for interest rate

$$di = \zeta(i_0 - i) + \sigma_i dB_i$$

- Empirical evidence by Mueller, Tahbaz-Salehi, and Vedolin (2017)
  - After the Fed raises interest rate unexpectedly, the risk premium of investing in foreign currencies decline
- Impulse responses in the model ▸ Big Picture



Deviation from Covered Interest Rate Parity

- Deviation from covered interest rate parity (CIP)

$$-x_t = \underbrace{-i_t^{\$}}_{\text{short}} \underbrace{+s_t - f_t + i_t^*}_{\text{long}} > 0$$

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- Interpretation through my model
  - Dollar in cash is cheaper because it is more liquid

▸ Big Picture ▸ Liquidity premium and currency risk premium

Empirical Evidence: Overview

1. Interest rate, bank leverage, and currency return ▸ Go
   - Low interest rate, high bank leverage, low currency return
   - Positive spread between lowest and highest leverage portfolios
   - A leverage risk factor prices the cross-section

Empirical Evidence: Overview

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3. Carry trade *CAPM beta* increases in stock market volatility

▸ Data

Panel Regression

	Interest rate dif		Currency return	
	(1)	(2)	(1)	(2)
Capital ratio	0.463**	0.113**	0.279**	0.208**
	(0.071)	(0.005)	(0.100)	(0.094)
Inflation		0.948**		0.374
		(0.098)		(0.570)
GDP		-0.429**		-0.587**
		(0.031)		(0.025)
R^2	0.134	0.468	0.124	0.341

Note: Fama-Macbeth regression results of interest rate difference (left panel) and currency return (right panel) on bank capital ratio (the inverse of leverage, in percentage). Data are monthly including 22 countries, from Jan 1990 to Dec 2016. Annual measures of bank capital ratio and GDP share are used repetitively for months within a year. Standard errors are Newey-West adjusted with 120 lags.

▸ Big Picture ▸ Including emerging economies

Currency Portfolios

	(1)	(2)	(3)	(3)-(1)
Panel A: Leverage sorted portfolios				
Interest rate dif	0.050	1.068	1.669	1.619
Bank capital ratio	4.476	5.738	7.612	3.135
Excess return	-0.687	0.182	1.465	2.152
Standard deviation	8.513	9.165	8.711	5.550
Sharpe ratio	-0.081	0.020	0.168	0.388

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Panel B: Interest rate sorted portfolios				
Interest rate dif	-0.734	1.128	2.540	3.274
Bank capital ratio	5.324	5.738	6.548	1.224
Excess return	-0.526	-0.226	1.635	2.161
Standard deviation	7.602	9.738	9.242	6.308
Sharpe ratio	-0.069	-0.023	0.177	0.343

- (1) to (3): low interest/high leverage to high interest/low leverage

▸ Big Picture

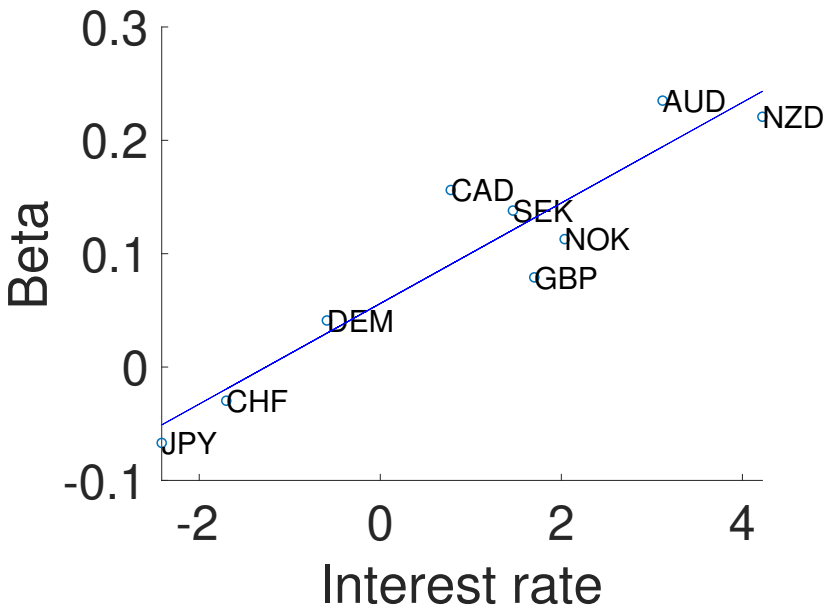
Linear Factor Model with Lev-Factor

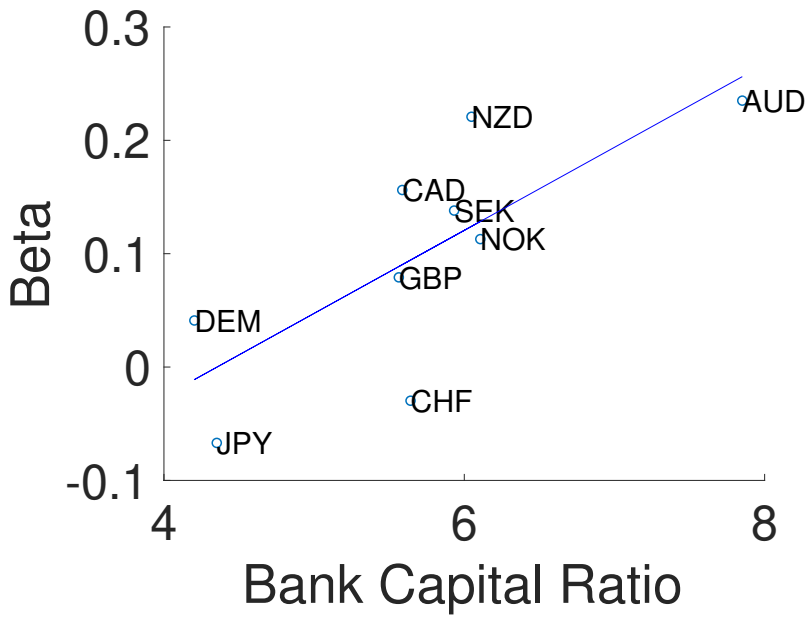
	Lev-1	Lev-2	Lev-3	Int-1	Int-2	Int-3
			Panel A: Risk Factor Exposure			
α	0.269	0.060	0.269	-0.036	-0.127	0.716
	(1.613)	(1.813)	(1.613)	(1.484)	(1.927)	(1.769)
β	-0.444**	0.056	0.556**	-0.228**	-0.046	0.427**
	(0.084)	(0.094)	(0.084)	(0.077)	(0.100)	(0.092)
R^2	0.084	0.001	0.125	0.028	0.001	0.066
Obs	312	312	312	312	312	312
			Panel B: Price of Risk			
		Two-step			GMM	
		2.552*			2.134*	
		(1.543)			(1.107)	

Note: Panel A shows the exposure to Lev-factor across the currency portfolios sorted on bank leverage and unconditional average interest rate difference. Panel B reports the estimated price of Lev-factor risk using two-step and GMM methods. Shanken (1992)'s adjustment is used when computing two-step estimates' standard error. In GMM estimation, I use Hansen and Jaganathan (1997)'s scale-invariant weight matrix. All estimates of price of risk are annualized.

▸ Big Picture

Exchange Rate and Global Bank Stock Return





Note: Relationship of interest rate (the left panel) and bank capital ratio (the right panel) with exchange rate beta with global bank stock return. Data from November 1983 to December 2016. Euro is used for "DEM" after 1999.

▸ Big Picture

Conclusion

- An economic explanation of the carry trade risk premium
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- An economic explanation of the carry trade risk premium
  - Low nominal rate $\rightarrow$ high bank leverage $\rightarrow$ appreciation in bad times
- Empirical evidence for the main model implications
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  - Low rate currencies appreciate in bad times
  - Carry trade *CAPM beta* increases with the global stock volatility

Parameters

Variable	Notation	Value
Panel A: Preference Parameters		
Households' risk aversion	γ_h	30
Bankers' risk aversion	γ_b	5
Households' IES	ψ_h	1.2
Bankers' IES	ψ_b	3
Preference over nontrade goods	α	0.975
Elasticity of substitution across goods	θ	0.5
Time discount rate	ρ	0.005
Exit rate	κ	0.02
Panel B: Endowment Parameters		
Drift of dividend process	μ_x	0.025
Diffusion of dividend process	σ_x	0.025
Ratio of endowment	τ	0.160
Panel C: Foreign Return Parameters		
Drift of foreign asset return	r^*	0.0236
Diffusion of foreign asset return	σ_q^*	0.02
Panel D: Interest Rate Parameters		
Size of funding shock	λ	0.2
Persistence of interest rate	$1-\zeta$	0.9
Volatility of interest rate	σ_i	$0.004\sqrt{1-(1-\zeta)^2}$
Panel E: Other Parameters		
Wealth redistribution share	$\bar{\omega}$	0.95

Back

Discussion: Bank Leverage

Recall the market clearing condition:

$$P = W^h w_h^h + W_b w_h^b$$

Divide each side by $W = P + NFA$:

$$1 \approx 1 - \chi \frac{QX}{W} = \omega w_h^h + (1 - \omega) w_h^b$$

Thus:

$$w_h^b \leq \frac{1 - \omega w_h^h}{1 - \omega} < \frac{1}{1 - \omega}$$

Back

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Low interest rate i, high bank leverage w_h^b, appreciation in bad shock σ_{qx}, large asset return exposure σ_{sx}, high foreign currency risk premium $\mu_f - r$

i	0	1	2	3	4	5
Panel A: Asset Prices (in percent)						
μ_s	4.074	3.969	3.928	3.957	4.045	4.192
r	0.847	1.753	1.991	2.000	2.112	2.401
$\mu_s - r$	3.227	2.216	1.937	1.957	1.933	1.791
σ_{sx}	8.237	6.455	5.286	4.151	3.667	3.155
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Panel B: Portfolio Choices						
w_h^b	1.946	1.924	1.812	1.571	1.454	1.373
w_f^b	-0.039	0.062	0.148	0.191	0.217	0.230
w_h^h	0.257	0.378	0.489	0.616	0.696	0.786
w_f^h	0.025	-0.049	-0.099	-0.132	-0.151	-0.138
Panel C: State Variables						
ω	0.542	0.581	0.603	0.592	0.593	0.629
χ	-0.177	-0.196	-0.220	-0.218	-0.231	-0.227

Back

Liquidity Premium and Risk Premium

- Jiang, Krishnamurthy, and Lustig (2018)
  - Based on VAR decomposition

$$N_{FX} = N_{LP} + N_{ID} + N_{RP}$$

  - Positive correlation between dollar liquidity premium and risk premium

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- A slightly extended version of the model (with dollar specialty)
  - Dollar and domestic cash imperfect substitutes (>1)
  - Dollar liquidity premium $\uparrow \rightarrow$ cost of liquidity $\downarrow \rightarrow$ risk premium $\uparrow$

Back

Data

- Forward and spot rate: Datastream, 1983-2016
- 22 advanced economies
  - Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, South Korea, Spain, Sweden, Switzerland, UK, US
- Bank balance sheet: 1990-2016, from SNL Financial
- Bank stock returns: Datastream, 1983-2016
- Countries using euro: only in the sample before 1999

▸ Empirical overview

Panel Regression with EMs

	Interest rate dif		Currency return	
	(1)	(2)	(1)	(2)
Capital ratio	0.385**	0.267**	0.419**	-0.038
	(0.033)	(0.047)	(0.128)	(0.061)
Inflation		0.541**		0.114
		(0.031)		(0.501)
GDP		-0.323**		-0.210
		(0.032)		(0.469)
R^2	0.079	0.446	0.064	0.198

Note: Fama-Macbeth regression results of interest rate difference (left panel) and currency return (right panel) on bank capital ratio (the inverse of leverage, in percentage). Data are monthly including 44 advanced and emerging economies, from Jan 1990 to Dec 2016. Annual measures of bank capital ratio and GDP share are used repetitively for months within a year. Standard errors are Newey-West adjusted with 120 lags.

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