Are Intermediary Constraints Priced?

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Introduction

- Intermediaries face regulatory and other constraints
  - e.g. leverage ratio requirements
- These constraints prevent intermediaries from closing arbitrage opportunities
  - e.g. covered interest parity violations
- Is the risk that these constraints tighten a priced risk factor?
- Most direct test: does betting on arbitrage violations shrinking earn a risk premium?
- Yes: there is a significant risk premium, and exposure to this risk factor is priced in the cross-section

Model Overview

- Manager with CRRA preferences runs intermediary (He and Krishnamurthy [2011])
- Faces regulatory constraint (He and Krishnamurthy [2017])
- CIP violation reveals shadow price (multiplier) of this constraint
- Exp. return on wealth portfolio higher when constraint tighter
- $\gamma \neq 1$: Intertemporal hedging concern (Campbell [1993])
  - with EZ prefs, would be $IES \neq 1$
- Implication: concern for risk that constraint tightens in future
- Persistent shocks have high prices of risk

Model and Hypothesis

- We build an intermediary-based asset pricing model (He and Krishnamurthy [2011, 2017]) to motivate:

$$m_{t+1} = \mu_t - \gamma r^w_{t+1} + \xi |x_{t+1,0,1}|,$$

  - m_{t+1} is log SDF
  - r^w_{t+1} is return on intermediary manager's wealth
  - γ is intermediary manager's CRRA risk-aversion
  - $x_{t+1,0,1}$ is one-period spot CIP violation at time $t+1$
  - Hypothesis: ξ meaningfully different from zero

Model Takeaways

- Exposure to CIP violation shocks should be priced
  - In particular, should focus on largest CIP violation
- SDF omits factors
  - Anything predicting future rates, vol, arbitrage should be priced
- CIP shocks could be supply, demand, or regulation
  - Our model is silent on relative importance
- CIP shocks small (basis points), but ξ could be large
  - persistence and leverage both matter here
- CIP shocks and wealth return likely correlated
  - Controlling for wealth return important and difficult

How to Test It?

- Look at currency pair that doesn't change sign, ignore $|\cdot|$
- Idea: trading strategy that bets on size of $x_{t+1,0,1}$ at time t
- We call this strategy "forward CIP trading strategy"
  - not an arbitrage, but a risky bet on the size of future arbitrage
- We review CIP, then construct the forward trading strategy

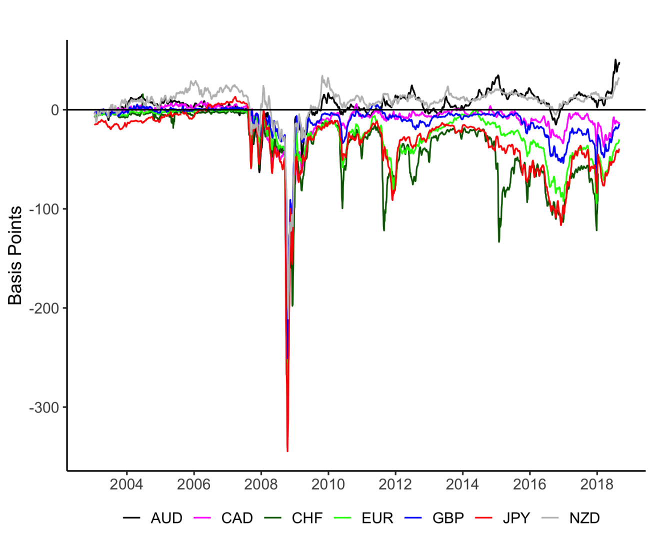
Covered Interest Parity

(Log) Spot CIP Basis, currency c:

$$x^c_{t,0,\tau} = r^{\$}_{t,0,\tau} - r^c_{t,0,\tau} + \frac{12}{\tau}(f^c_{t,\tau} - s^c_t)$$

- $r_{t,0,\tau}, r^{\$}_{t,0,\tau}$: τ-month log rates at time t. $s_t, f_{t,\tau}$: spot and τ-month fwd log exchange rates (foreign currency per USD)
- Difference between USD rate and synthetic USD rate (standard definition, Du et al. [2018])
- All FX and rate data from Bloomberg: Benchmark results use OIS rates. Robustness results use IBOR, FRA rates.
- Pre-crisis: Jan 2003-June 2007, Crisis: July 2007-June 2010, Post-Crisis: July 2011-Aug 2018
- Note: spot CIP spikes at quarter/year-end

Covered Interest Parity (3M OIS)



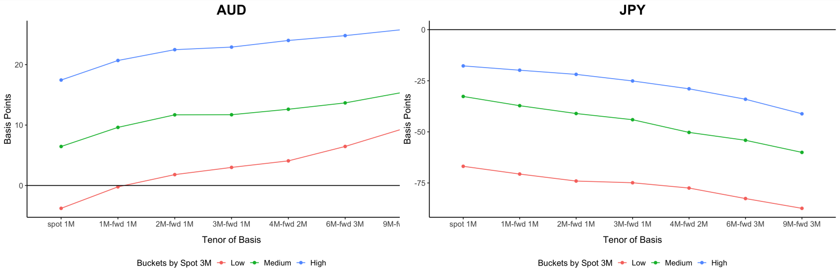
Forward Covered Interest Parity

(Log) h-month forward starting CIP Basis, currency c:

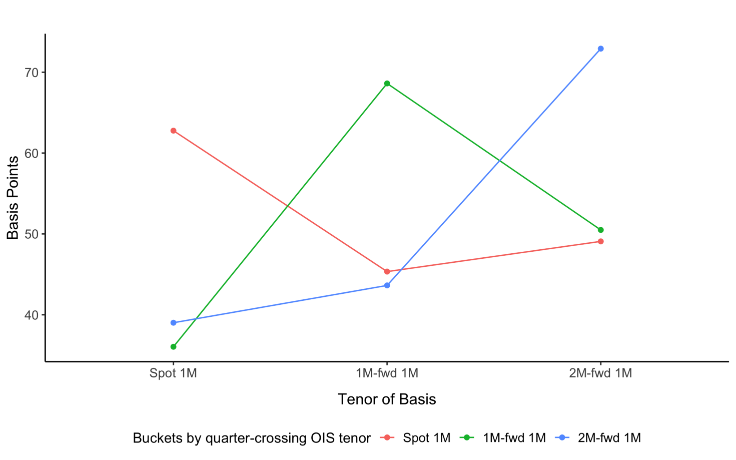
$$\begin{aligned} x^c_{t,h,\tau} &= r^{\$}_{t,h,\tau} - r^c_{t,h,\tau} + \frac{12}{\tau}(f^c_{t,\tau+h} - f^c_{t,h}) \\ &= \frac{h+\tau}{\tau} x^c_{t,0,h+\tau} - \frac{h}{\tau} x^c_{t,0,h} \end{aligned}$$

- $r_{t,h,\tau}, r^{\$}_{t,h,\tau}$: h-month forward τ-month log rates at time t
- Assumes no arbitrage between spot and forward OIS swaps
- Note analogy to forward interest rates, term structure

Term Structure of Forward CIP



AUD-JPY Basis and Quarter End



Forward CIP Trading Strategy

1. Initiate h-month forward τ-month forward CIP trade
2. h-months later, unwind

- Profits for the holding period h:

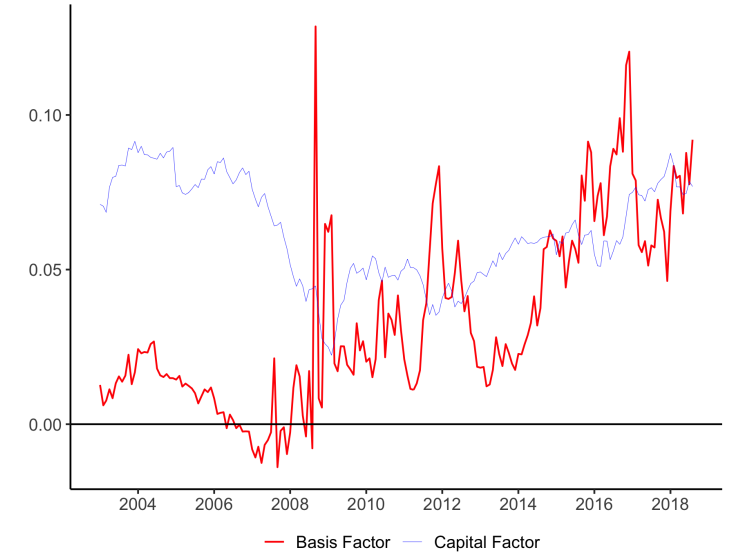
$$\pi^{c}_{t+h,h,\tau} \approx \frac{\tau}{12}(x^{c}_{t,h,\tau} - x^{c}_{t+h,0,\tau})$$

- Approximation due to discounting effects
- $\frac{\tau}{12}$ is like a bond duration
- A bet on whether slope of forward CIP curve is realized
  - Recall again analogy to term structure
- Note: implementable even if interest rates for the spot CIP arbitrage are not tradable or not true marginal rates

Portfolios

- Portfolios of forward arbitrages: "Carry" and "Dollar"
- "Carry" is AUD profits minus JPY profits
    - This is also biggest spot basis, which model suggests
- "Dollar" is equal-weighted from all currencies (vs. USD)
- Motivated by literature (Lustig et al. [2011], Verdelhan [2018])
- Paper has alternative definitions in robustness appendix

Carry Basis and HKM Factor



Results

- We present mean profit per dollar notional and Sharpe ratios for forward CIP trading strategy
- We focus on 1-month forward 3m tenor based on OIS
    - generate monthly returns, then annualize
- 3-month forward and IBOR/FRA-based results in appendix
- We divide results by pre/crisis/post
    - Model: risk premium only when CIP due to regulation (post-crisis)

Portfolio Results

Table 1: Portfolio Returns on OIS 1M-forward 3M Forward CIP Trading Strategy

	Mean (bps)			Sharpe Ratio		
	Pre-Crisis	Crisis	Post-Crisis	Pre-Crisis	Crisis	Post-Crisis
Carry	2.44	-4.37	14.25***	0.61	-0.16	1.38***
s.e.	(1.34)	(10.79)	(3.26)	(0.34)	(0.38)	(0.33)
Dollar	-1.46	6.16	0.07	-0.68*	0.18	0.02
s.e.	(0.77)	(16.53)	(1.52)	(0.34)	(0.44)	(0.33)

Interpretation

- Carry portfolio has significant Sharpe ratio
- Recall SDF:

$$m_{t+1} = \mu_t - \gamma r^w_{t+1} + \xi |x_{t+1,0,1}|$$

- Either ξ big or r^w_{t+1} and $x_{t+1,0,1}$ correlated
- What generates returns?
    - Future spot CIP deviations do not rise as much as predicted by the current term structure slope.
    - Paper: Campbell and Shiller [1991] style return predictability (slope predicts returns)
    - No evidence for different quarter-end risk premia

Cross-Sectional Implications

- Our forward arbitrage directly tests if the risk that the basis gets bigger is a priced factor
- Our model, however, gives an SDF
  - All assets exposed to forward CIP trading strategy returns (r^x_{t+1}) should earn excess returns
- Cross-sectional test, building on He et al. [2017] (HKM):

$$R^i_{t+1} - R^f_t = \mu_i + \beta^i_w (R^w_{t+1} - R^f_t) + \beta^i_x r^x_{t+1} + \epsilon^i_{t+1},$$

$$E[R^i_{t+1} - R^f_t] = \alpha + \beta^i_w \lambda_w + \beta^i_x \lambda_x.$$

- From mean return, we expect $\lambda_x \approx -5bps$

Cross-Sectional Details

- We study Fama-French Size x Value 25, US Tsy/Corp. Bonds, FX Portfolios (Lustig et al. [2011]), and Sovereign bonds (Borri and Verdelhan [2015])
    - Also use non-AUD/JPY forward forward CIP trading strategy returns as test assets
    - Adding more asset classes is work in progress
- Non-log returns, consistent w/ HKM but not model
- We estimate betas and mean returns on different samples
    - betas: post-crisis only, consistent with our theory
    - means: longest possible sample for each asset class
- Cochrane [2009] GMM standard errors to account for estimated betas
- Try both HKM proxies for intermediary wealth return
- Monthly data

Cross-Sectional Asset Pricing Test, 2-Factor

	US	Sov	FX	FF	US/Sov/FX
Int. Equity	0.377	1.362	1.843***	0.599	1.277*
	(0.918)	(0.783)	(0.427)	(0.558)	(0.511)
Basis Shock	-0.169*	-0.0784	-0.0719	0.0271	-0.0971*
	(0.0754)	(0.0501)	(0.0466)	(0.0629)	(0.0380)
Intercepts	Yes	Yes	Yes	Yes	Yes
N (assets)	20	6	11	25	37
N (beta)	98	98	98	98	
N (mean)	234	283	418	1106	

Cross-Sectional Asset Pricing Test, 2-Factor

	US/Sov/FX	Forward Arb	Forward Arb
Int. Equity	1.277*	0.0936	2.000***
	(0.511)	(0.970)	(0.112)
Basis Shock	-0.0971*	-0.0487**	
	(0.0380)	(0.0153)	
Intercepts	Yes	Yes	Yes
N (assets)	37	10	10
N (beta)		98	98
N (mean)		98	98

Cross-Sectional Asset Pricing Test, 3-Factor

	US	Sov	FX	FF	US/Sov/FX
Market	1.067	0.459	0.887***	-0.0248	0.709
	(0.645)	(0.483)	(0.176)	(0.524)	(0.384)
HKM Factor	-1.224	1.712	0.399	0.529	0.207
	(1.408)	(1.365)	(1.259)	(0.541)	(0.645)
Basis Shock	-0.0602	-0.0605	-0.0588	0.0345	-0.101**
	(0.0345)	(0.0465)	(0.0339)	(0.0539)	(0.0332)
Intercepts	Yes	Yes	Yes	Yes	Yes
N (assets)	20	6	11	25	37
N (beta, mos.)	98	98	98	98	
N (mean, mos.)	234	283	418	1106	

Cross-Sectional Asset Pricing Test, 3-Factor

	US/Sov/FX	OIS-FA	OIS-FA
Market	0.709	-4.227	2.210***
	(0.384)	(4.219)	(0.208)
HKM Factor	0.207	-2.575	2.086***
	(0.645)	(2.728)	(0.110)
Basis Shock	-0.101**	-0.0835*	
	(0.0332)	(0.0412)	
Intercepts	Yes	Yes	Yes
N (assets)	37	10	10
N (beta, mos.)		98	98
N (mean, mos.)		98	98

Cross-Sectional Takeaways

- Price of basis shock risk broadly consistent with forward arbitrage, except for equities
  - HKM also have difficulty pricing equities
  - Perhaps related to smaller role of intermediaries (or different intermediaries)
- Including basis shock attenuates impact of HKM factor
  - HKM factor is like a book-to-market ratio for bank stocks
  - not surprising it is related to future investment opportunities
  - or perhaps basis shock is a better measure of wealth return

Conclusion

- The risk that CIP violations become bigger is priced
- Model: risk of intermediaries becoming more constrained
- This should be expected given intermediary asset pricing (He and Krishnamurthy [2011]) meets intertemporal hedging (Campbell [1993])
- Hard to explain existence of arbitrage, why arbitrage risk is priced, and why it co-moves with intermediary wealth without central role for intermediaries

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