Are Intermediary Constraints Priced?

Wenxin Du (Chicago and NBER)
Benjamin Hébert (Stanford and NBER)
Amy Huber (Stanford)

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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?
- Direct test: does betting on arbitrage violations shrinking earn a risk premium?
- Yes: there is a risk premium, and exposure to this risk is priced in the cross-section

Model Overview

- We build on He and Krishnamurthy [2011, 2017] to motivate:

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

  - Manager with Epstein-Zin preferences runs intermediary
  - Faces regulatory constraint (which creates CIP violation)
  - m_{t+1}: log SDF γ: EZ RRA r^w_{t+1}: manager wealth return
  - $x_{t+1,0,1}$ is one-period spot CIP violation at time $t+1$
  - idea: $x_{t+1,0,1}$ measures multiplier on regulatory constraint, multiplier proxy for investment opporunities
  - $\gamma \neq 1$: Intertemporal hedging (Campbell [1993], Kondor and Vayanos [2019])

Model Takeaways

- Model implications:
  - focus on largest CIP violation (fortunately, doesn't change sign)
  - SDF omits factors
  - CIP shocks could be supply, demand, or regulation
  - CIP should be correlated with other arbitrages/near-arbitrages
  - CIP shocks and wealth return likely correlated
- Test: 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

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 2010-Aug 2018

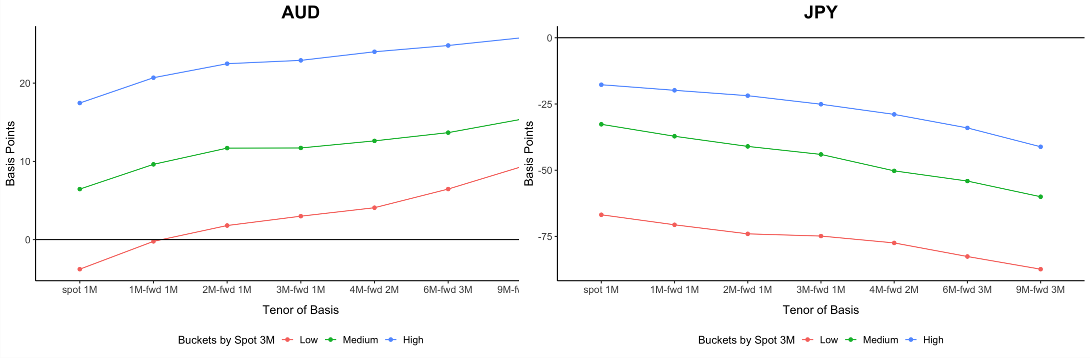
Forward Covered Interest Parity

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

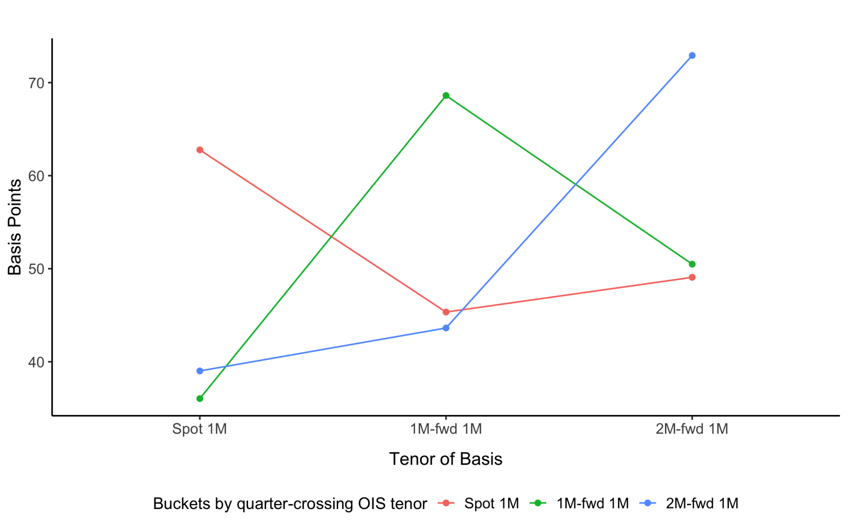
$$
\begin{aligned}
x^c_{t,h,\tau} &= r^{\$}_{t,h,\tau} - r^c_{t,h,\tau} + \frac{12}{\tau}(f^c_{t,\tau+h} - f^c_{t,h}) \\
&= \frac{h+\tau}{\tau} x^c_{t,0,h+\tau} - \frac{h}{\tau} x^c_{t,0,h}
\end{aligned}
$$

- $r_{t,h,\tau}, r^{\$}_{t,h,\tau}$: 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:

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

- $\frac{\tau}{12}$ 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

Portfolio Results

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

	Mean (bps)			Sharpe Ratio		
	Pre-	Crisis	Post-	Pre-	Crisis	Post-
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)

- 3-month forward and IBOR/FRA-based results in appendix
- Future spot basis does not rise as much as predicted by term structure slope
- We show in paper that slope predicts returns ala Campbell and Shiller [1991]

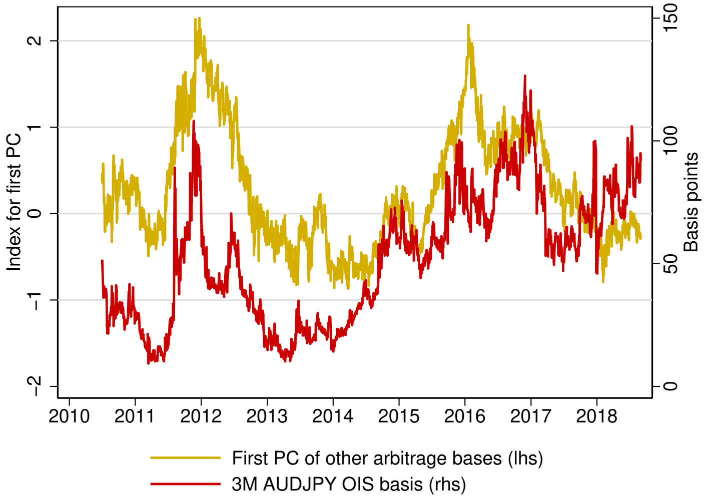
Why CIP?

- In our model, nothing is special about CIP per se
    - Any arbitrage can be used to measure shadow price on regulatory constraint
    - Consequently, all arbitrages should co-move
- In the real world, CIP is particularly clean:
    - It was zero pre-crisis, and can be measured accurately
    - It doesn't involve cheapest-to-deliver options or other nuisances
    - It has a rich term structure we can use to construct forward arbitrages

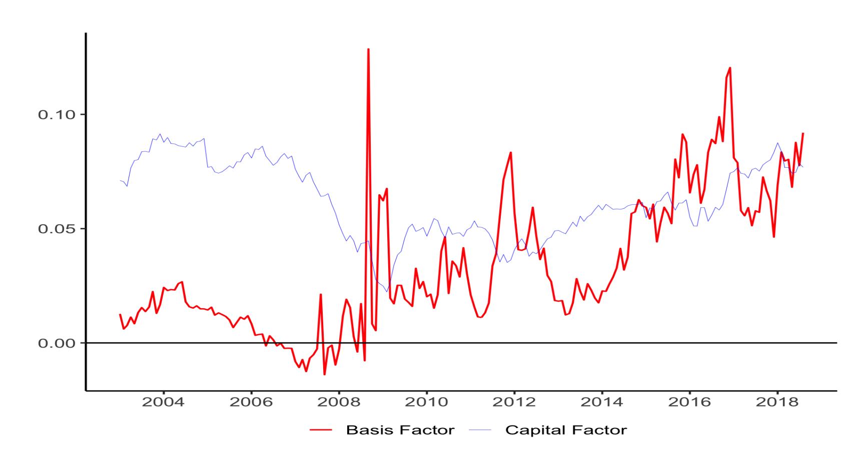
Comparing CIP and Other Arbitrages

- We check for co-movement with seven near-arbitrages:
  - bond-CDS, CDS-CDX, Libor tenor basis, 30Y swap spread, KfW vs Bunds, Refco vs Treasurys, TIPS asset swap
  - Each of these corresponds to one or more papers in the literature
  - These are all long-term (e.g. 5 years)
  - Construct 1st principal component in levels
- We find roughly 51% corr. between 1st PC and Classic Carry spot basis post-crisis
- We then compare spot basis to intermediary capital measure from He et al. [2017]

CIP vs 1st PC


Index for first PC
Basis points
2
1
0
−1
−2
150
100
50
0
2010
2011
2012
2013
2014
2015
2016
2017
2018
First PC of other arbitrage bases (lhs)
3M AUDJPY OIS basis (rhs)

Carry Basis and HKM Factor



- Basis factor rescaled (0.05 = 50 bps CIP violation)

Asset Pricing Interpretations

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

- Either ξ big or r^w_{t+1} and $x_{t+1,0,1}$ correlated
  - Model: $\xi > 0 \Leftrightarrow \gamma < 1$ (sign of intertemporal hedging effect)
- Equity return on broker dealers as proxy for r^W_{t+1} (He, Kelly, Manela, 2017),

	Intermediary return	Forward CIP return
Price of risk (mean excess return)	0.610*	0.048***
	(0.288)	(0.011)
SDF parameters (γ, ξ)	0.658	305***
	(1.768)	(91.7)

- Alternative interpretation: forward CIP trading return is a better proxy for r^w_{t+1} than the intermediary equity return.

Cross-Sectional Implications

- Forward arbitrage returns directly test if the risk of the basis widening is priced
- Our model, however, gives an SDF
  - All assets exposed to forward CIP 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 $\lambda_x = -4.8bps$, $\lambda_w = 61bps$
  - We formally test this alternative hypothesis

Cross-Sectional Details

- We study Fama-French Size x Value 25, US Tsy/Corp. Bonds, FX Portfolios (Lustig et al. [2011]), Sovereign bonds (Borri and Verdelhan [2015]), Commodity Futures (HKM and Yang [2013]), SPX options (Constantinides et al. [2013])
  - Also use non-AUD/JPY forward forward CIP trading strategy returns as test assets
  - Adding corporate CDS 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
  - like a conditional beta model with break post-crisis
- Cochrane [2009] GMM standard errors to account for estimated betas
- Monthly data

Cross-Sectional Asset Pricing Test, 2-Factor

	US	Sov	FX	FF	Commod	Options	FwdArb	AllexFF	FwdArb
Int. Equity	0.499	1.363	1.845***	0.601	1.031*	1.377**	0.0857	0.999***	1.996***
	(0.898)	(0.782)	(0.425)	(0.558)	(0.425)	(0.422)	(0.968)	(0.221)	(0.110)
Basis Shock	-0.150	-0.0784	-0.0718	0.0271	-0.0171	-0.134**	-0.0487**	-0.0482***	
	(0.0781)	(0.0502)	(0.0465)	(0.0628)	(0.0221)	(0.0410)	(0.0153)	(0.0138)	
Intercepts	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MAPE (%)	0.021	0.022	0.060	0.142	0.363	0.143	0.007		0.008
H1 p-value	0.417	0.166	0.005	0.345	0.174	0.012	0.785	0.217	0.000
N (assets)	9	6	11	25	23	18	10	77	10
N (beta, mos.)	98	98	98	98	98	90	98		98
N (mean, mos.)	360	283	418	1106	331	264	98		98

Cross-Sectional Asset Pricing Test, 3-Factor

	US	Sov	FX	FF	Commod	Options	FwdArb	AllexFF	FwdArb
Market	1.007*	0.459	0.887***	-0.0248	0.627***	0.464**	-4.223	0.453***	2.206***
	(0.483)	(0.483)	(0.176)	(0.524)	(0.180)	(0.148)	(4.215)	(0.100)	(0.208)
HKM Factor	-1.274	1.712	0.399	0.529	0.766	2.973	-2.572	0.383	2.083***
	(0.958)	(1.365)	(1.259)	(0.541)	(0.580)	(2.044)	(2.726)	(0.505)	(0.110)
Basis Shock	-0.0504	-0.0605	-0.0588	0.0345	-0.0064	-0.0849	-0.0834*	-0.0498***	
	(0.0804)	(0.0465)	(0.0339)	(0.0539)	(0.0263)	(0.0541)	(0.0411)	(0.0107)	
Intercepts	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MAPE (%)	0.008	0.021	0.062	0.149	0.349	0.146	0.005		0.009
H1 p-value	0.658	0.906	0.358	0.223	0.119	0.364	0.483	0.098	0.000
N (assets)	9	6	11	25	23	18	10	77	10

Cross-Sectional Asset Pricing Test, 2-Factor PC1

	US	Sov	FX	FF	Commod	Options	FwdArb	AllexFF
Int. Equity	0.362	1.237	1.561**	0.825	1.177**	1.708***	-0.645	1.204***
	(0.440)	(0.668)	(0.492)	(0.629)	(0.447)	(0.371)	(1.375)	(0.257)
AR1 Resid of PC1	-0.0654***	-0.0793***	0.0441	-0.0288	-0.0236	-0.0807***	-0.0856**	-0.0438***
	(0.0151)	(0.0212)	(0.0325)	(0.0927)	(0.0251)	(0.0207)	(0.0310)	(0.00978)
Intercepts	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MAPE (%)	0.036	0.041	0.068	0.158	0.352	0.192	0.005	
H1 p-value	0.568	0.350	0.054	0.737	0.207	0.003	0.360	0.021
N (assets)	9	6	11	25	23	18	10	77

- AR(1) residual of PC1 scaled to have s.d. of basis shock

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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